INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

X.45
(10/96)

SERIES X: DATA NETWORKS AND OPEN SYSTEM COMMUNICATION

Public data networks – Interfaces

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, designed for efficiency at higher speeds

ITU-T Recommendation X.45

(Previously CCITT Recommendation)

ITU-T X-SERIES RECOMMENDATIONS

DATA NETWORKS AND OPEN SYSTEM COMMUNICATION

For further details, please refer to ITU-T List of Recommendations.

FOREWORD

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

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

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation X.45, was prepared by ITU-T Study Group 7 (1993-1996) and was approved by the WTSC Resolution No. 1 procedure on the 5th of October 1996.

NOTE

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

CONTENTS

SUMMARY

This Recommendation specifies the interface between packet mode DTEs and public data networks for physical links which have data rates higher than those of the scope of Recommendation X.25.

Full interworking compatibility between X.25 DTEs and X.45 DTEs is provided. In particular credit based flow control is available for both directions of each virtual circuit at each DTE/DCE interface. For X.45 DTEs an unassured virtual circuit option is offered for virtual circuits where data losses are preferred to extra delays in case of transmission errors.

Protocol of this Recommendation can be used on underlying layers which are functionally equivalent to HDLC layer 2.a, in particular on ATM-VPs and VCs used with the CPCS of AAL 5.

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, DESIGNED FOR EFFICIENCY AT HIGHER SPEEDS

(Geneva, 1996)

1 Scope

The purpose of this Recommendation is to specify procedures to be used for supporting X.25 compatible services at higher access speeds than Recommendation X.25 itself. Also, in order to add a new flexibility regarding the trade-off between error correction and variations of propagation delay, it includes a non-assured data transfer option.

It should be noted that this Recommendation is not intended to be a replacement of Recommendation X.25. It is an alternative that is more suitable than Recommendation X.25 for higher speed operation in particular in the multi-Mbit/s range of access speeds. The use of the interface specified in this Recommendation is a network option; it may not be implemented in all networks.

This Recommendation specifies a combination of protocol layers which still has high level of efficiency when the product of bit rate times propagation delay reaches the equivalent of hundreds or even thousand of packets. This high level of efficiency is relative to the amount of overhead per data packet, the capacity to reach high throughputs in data octets and data packets per second, the window sizes for reaching these throughputs, and effects of transmission errors on effective data rates and on end-to-end delays.

In particular, the mode of operation specified in this Recommendation for transmission error conditions is such that a transmission error on a packet of one virtual circuit entails no retransmission and no processing delay for other virtual circuits. For this, the sharing out of functions between the link layer of the protocol (layer 2) and the virtual circuit layer (layer 3) is different from that of X.25.

Although the X.45 protocol is different from the X.25 protocol, the X.25 service is fully provided by this Recommendation, ensuring that there is a full interoperability between an X.45 DTE and an X.25 DTE connected either to the same public data network or to different public data networks. An important feature of the X.45 protocol is that it is symmetrical except for those signalling aspects which are inherently non-symmetrical (e.g. cause codes, addressing, etc.). Hence its applicability could be extended to multi-point links.

2 References

The following Recommendations, and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision: all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation X.25 (1996), *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*.

– ITU-T Recommendation Q.931 (1993), *ISDN user-network interface layer 3 specification for basic call control*.

3 Terms and definitions

For the purpose of this Recommendation the following definitions apply:

3.1 **frame**: PDU meaningful for the entire link.

3.2 **packet**: PDU meaningful for only one virtual circuit and transmitted over that particular virtual circuit.

3.3 **message**: Signalling PDU.

4 Abbreviations

For the purposes of this Recommendation, the following abbreviations apply:

AAL	ATM Adaptation Layer
ATM	Asynchronous Transfer Mode
CPCS	Common Part Convergence Sublayer
DCE	Data Circuit-terminating Equipment
DTE	Data Terminal Equipment
HDLC	High level Data Link Control
LAN	Local Area Network
MAC	Media Access Control
PDU	Protocol Data Unit
PVC	Permanent Virtual Circuit
Rsrvd	Reserved
SAP	Service Access Point
SDU	Service Data Unit
SVC	Switched Virtual Circuit
VC	Virtual Circuit
VP	Virtual Path

See also Tables 9-1, 9-2 and 11-1.

5 Convention

No special convention is defined for the purpose of this Recommendation.

6 Description of services

6.1 General

Services offered by a network across an X.45 interface are the same as those across an X.25 interface.

In addition, support of non-assured data transfer may be offered as an option on a per virtual circuit basis for calls where a bounded transit delay is more important than the absence of data loss. This may be the case for instance where data are encapsulated connectionless packets which are subject to end-to-end error protection.

Compatibility of services between Recommendation X.25 and this Recommendation implies that virtual circuits can be established between an X.45 interface and an X.25 interface or between two X.45 interfaces with the same functional properties as between two X.25 interfaces.

Annex A provides additional specifications to ensure exhaustively the interworking between Recommendation X.25 and this Recommendation.

For communications between two X.45 interfaces belonging to different networks, services will be restricted to those of Recommendation X.25 if Recommendation X.75 is used at a network-to-network interface.

6.2 Service parameters

Service parameters recapitulated hereafter are related to link and VC-level procedures. Service parameters related to signalling procedures, i.e. user facilities, are described in clause 14.

Appendix I provides a list of subscription parameters which includes service parameters and user facilities when applicable.

6.2.1 Access rate

The access rate is the maximum transfer rate at which the DTE may send/receive data to/from the network. It is determined by the speed of the underlying media that is selected from a set supported by the network at subscription time.

NOTE – If the underlying media provides asymmetrical speeds, then two access rates are defined one for each direction of data transmission.

6.2.2 Maximum PDU size

For the whole DTE/DCE interface, and for each direction of data transmission, the maximum PDU size is determined by the receiver which signals this maximum PDU size to the sender during link set-up.

6.2.3 Maximum packet size

For each virtual circuit and for each direction of data transmission, the maximum packet size is determined at subscription time in case of a permanent virtual circuit or by the receiver which signals this maximum packet size to the sender during call set-up in case of switched virtual circuit.

6.2.4 Throughput

Throughput for a virtual circuit is the number of user data transferred in one direction per unit time. Throughput for one direction of transmission is an inherent characteristic of the virtual circuit related to the amount of resources available to this virtual circuit.

The optimal conditions to maximise the throughput include the following :

1) the underlying media at the local and remote DTE/DCE interfaces do not constrain the throughput;
2) flow control procedures at the local and remote DTE/DCE interfaces do not constrain the throughput;
3) the traffic characteristics of other virtual circuits do not constrain the throughput;
4) the receiving DTE is not flow controlling the DCE such that the throughput is not attainable.

The throughput is expressed in bits per second.

In case of permanent virtual circuit, the throughput is determined at subscription time for each direction of data transmission.

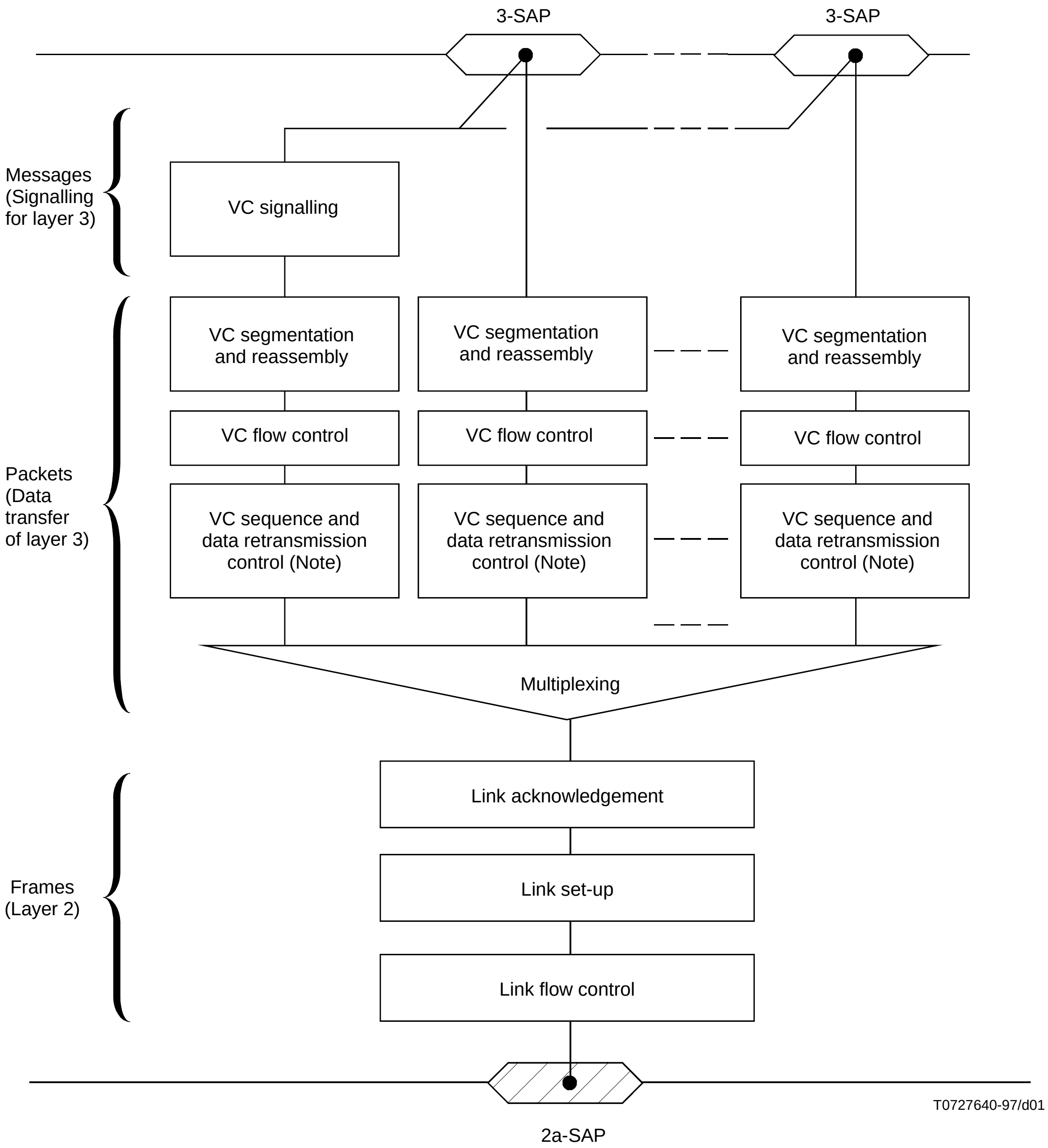
In case of switched virtual circuit, the throughput is determined during call set-up for each direction of data transmission.

6.2.5 Assured/non-assured data transfer

The data transfer option: assured or non-assured is selected for each virtual circuit, at subscription time in case of permanent virtual circuit or during call set-up in case of switched virtual circuit.

7 Architecture of the protocol

Figure 7-1 presents the relationship between layers and sublayers of this Recommendation.



NOTE – Data retransmission control applies only for assured virtual circuits.

FIGURE 7-1/X.45

Architecture of the protocol

7.1 Service provided by the underlying layer

The lowest sublayer of X.45 protocol is located above a MAC layer service (layer 2.a): the underlying service which is used provides for the transfer of frames between two services access points. For each frame either a complete loss, or a completely uncorrupted transfer occurs (a single bit error implies the complete loss of the frame). The sequential order of the frames is preserved.

HDLC frame structure over a duplex bit stream, AAL 5 (CPCS part) over an ATM-VP or VC, and MAC frames between two stations of a LAN, are possible instances of this underlying service.

7.2 Link Flow Control

The Link Flow Control entity ensures that a transmitting entity always remains compatible with the varying capacity of the corresponding entity.

7.3 Link set-up

The link set-up entity includes means for set-up and disconnection of the link and for exchanging parameters concerning PDU sizes and formats.

7.4 Link acknowledgement

The link acknowledgement entity ensures, at the link layer, that higher sublayers know which packets have been successfully transmitted and which ones have been lost. The loss detection entity makes no attempt at retransmitting any lost packet.

The link acknowledgement entity also ensures that after a silence period during which no "useful" traffic was exchanged, it can be detected if the peer entity is no longer in operation (keep alive function).

7.5 Multiplexing

The multiplexing entity supports means to multiplex several virtual circuits into a link layer. It uses a pair of identifiers to identify each virtual circuit established between the two sides of an X.45 interface. Each side of the interface independently selects the identifier to identify the virtual circuit.

At each side of the X.45 interface, an identifier is reserved for a signalling virtual circuit which is permanently established and which is used to exchange signalling messages concerning other virtual circuits.

7.6 VC sequence and retransmission control

The VC sequence and retransmission control entity ensures that packets which have been lost by lower layers are retransmitted unless they are *data* packets belonging to a virtual circuit where the non-assured data transfer option has been selected or unless the lost packet is superseded by another packet.

This entity ensures that the sequence order of received data packets can always be preserved despite the possibility of losses and retransmissions.

In the case of non-assured data transfer option, it ensures when at least one PDU of a segmented SDU has been lost while at least one PDU of the same SDU has been successfully transmitted, this SDU will be recognised by the receiving entity as incomplete without an unbounded wait for its termination.

It also coordinates with the VC-signalling entity to clear virtual circuits.

7.7 VC-flow control

The VC-flow control entity ensures that, for each virtual circuit and for each direction, *data* packets are always transmitted at a rate which is compatible with the downstream buffering capacity of that virtual circuit.

For interrupt data, a separate flow control is performed on a per virtual circuit basis (see 10.14).

7.8 VC segmentation and reassembly

The VC segmentation and reassembly entity ensures that SDUs may have lengths which are independent from the maximum size of the PDUs.

7.9 VC signalling

The VC-signalling entity is in charge of the set-up and clearing of virtual circuits which share the same link.

8 Description of the DTE/DCE interface (physical layer)

At the physical layer, any relevant DTE/DCE standardised interface may be used.

9 Coding of frames and packets

9.1 General

9.1.1 Format

The PDU format features four octets at each line as shown in Figure 9-1.

Octets	1	2	3	4
Bits	8 1	8 1	8 1	8 1
	Field 1	Field 2		
	Field 3	Field 4		

FIGURE 9-1/X.45

Example of PDU presentation

The octets are numbered in ascending order from left to right and from top to bottom. For instance, Field 3 in Figure 9-1 is the fifth octet of the PDU.

When a field contains more than one octet, the most significant octet is that with the lowest order number and the least significant octet is that with the highest order number. The bits of each octet are numbered in ascending order from right to left. The most significant bit is bit 8 and the least significant bit is bit 1. For instance, bit 8 of octet 2 is the most significant bit of the Field 2 in Figure 9-1 and bit 1 of octet 4 is the least significant bit.

Any reserved field shall be sent set to 0 and not interpreted on reception.

9.1.2 Order of transmission

The octets are transmitted in ascending order, and the bits of each octet are transmitted in ascending order. In the example of Figure 9-1, this means that bit 1 of octet 1 is transmitted first, and bit 8 of octet 8 is transmitted last.

9.1.3 List of frames and packets

Table 9-1 gives the function and the abbreviation for the specified frames and packets.

TABLE 9-1/X.45

List of frames and packets

Description	Function	Abbreviations	References
Link flow control initialisation frame	Link flow control initialisation	LI	9.2.1
Link flow control frame	Flow control at link level	LF	9.2.2
Link set-up frame	Link set-up and disconnection	LS	9.2.3
Link acknowledgement frame	Link acknowledgement	LA	9.2.4
VC flow control packet	Flow control at VC level	VF	9.3.1
Data packet	Data transfer	D	9.3.2
Interrupt packet	Interrupt data transfer	ID	9.3.3
Interrupt confirmation packet	Interrupt data transfer	IC	9.3.4
Signalling synchronisation packet	Synchronisation between the virtual circuit and the corresponding signalling	SS	9.3.5
Reset request packet	Virtual circuit reset	RR	9.3.6
Reset confirmation packet	Virtual circuit reset	RC	9.3.7
Abort packet	Abort of non-assured SDU	A	9.3.8

9.2 Description of frames

9.2.1 Link flow control initialisation frame

The *Link flow control initialisation* frame is used to initialise flow control at the link level and to request transmission of a *link flow control initialisation* frame in the opposite transmission direction [Request (Ri) bit]. Its format is given in Figure 9-2. The *link flow control initialisation* frame uses the virtual circuit identifier of the signalling virtual circuit. It is not subject to link flow control

Ri	Rsrvd	Type: "LI"	YI
B(R)			

FIGURE 9-2/X.45

Link flow control initialisation (LI) frame format

9.2.2 Link flow control frame

The *Link flow control* frame is used to notify the peer entity of new link credits and to request transmission of a *link flow control* frame in the opposite transmission direction [Request (Rf) bit]. Its format is given in Figure 9-3. The *link flow control* frame uses the virtual circuit identifier of the signalling virtual circuit. It is subject to link flow control with special processing if there is a risk of deadlock. If a *link flow control* frame is lost, it needs no retransmission since the next *link flow control* frame supersedes the lost one.

Rf	Rsrvd	Type: “LF”	YI
B(R)			
C(S)			

FIGURE 9-3/X.45

Link Flow (LF) control frame format

9.2.3 Link set-up frame

The *link set-up* frame is used to initialise or re-initialise the link between the two sides of the interface and to negotiate the format (basic or extended) being used. Its format is given in Figure 9-4. The *link set-up* frame uses the virtual circuit identifier of the signalling virtual circuit. It contains for both directions the maximum number of segments in a PDU [L(S) and L(R)] and a Request bit (Rs) to request transmission of a *link set-up* frame from the peer entity. This frame is subject to link flow control. If a *link set-up* frame is lost, it needs no retransmission since the next *link set-up* frame supersedes the lost one.

Rs	Rsrvd		Type: “LS”	YI		
MS	YS	EF	Reserved (5 bits)	Reserved (8 bits)	L(S)	L(R)

FIGURE 9-4/X.45

Link Set-up (LS) frame format

9.2.4 Link acknowledgement frame

The link acknowledgement frame is used to signal acknowledgement to the peer entity. Its basic format is given in Figure 9-5 and its extended format in Figure 9-6. The *link acknowledgement* frame uses the virtual circuit identifier of the signalling virtual circuit. It contains :

- the next sequence number NN(S), equal to the next N(S) to be transmitted.
- the acknowledgement list, consisting of an alternate succession of positively and negatively acknowledged sequence of PDUs: A_1(R), A_2(R), ..., A_{k-1}(R), A_k(R) ; each sequence is designated by its upper bound;
- the list length, expressed in number of elements of the list (odd or even);
- the type of the first element of the list (T field): reset if the first element is a positive acknowledgement, set if it is a negative acknowledgement;
- the acknowledgement of the peer entity acknowledgement list [AA(S) field], equal to the last received A_k(R) from the peer entity;
- a Request bit (Ra) to force, when it is set, the peer entity to respond to this frame.

<table>
<tr><td>Ra</td><td>Rsrvd</td><td>Type “LA”</td><td colspan="2">YI</td></tr>
<tr><td colspan="4">NN(S)</td><td>AA(S)</td></tr>
<tr><td>T</td><td>Rsrvd</td><td colspan="2">k</td><td>A_1(R)</td></tr>
<tr><td colspan="4">A_2(R)</td><td>A_3(R)</td></tr>
<tr><td colspan="5">- - -</td></tr>
<tr><td colspan="4">A_{k-2}(R)</td><td>A_{k-1}(R)</td></tr>
<tr><td colspan="4">A_k(R)</td><td></td></tr>
</table>

FIGURE 9-5/X.45

Link Acknowledgement (LA) frame non-extended format

<table>
<tr><td>Ra</td><td>Rsrvd</td><td>Type “LA”</td><td>YI</td></tr>
<tr><td colspan="4">NN(S)</td></tr>
<tr><td colspan="4">AA(S)</td></tr>
<tr><td>T</td><td>Rsrvd</td><td colspan="2">k</td></tr>
<tr><td colspan="4">A_1(R)</td></tr>
<tr><td colspan="4">A_2(R)</td></tr>
<tr><td colspan="4">A_3(R)</td></tr>
<tr><td colspan="4">- - -</td></tr>
<tr><td colspan="4">A_{k-2}(R)</td></tr>
<tr><td colspan="4">A_{k-1}(R)</td></tr>
<tr><td colspan="4">A_k(R)</td></tr>
</table>

FIGURE 9-6/X.45

Link Acknowledgement (LA) frame extended format

9.3 Description of packets

9.3.1 VC-flow control packet

The *VC-flow control* packet is used to notify the peer entity of new VC credits. Its basic format is given in Figure 9-7 and its extended format in Figure 9-8. Losses of the *VC-flow control* packet are detected and notified. It needs no retransmission since the next *VC-flow control* packet supersedes the lost one. The *VC-flow control* packet is subject to link flow control and is not subject to the VC-flow control.

Ra	Rsrvd	Type: “VF”	YI
N(S)		Bi(R)	

FIGURE 9-7/X.45

VC-flow control (VF) packet non-extended format

Ra	Rsrvd	Type: “VF”	YI
N(S)			
Bi(R)			

FIGURE 9-8/X.45

VC-flow control (VF) packet extended format

9.3.2 Data packet

The *data* packet is used to transfer the successive segments of an data SDU via a connection. Its basic format is given in Figure 9-9 and its extended format in Figure 9-10. It contains the Interrupt count (I) bit, the Beginning (B) bit, the End (E) bit and a qualifier (Q) bit. Losses of *data* packets are detected. If the virtual circuit is in the assured data transfer mode such detected losses are recovered. The *data* packet is subject to link flow control and to VC-flow control.

Ra	Rsrvd	I	Q	B	E	0	YI
N(S)							Ni(S)
Data							

FIGURE 9-9/X.45

Data (D) packet non-extended format

<table>
<tr><td>Ra</td><td>Rsrvd</td><td>I</td><td>Q</td><td>B</td><td>E</td><td>0</td><td>YI</td></tr>
<tr><td colspan="8">N(S)</td></tr>
<tr><td colspan="8">Ni(S)</td></tr>
<tr><td colspan="8">Data</td></tr>
</table>

FIGURE 9-10/X.45

Data (D) packet extended format

9.3.3 Interrupt packet

The *interrupt* packet is used to transfer a limited amount of data on a connection without being submitted to the VC-flow control of that connection. Its basic format is given in Figure 9-11 and its extended format in Figure 9-12. The maximum length of the data field in an *interrupt* packet is 32 octets. Loss of the *interrupt* packet is detected and recovered. The *interrupt* packet is subject to link flow control. The *interrupt* packet is not subject to VC-flow control.

<table>
<tr><td>Ra</td><td>Rsrvd</td><td>Type: “ID”</td><td colspan="2">YI</td></tr>
<tr><td colspan="4">N(S)</td><td>Reserved</td></tr>
<tr><td colspan="5">Data</td></tr>
</table>

FIGURE 9-11/X.45

Interrupt (ID) packet non-extended format

<table>
<tr><td>Ra</td><td>Rsrvd</td><td>Type: “ID”</td><td>YI</td></tr>
<tr><td colspan="4">N(S)</td></tr>
<tr><td colspan="4">Reserved</td></tr>
<tr><td colspan="4">Data</td></tr>
</table>

FIGURE 9-12/X.45

Interrupt (ID) packet extended format

9.3.4 Interrupt confirmation packet

The *interrupt confirmation* packet is used to acknowledge an *interrupt* packet. Its basic format is given in Figure 9-13 and its extended format in Figure 9-14. Loss of the *interrupt confirmation* packet is detected and recovered. The *interrupt confirmation* packet is subject to link flow control and is not subject to VC-flow control.

Ra	Rsrvd	Type: "IC"	YI
N(S)			

FIGURE 9-13/X.45

Interrupt Confirmation (IC) packet non-extended format

Ra	Rsrvd	Type: "IC"	YI
N(S)			

FIGURE 9-14/X.45

Interrupt Confirmation (IC) packet extended format

9.3.5 Signalling synchronisation packet

The *signalling synchronisation* packet is used to synchronise the data transfer on a given virtual circuit with the out-of band signalling relevant to that particular virtual circuit in the disconnect phases. Its basic format is given in Figure 9-15 and its extended format in Figure 9-16. Loss of the *signalling synchronisation* packet is detected and recovered. It is subject to link flow control and is not subject to VC-flow control.

Ra	Rsrvd	Type: "SS"	YI
N(S)			NNi(S)

FIGURE 9-15/X.45

Signalling Synchronisation (SS) packet non-extended format

Ra	Rsrvd	Type: “SS”	YI
N(S)			
NNi(S)			

FIGURE 9-16/X.45

Signalling Synchronisation (SS) packet extended format

9.3.6 Reset request packet

The *reset request* packet is used to request re-initialisation of the virtual circuit between two entities. Its basic format is given in Figure 9-17 and its extended format in Figure 9-18. Loss of the *reset request* packet is detected and recovered. It is subject to link flow control and is not subject to VC-flow control.

Ra	Rsrvd	Type: “RR”	YI	
N(S)				Bi(R)
Reset Data: Cause information element (see 11.2.4.7)				

FIGURE 9-17/X.45

Reset Request (RR) packet non-extended format

Ra	Rsrvd	Type: “RR”	YI
N(S)			
Bi(R)			
Reset Data: Cause information element (see 11.2.4.7)			

FIGURE 9-18/X.45

Reset Request (RR) packet extended format

9.3.7 Reset confirmation packet

The *reset confirmation* packet is used to confirm re-initialisation of the virtual circuit between two entities. Its basic format is given in Figure 9-19 and its extended format in Figure 9-20. Loss of the *reset confirmation* packet is detected and recovered. It is subject to link flow control and is not subject to VC-flow control.

Ra	Rsrvd	Type: “RC”	YI	
N(S)				Bi(R)

FIGURE 9-19/X.45

Reset Confirmation (RC) packet non-extended format

Ra	Rsrvd	Type: “RC”	YI
N(S)			
Bi(R)			

FIGURE 9-20/X.45

Reset Confirmation (RC) packet extended format

9.3.8 Abort packet

The *abort* packet is used to signal to the peer entity that the complete sequence being transmitted will not be terminated. Its basic format is given in Figure 9-21 and its extended format in Figure 9-22. Loss of the *abort* packet is detected and recovered. It is subject to link flow control and is not subject to VC-flow control.

Ra	Rsrvd	Type: “A”	YI	
N(S)				NNi(S)

FIGURE 9-21/X.45

Abort (A) packet non-extended format

Ra	Rsrvd	Type: “A”	YI
N(S)			
NNi(S)			

FIGURE 9-22/X.45

Abort (A) packet extended format

9.4 Meaning of the frame and packet fields

Table 9-2 gives the meaning and length of the field used in the specified frames and packets.

TABLE 9-2/X.45

List of the fields

Field	Length (bits) (Note)	Meaning (Note)	Frame / Packet
Type	8	Type field	All
YI	24	Your virtual circuit identifier	All
Ri	1	Request for the transmission of a LI frame	LI
B(R)	32	Link layer bound, rank of the first segment that the receiver is not ready to accept (modulo 2^{32}).	LI, LF
Rf	1	Request for the transmission of a LF frame	LF
C(S)	32	Number of previously transmitted segments (modulo 2^{32})	LF
MS	1	My-desired-link-state	LS
YS	1	Your-desired-link-state	LS
EF	1	Extended Format	LS
Rs	1	Request for the transmission of a LS frame	LS
L(S)	8	Maximum number of segments in a PDU that the transmitter will not exceed	LS
L(R)	8	Maximum number of segments in a PDU that the receiver is ready to accept	LS
N(S)	16/32	Link sequence number of the PDU: the rank of a PDU at higher sublayer than LA (modulo $2^{16}/2^{32}$)	All except LI, LF, LS
NN(S)	16/32	Link sequence number of the next non-LA-PDU to be transmitted (modulo $2^{16}/2^{32}$)	LA
A_i(R)	16/32	Element of the acknowledgement list (positive or negative) (modulo $2^{16}/2^{32}$)	LA
k	12/28	Number of elements of the acknowledgement list; may be zero	LA
AA(S)	16/32	Acknowledgement of the last item of the acknowledgement list received from the peer entity (modulo $2^{16}/2^{32}$)	LA
T	1	Type of the first acknowledgement (0 = positive, 1 = negative)	LA
Ra	1	Set to request a link acknowledgement frame from the peer entity	All except LI, LF, LS
I	1	Interrupt count (modulo 2)	D
Q	1	Qualifier bit of the data SDU	D
B	1	Beginning of the data SDU indication	D
E	1	End of the data SDU indication	D
Bi(R)	16/32	VC-layer bound, rank of the first segment that the receiver is not ready to accept for the virtual circuit No. i (modulo $2^{16}/2^{32}$)	VF
Ni(S)	16/32	VC-sequence number of the PDU, the number of previously transmitted segments for the virtual circuit No. i (modulo $2^{16}/2^{32}$)	D
NNi(S)	16/32	VC-sequence number of the next PDU (i.e. *data* or *signalling synchronisation* packets) to be transmitted (modulo $2^{16}/2^{32}$)	SS, A
NOTE – When two lengths or modulo are defined for a given field, the first number corresponds to the non-extended format and the second number to the extended format.			

9.5 Coding of the Type field

The Type field is present in every frame and every packet. Its coding is given in Table 9-3.

TABLE 9-3/X.45

Coding of the Type field

Frame / Packet	Abbreviations	Type 8	7	6	5	4	3	2	1
Link flow control initialisation frame	LI	*Rf*	*reserved*		**1**	**0**	**1**	**0**	**1**
Link flow control frame	LF	*Rf*	*reserved*		**0**	**0**	**1**	**0**	**1**
Link set-up frame	LS	*Rs*	*reserved*		**0**	**1**	**0**	**0**	**1**
Link acknowledgement frame	LA	*Ra*	*reserved*		**0**	**1**	**0**	**1**	**1**
VC-flow control packet	VF	*Ra*	*reserved*		**0**	**1**	**1**	**0**	**1**
Data packet	D	*Ra*	*reserved*		**I**	*Q*	*B*	*E*	**0**
Interrupt packet	ID	*Ra*	*reserved*		**1**	**0**	**0**	**0**	**1**
Interrupt confirmation packet	IC	*Ra*	*reserved*		**1**	**0**	**0**	**1**	**1**
Signalling synchronisation packet	SS	*Ra*	*reserved*		**1**	**0**	**1**	**1**	**1**
Abort packet	A	*Ra*	*reserved*		**1**	**1**	**1**	**0**	**1**
Reset request packet	RR	*Ra*	*reserved*		**1**	**1**	**0**	**0**	**1**
Reset confirmation packet	RC	*Ra*	*reserved*		**1**	**1**	**0**	**1**	**1**

The following code points of the Type field:

0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	1
0	0	0	0	0	1	1	1
0	0	0	0	1	1	1	1

correspond to the LAPB addresses used either in single link operation or in multilink operation.

Therefore such code points are not used in this Recommendation to allow dynamic detection of the protocol being used on the DTE/DCE interface, i.e. discrimination between LAPB single link operation, LAPB multilink operation, and this Recommendation.

10 Link and VC-level procedures

This clause describes the procedures of the link and virtual circuit level of the two sides of the interface with the exception of the signalling procedures (see clauses 12, 13 and following).

10.1 Identification of the link connection

When a physical connection has only two end-points (point-to-point connection), assignment of a PDU to the link connection is implicit: every PDU received over the physical connection belongs to the link connection.

When a physical connection has more than two end-points (e.g. multi-point connection), the link connection using this physical connection is identified through the virtual circuit identifier of each received PDU. In the case of the *link set-up*, *link flow control* and *link acknowledgement* frames, which are meaningful for an entire given link, the virtual circuit identifiers of the signalling virtual circuit of each link is used for each direction. In the case where an entity handles several link connections over a single physical connection, it allocates the virtual circuit identifiers, as and when virtual circuits are set up, for the physical connection as a whole, irrespective of the links to which the virtual circuits belong.

In the case of multi-point physical connection (e.g. on a LAN), an entity, before using a link with a peer entity, must know (either through a previously configured table, or an external protocol) the signalling virtual circuit identifier used in the receive direction by the peer entity for that link, and the signalling virtual circuit identifier it has to use in the transmit direction for that link.

In the case of point-to-point physical connection, the virtual circuit identifiers pair used for signalling virtual circuit is (0,0).

10.2 Generic status request procedure

If an entity does not receive a response for an action it has taken that requires a response, it sends a status-request. This mechanism ensures that deadlock cannot occur in procedures based on states exchanges.

Table 10-1 provides the sublayers where status-request procedure is used and associated request bits.

TABLE 10-1/X.45

Request bits

Procedure	Frame designation	Request bit
Link flow control initialisation	LI	Ri
Link flow control	LF	Rf
Link set-up	LS	Rs
Link acknowledgement	LA	Ra

10.3 Future upgrades with upward compatibility

To allow for upgrades and to ensure upward compatibility, an entity must accept *link flow control* and *link set-up* frames which are longer than the presently defined length. Any additional octets shall be at the end of the presently defined format and shall not be interpreted on reception.

10.4 Segment definition

A segment corresponds either to a PDU with no variable length field, or to up to 64 octets beyond the minimum header of 8 octets in case of the basic format, 12 octets in the extended format. Thus a *data* packet counts for one segment if it contains 0 to 64 octets of data, for 2 segments if it contains 65 to 128 octets of data, and so on.

NOTE – The fact that for *data* packet, only data octets are included in the count of 64 octets per segment ensures that data received by a network in number of segments will always be delivered to their destination DTE in the same number of segments independently of the length of *data* packet headers. They may be delivered in a smaller or larger number of packets, but a segment received by a network will never be delivered as two pieces belonging to two different packets. In particular a 128-octet packet of Recommendation X.25 always corresponds to 2 segments of this Recommendation.

Table 10-2 gives the number of segments of the defined frames and packets.

TABLE 10-2/X.45

Number of segments per frame or per packet

Frame/Packet		Abbreviations	Segment
Link flow control	frame	LF	1
Link set-up	frame	LS	1
Link acknowledgement	frame	LA	1 per group of 64 octets after the AA(S) field
VC-flow control	packet	VF	1
Data packet	packet	D	1 per group of 64 octets in the data field
Interrupt	packet	ID	1
Interrupt confirmation	packet	IC	1
Abort	packet	A	1
Signalling Synchronisation	packet	SS	1
Reset request	packet	RR	1
Reset confirmation	packet	RC	1

10.5 Flow control at the link layer

10.5.1 General

The link flow control applies to each PDU (see 10.5.3 for an exception in the case of the *link flow control* frame).

The link flow control applies to each transmission direction and is based on a credit allocation mechanism whereby the receiver authorises the sender to transmit new PDUs.

10.5.2 Flow control unit

The flow control unit is the segment.

Segment based flow control is such that, for reaching a given data rate on a link with a given propagation delay, a minimum window size is sufficient (i.e. the product of data rate and round trip delay), irrespective of whether data to be transmitted are in small SDUs (and consequently in small packets) or in large SDUs (for which large packets are possible).

10.5.3 Flow control principle at the link layer

The receiver maintains an internal counter for the received segments. The sender maintains an internal counter for the transmitted segments.

Flow control is exerted by the receiver which transmits to the sender its link layer bound which corresponds to the rank of the first segment that the receiver is not ready to accept. This means that the link layer bound received corresponds to the permissible upper limit value for the internal counter the sender keeps for the transmitted segments. For each PDU sent, this internal counter is incremented by the number of segments the PDU counts for.

A sender must not transmit a PDU beyond the reception window, i.e. a PDU whose last segment exceeds the link layer bound. Thus implementations are possible where flow controlled PDUs are never discarded due to a lack of receive buffers at the receiving side of the interface.

The *link flow control* frame does not comply with the previous rule. If the permissible upper limit is reached, it is still possible to send a *link flow control* frame.

10.5.4 Credit allocation procedure at the link layer

The link layer bound values are carried in the B(R) field in the *link flow control* frame.

The way the receiver determines the value of the link layer bound depends mainly on the availability of reception buffers and on the bit rate times round-trip-delay product.

Since the B(R) field of the *link flow control* frame corresponds to the rank of the first segment that the receiver is not ready to accept, successive values of the B(R) field must be either unchanged or increased.

The receiver sends increasing values of the link layer bound in a *link flow control* frame when the number of released buffers has significantly increased (e.g. every third of window).

In case of discontinuity in PDUs reception, or discarding of PDUs, the receiver increases the link layer bound by the number of segments it has never received. This number is the difference between the number of segments actually received by the receiver and the number of segments included in the C(S) field (number of previously transmitted segments) of the received *link flow control* frame.

10.5.5 Request for the transmission of a link flow control frame

An entity requests the peer entity to transmit a *link flow control* frame by setting the Rf bit to 1 in a *link flow control* frame the entity transmits.

On receiving a *link flow control* frame with the Rf bit set to 1, the receiver must respond with a *link flow control* frame to indicate the current value of its link layer bound [B(R) field] and the current value of the internal counter it keeps for the transmitted segments [C(S) field].

When an entity transmits a *link flow control* frame with Rf bit set to 1, it starts the TIMER_LF timer. On TIMER_LF time-out, a *link flow control* frame with Rf bit set to 1 is transmitted and the TIMER_LF is restarted. TIMER_LF is stopped when a *link flow control* frame is received.

This procedure may be used by an entity when it has not the right to send segments in sufficient quantity for the PDUs it has to send. For instance, in case increasing values of link layer bound sent by the receiver are not received by the sender because a *link flow control* frame has been lost. The sender uses the criterion that a significant part of the window has been used (e.g. two third of window) to trigger the request for the transmission of a *link flow control* frame.

10.5.6 Self initialisation of the link flow control sublayer

At initialisation time, the entity sends a *link flow control initialisation* frame with B(R) field set to the initial link layer bound (assuming the transmitter of the peer entity restarts its segment numbering from 0), and with Ri bit set to 1 in order to request the peer entity to transmit, as a response, an initialisation *link flow control initialisation* frame.

When an entity transmits a *link flow control initialisation* frame with the Ri bit set to 1, it starts TIMER_LF timer and discards any received PDU until a response is received. On TIMER_LF time-out, a *link flow control initialisation* frame is transmitted, and TIMER_LF is restarted. TIMER_LF is stopped when a *link flow control initialisation* frame is received from the peer entity.

When a link flow control entity receives a *link flow control initialisation* frame it processes B(R) field, and if requested by the Ri bit set to 1, it sends at the first opportunity an initialisation *link flow control* frame with its own B(R) field set to the initial link layer bound.

10.6 Link set-up and disconnection

10.6.1 General principles

Each entity signals to the peer entity which state it desires to attain. An entity which wishes to set up the link is in the "ON" desired state. An entity which does not wishes to set up the link or wishes to disconnect it, is in the "OFF" desired state.

The link set-up / disconnection procedure is based on the mutual exchange of the desired states in the MS (my-desired-link-state) and YS (your-desired-link-state) bits of the *link set-up* frame.

10.6.1.1 MS and YS-bit coding

The MS bit contains the desired state of the entity which sends the *link set-up* frame.

The YS bit contains the last seen desired state of the peer entity. It contains the value of the MS bit of the last received *link set-up* frame.

The coding of the MS and YS bits is as follows:

- bit set to 0 means that the desired state is "OFF";
- bit set to 1 means that the desired state is "ON".

The initial value of the YS bit is 0.

10.6.1.2 Request for the transmission of a link set-up frame

An entity requests the peer entity to transmit a *link set-up* frame by setting the Rs bit to 1 in a *link set-up* frame the entity transmits.

On receiving a *link set-up* frame with the Rs bit set to 1, the receiver must respond with a *link set-up* frame to indicate the current value of its desired state (MS bit) and the current value of its last seen desired state of the peer entity (YS field).

When an entity transmits a *link set-up* frame with Rs bit set to 1, it starts the TIMER_LS timer. On TIMER_LS time-out, a *link set-up* frame with Rs bit set to 1 is transmitted and the TIMER_LS is restarted. TIMER_LS is stopped when a *link set-up* frame is received.

10.6.1.3 Signalling of a new desired state

The first indication of a new desired state is given with the Rs bit of the *link set-up* frame set to 1, to signal an unconfirmed desired state.

As long as this new desired state is not seen by the peer entity (this is detected by the reception of a *link set-up* frame with a YS bit which does not match the new desired state), the *link set-up* frame which signals the new desired state is retransmitted with the Rs bit set to 1.

10.6.2 Link set-up

This function sets up a link connection over a previously activated physical connection.

In the initial state, both entities do not know the state of the peer entity. As long as the state of the peer entity remains unknown, the YS bit of every sent *link set-up* frame is set to 0.

The entity which wishes to set up the link, enters the "ON" desired state and sends its state in the *link set-up* frame with the MS bit set to 1 and the YS bit set according to the known state of the peer entity, using the procedure described in 10.6.1.3.

An entity considers that the link is set up when:

- its state is "ON" and has been seen as "ON" by the peer entity; and
- the state of the peer entity is seen as "ON".

As long as the link is not set up and as long as its desired state is "ON", an entity keeps sending *link set-up* frames. There are no limits to the number of attempts.

An entity may discover an accidental disconnection of the link. In such a case, it returns to its initial state.

10.6.3 Link disconnection

An entity which wishes to disconnect the link, enters the "OFF" desired state and sends its state in the *link set-up* frame with the MS bit set to 0 and the YS bit set according to the known state of the peer entity, using the procedure described in 10.6.1.3.

After MAX_LS (MAX_LS is a link parameter) successive transmissions of such *link set-up* frame without successful response (i.e. either no response or reception of *link set-up* frame with YS bit set to 1), the entity considers that the link is disconnected.

10.6.4 Format negotiation

The choice between the non-extended format and the extended format is negotiated during link set-up, simultaneously for the link layer (*link acknowledgement* frame) and for the VC layer.

Support of both the non-extended and the extended formats is mandatory in equipment that is used at a DTE/DCE interface implementing this Recommendation.

Each entity indicates a format in the Extended Format (EF) bit of the LS frame:

- EF bit set to 0 means that non-extended format is required;
- EF bit set to 1 means that extended format is preferred.

The DCE shall send *link set-up* frames with the EF bit set to 1.

When receiving the format indicated by the peer entity, each entity determines which format has to be used taking into account the following rules:

- the extended format shall be employed if both entities indicate the extended format;
- in all other cases, the non-extended format shall be employed.

Thus a DTE selects freely the non-extended or the extended format.

NOTE – Also, if X.45 protocol is used in a DTE-to-DTE environment, the two DTEs using the above procedure, can work with either format, provided both ask for the same one. If both DTEs do not indicate the same format no particular choice is necessarily the better, but the procedure has to converge to one of them (i.e. the non-extended format for consistency with DTE/DCE environment).

10.6.5 Maximum PDU size negotiation

The maximum PDU sizes for both direction of data transmission is negotiated during link set-up, simultaneously for the link layer (*link acknowledgement* frame) and for the VC layer (*data* packet).

Each entity indicates:

- in the L(S) field, the maximum number of segments it will not exceed in PDU it transmits;
- in the L(R) field, the maximum number of segments it is ready to accept in a PDU it receives.

When receiving maximum PDU sizes indicated by the peer entity, each entity determines which maximum PDU sizes will be used taking into account the following rule:

- for each direction of data transmission, the maximum number of segment of PDUs is equal to the minimum of:
  - the L(S) transmitted in this direction; and
  - the L(R) transmitted in the reverse direction.

10.7 Procedure for positive and negative acknowledgements of PDU

10.7.1 General principle

Acknowledgement is performed at the link level and thus concerns all packets irrespective of the virtual circuit they belong to. The higher the traffic on a given link, the smaller the response time is in case of error.

Each transmitted PDU relevant of this procedure (i.e. all except LF-PDU, LS-PDU and LA-PDU) is either positively or negatively acknowledged by the receiver. A positive acknowledgement signals a sequence of consecutive correctly received PDUs ; a negative acknowledgement signals a sequence of consecutive lost or rejected PDUs.

The receiver maintains and transmits to the sender its list of pending acknowledgements. The transmitter sends to the receiver a copy of the last acknowledgement it has received. The receiver eliminates from the list of its pending acknowledgements all those which are older than the last one the transmitter indicated it has received.

The frequency of positive acknowledgements sent by the receiver is driven by the transmitter itself. For that purpose, the transmitter explicitly sets a Request acknowledgement bit in a PDU for which it wants an acknowledgement to be triggered.

Negative acknowledgements are, on the other hand, spontaneously transmitted by the receiver.

10.7.2 Acknowledgement state variables

Each acknowledgeable PDU is sequentially numbered and may have the value 0 through $2^{16} - 1$ when the basic format is used and through $2^{32} - 1$ when the extended format is used. The sequence numbers cycle through the entire range, modulo 2^{16} for the basic format, modulo 2^{32} for the extended format. All arithmetic operations on the following state variables and sequence numbers are affected by the modulus: VT(N), VT(AA), VR(N), VR(A_i).

Variables maintained at the transmitter :

- VT(N) – Send state variable: The sequence number of the next acknowledgeable PDU to be transmitted. Incremented after the transmission of every acknowledgeable PDU.
- VT(AA) – Acknowledgement of the acknowledgement-list variable: Highest acknowledgement received from the peer entity receiver.

Variables maintained at the receiver :

- VR(N) – Receive state variable: The sequence number of the next in-sequence PDU expected to be received. Incremented upon receipt of the next in-sequence acknowledgeable PDU.
- VR(A_i) – Pending acknowledgement-list variable: The list of upper sublayer PDU successfully received or unsuccessfully received (i.e. lost or rejected). The list is composed of an alternate succession of positively and negatively acknowledged sequences of PDUs: A_1, A_2, ..., A_{k-1}, A_k; each sequence is designated by its upper bound; the list is ordered.
- VR(k) – Pending acknowledgement-list size: The number of elements in the pending acknowledgement-list. It is always less than max_K if the last element of the list is a positive acknowledgement.
- VR(tA_1) – Type of the first element of the acknowledgement-list: Set to 0 if it is a positive acknowledgement, set to 1 if it is a negative acknowledgement.

10.7.3 Acknowledgement timers

Timer maintained at the transmitter:

- Timer_CLOSER: Unacknowledged sequence closer. The maximum time between the transmission of the last PDU from the upper sublayer and transmission of another PDU if no acknowledgement has been received yet. The aim of this timer is to stimulate the negative acknowledgement of a PDU which has been lost and which has been followed by no other PDU in the same direction.
- Timer_AR: ack-list request. The maximum time between requests for the status of the receiver by sending an Ra bit set to 1.

Table 10-3 describes the mode of operation of acknowledgement timers.

The mode of operation of Timer_AR is such that it ensures a minimum frequency at which the status of the receiver is requested by sending an Ra bit set to 1. This request triggers a transmission from the peer entity of a *link acknowledgement* frame the reception of which is used to detect if the peer entity is still in operation.

TABLE 10-3/X.45

Acknowledgement timers

Name	Cause for start/restart	Normal stop	At expiry	Comments
Timer_CLOSER	Transmission of any PDU from upper sublayer	Acknowledgement (positive/negative) is received for the last sent PDU of upper sublayer	Send a *link acknowledgement* frame Restart timer_CLOSER	A small value tends to accelerate detection of losses of isolated PDU
Timer_AR	Link set-up Any PDU sent with Ra bit set to 1	Always running when link is set up	Send a *link acknowledgement* frame with Ra bit set to 1 Restart timer_AR	

10.7.4 Acknowledgement parameters

Parameter of the transmitter :

- Max_CLOSER: Maximum consecutive expirations of the timer_CLOSER without reception of acknowledgement before signalling a disconnection of the link to the management entity.
- Max_AR: Maximum consecutive expirations of the timer_AR without reception of a link acknowledgement frame.

Parameters of the receiver :

- Max_K: Maximum length of the pending acknowledgement-list (value > 1).

10.7.5 Transmission of an acknowledgeable PDU

If there is a new acknowledgeable PDU to transmit (i.e. a PDU coming from the upper sublayer), and if the underlying sublayer permits it, the N(S) field of the PDU is assigned to the current value of VT(N), the variable VT(N) is incremented, the PDU is transmitted, and the timer_CLOSER is (re-)started.

If the Timer-AR has expired, the Request acknowledgement bit (Ra) is set to 1 in the transmitted PDU to stimulate the sending of the current acknowledgement list by the receiver. The Request acknowledgement bit (Ra) may also be set to 1 if some number of acknowledgeable PDUs have been transmitted since the last transmission of an Ra bit set to 1. This number may be implementation dependent, is optional, and may change from time to time. Its value has no effect on proper operation but short values, while increasing overhead, tend to accelerate buffer release in the transmitter.

10.7.6 Reception of an acknowledgeable PDU

The result of the reception of such a PDU is a transformation of the pending acknowledgement-list. The building of the new list is constrained by the fact that if the list is full (i.e. its size equals to max_K) the last element must be a negative acknowledgement.

If the received PDU is the next expected one [i.e. N(S) equals to VR(N)]:

- If the list is positively-ended [i.e. if $VR(tA_1) = 0$ and k is odd, or $VR(tA_1) = 1$ and k is even]: the last element is set to the value of N(S), and the received PDU is delivered to the upper sublayer. This case is the only one as long as the number of pending negative acknowledgements remains low, as it is normal on a good quality link.
- If the list is negatively-ended and there is less than two free places: the last element is set to the value of N(S), and the received PDU is rejected.
- If the list is negatively-ended and there are at least two free places: a positive acknowledgement is added to the list and set to the value of N(S), and the received PDU is delivered to the upper sublayer.

If the received PDU is not the next expected one [i.e. N(S) differs from VR(N)]:

- If the list is positively-ended and there are at least three free places: a negative acknowledgement is added to the list and set to the value of [N(S) – 1] ; then a positive acknowledgement is added to the list and set to the value of N(S). The received PDU is delivered to the upper sublayer.
- If the list is positively-ended and there is less than three free places: a negative acknowledgement is added to the list and assigned to the value of N(S), and the received PDU is rejected.
- If the list is negatively-ended and there are at least two free places: the last element is set to the value of [N(S) – 1], a positive acknowledgement is added to the list and assigned to the value of N(S), the received PDU is delivered to the upper sublayer.
- If the list is negatively-ended and there is less than two free places: the last element is assigned to the value of N(S), and the received PDU is rejected.

NOTE – Regarding link flow control, the receiving entity may recycle credit allocated to received PDUs it has rejected.

In any case, VR(N) is assigned to [N(S) + 1]. If appropriate (according to conditions described in 10.7.8 below) a *link acknowledgement* frame is transmitted.

10.7.7 Reception of a link acknowledgement frame

The *link acknowledgement* frame conveys one information for the transmitter :

- An acknowledgement list: It indicates what PDUs the peer-entity receiver has successfully received or unsuccessfully received (i.e. lost or rejected). The transmitter determines and notifies to the upper sublayer, which PDUs are just recognised as successfully transmitted and which ones have been lost. Concerned PDUs are all those which were transmitted between values of the previously received end-of-list item, i.e. VT(AA), and the just received one, i.e. A_k(R). The transmitter assigns the value of A_k(R) to the VT(AA) variable. If each transmitted PDU has been acknowledged, the timer_CLOSER is stopped.

The *link acknowledgement* frame conveys two informations for the receiver:

1) The next non-LA-PDU sequence number [NN(S) field]: If it differs from VR(N), it implies that at least one acknowledgeable PDU has been lost. If the acknowledgement list is positively-ended: a negative acknowledgement is added to the list and assigned to the value of [NN(S) – 1]; else if the acknowledgement list is already negatively-ended: the last element is assigned to the value of [NN(S) – 1].
2) The acknowledgement of the pending acknowledgement list (AA(S) field): It indicates that the peer-entity transmitter has effectively received the acknowledgement list until the value of AA(S). The receiver sequentially compares the elements of its list to the value of AA(S): if VR(A_i) is less or equal to AA(S) it purges the list from VR(A_i), else it stops to scan the list. After partially purging the pending acknowledgement list, the receiver updates the value of the VR(tA_1) variable which identifies the type of the first element in the list.

The *link acknowledgement* frame also conveys the ack-list request: if it is received with the Ra bit set to 1, this is taken as a request for transmission of a link acknowledgement frame at the first opportunity.

10.7.8 Transmission conditions for link acknowledgement frame

A *link acknowledgement* frame is transmitted when the underlying sublayer has an opportunity for frame transmission and if one of the following conditions holds.

Coming from the transmitter:

- The timer_CLOSER has expired: In such a case the *link acknowledgement* frame will contain the Request bit (Ra) set to one.
- A *link acknowledgement* frame containing new negative acknowledgement(s) has been received.
- The Timer_AR has expired.

Coming from the receiver:

- A new negative acknowledgement has been added to the list.

Other:

- A frame with the Request bit (Ra) set has been received.

If the transmitted *link acknowledgement* frame contains a list of more than one element, The Timer_AR is (re-)started. If the *link acknowledgement* frame contains the Request bit, the Timer_CLOSER is (re-)started.

After max_CLOSER expirations of timer_CLOSER without reception of any acknowledgement, the link is disconnected.

After Max_AR expirations of Timer_AR without reception of any acknowledgement, the link is disconnected.

10.8 Error correction

The error correction procedure does not apply to *data* packets of virtual circuits in the non-assured data transfer mode.

10.8.1 Storage until reception of acknowledgement

Data packets of virtual circuit in the assured data transfer mode and *interrupt* packets must be kept in the sender entity memory until reception of acknowledgement for the purpose of subsequent transmission on possible loss.

The sender must also be able to retransmit *interrupt confirmation*, *signalling synchronisation*, *reset request*, *reset confirmation* and *abort* packets.

10.8.2 Selective retransmission of the PDUs

The entity which receives a *link acknowledgement* frame notifying a PDU loss (one or several gaps), handles the gaps one-by-one in order of appearance in the received list of negative acknowledgement. A negative acknowledgement already included in a previous *link acknowledgement* frame and thus already processed, is ignored.

On reception of a negative acknowledgement, the entity retransmits the PDUs concerned by the notification, according to the rules in Table 10-4.

A PDU being retransmitted does not use its old link sequence number but is given a new link sequence number.

NOTE – This new numbering at link level on retransmission does not affect the VC sequence number of *data* packets. This means that sequence numbers do not change at VC level on retransmission.

TABLE 10-4/X.45

Retransmission conditions

PDU	Retransmission conditions
VF	If no more recent *VC-flow control* packets have been sent (for that virtual circuit), a *VC-flow control* packet is transmitted with the current value of the VC layer bound in the Bi(R) field
D	Always, if the virtual circuit is in the assured data transfer mode Never, if the virtual circuit is in the non-assured data transfer mode
ID	Always
IC	Always
SS	Always
A	No *data* packets have been sent (for that virtual circuit)
RR	Always
RC	Always

10.9 Multiplexing /demultiplexing

10.9.1 General principle

A virtual circuit permits bi-directional transfer of data in the form of *data* packets or *interrupt* packets.

A DTE may simultaneously use several virtual circuits either switched or permanent, connected to one or several remote DTEs.

A virtual circuit is identified by a pair of identifiers, one per transmission direction. In each direction, the choice of a virtual circuit identifier is made by the receiver either during call set-up phase for switched virtual circuits or at subscription time for permanent virtual circuits. Each PDU contains the virtual circuit identifier of the receiver. The virtual circuit identifiers have local significance.

10.9.2 Signalling virtual circuit

As soon as the link connection is set up, a particular permanent virtual circuit is automatically ready for signalling purposes. This particular permanent virtual circuit, referred to as the signalling virtual circuit, is in the assured data transfer mode. The *data* packets which are transmitted over this particular virtual circuit contain exclusively the signalling messages for the other virtual circuits which have to be set up, cleared or managed.

The *link set-up*, *link flow control* and *link acknowledgement* frames use the virtual circuit identifier of the signalling virtual circuit.

In the case of a point-to-point physical connection, the virtual circuit identifier pairs used for the signalling virtual circuit is (0,0).

In the case of multi-point physical connection, the virtual circuit identifier pairs for the signalling virtual circuit is determined prior to link set-up (see 10.1).

10.10 Numbering of packets at the VC layer

The *data* packet contains a sequence number associated with the virtual circuit. This VC-sequence number contains the rank of the first segment of the packet, with respect to the number of segment previously sent on this virtual circuit in numbered packets, and is placed in the Ni(S) field. The first packet sent on the virtual circuit carries a VC-sequence number equal to 0.

10.11 Re-ordering of data packets

10.11.1 On assured virtual circuit

Since the error correction procedure on assured virtual circuit is performed via selective retransmission, *data* packets may be received out of sequence at the VC level.

The VC-sequence number makes it possible to re-order these received packets.

Data packets received out of sequence but within the transmission window are kept in the memory until every *data* packet whose VC-sequence number is smaller, has been received.

The final receiver (i.e. the receiving DTE) handles re-ordering of *data* packets. The network may also perform the re-ordering of the *data* packets before sending them on the remote DTE/DCE interface.

A network which receives *data* packets out of sequence at the VC level, due to losses on the DTE/DCE interface, may send the segments of these *data* packets out of sequence at the VC level (but not at link one) to the remote DTE taking into account the maximum length of *data* packet (for this particular virtual circuit) used on the remote DTE/DCE interfaces and SDU segmentation rules in complete packet sequence (see 10.13.1).

10.11.2 On non-assured virtual circuit

Since on a non-assured virtual circuit, lost *data* packets are not retransmitted, the received VC-sequence numbers are always increasing and re-ordering of *data* packets is not needed.

10.12 Flow control at the VC layer

10.12.1 General

Within a virtual circuit, flow control applies to the *data* packets which are carried over that particular virtual circuit.

It applies to each transmission direction and is based on mechanism whereby the receiver authorises the sender to transmit new data packets up to a certain limit, called VC-layer bound.

10.12.2 Flow control unit

The flow control unit at the VC layer is the same segment as the one defined and used at the link layer (See 10.4 and 10.5.2)

This same definition makes it possible to compute only once the number of segments of a received *data* packet for both layers simultaneously.

10.12.3 Flow control principle

The VC-layer bound transmitted to the sender corresponds to the rank of the first segment that the receiver is not ready to accept.

A sender must not transmit a *data* packet beyond the reception window, i.e. a *data* packet whose rank of the last segment exceeds the VC-layer bound of the receiver. All other packets are transmitted by the sender regardless the reception window is exceeded or not.

10.12.4 Credit allocation procedure at the VC layer

This procedure is applicable to both assured and non-assured virtual circuits.

The initial value of the VC-layer bound is carried in the *call request* and *call confirmation* messages. This initial value is a parameter. The subsequent values of the VC layer bound are carried in the Bi(R) field of the *VC-flow control* packet.

The way the receiver determines the value of the VC-layer bound depends mainly on the availability of reception buffers and on the throughput class of the virtual circuit.

Since the VC-layer bound field [Bi(R)] of a *VC-flow control* packet corresponds to the rank of the first segment that the receiver is not ready to accept, successive values of the Bi(R) field must be either unchanged or increased.

The receiver increases the value of its VC-layer bound when an additional buffer is available to receive a new *data* packet. The receiver may gather these increases of its VC-layer bound to save bandwidth and peer entity processing time. One method to gather the increases of VC-layer bound is to wait for a significant increase of the number of buffers being released (e.g. a third of the window).

10.12.5 Particular flow control procedure on non-assured virtual circuit

Since within a non-assured virtual circuit, *data* packets are not retransmitted on loss, the receiver considers a discontinuity in the sequence of received *data* packets as a release of buffers. This release of buffers can be used to trigger the transmission of a *VC-flow control* packet with a new (greater) value of the VC-layer bound.

10.13 Data transfer

Data are transmitted within *data* packets. The data field is transparently transmitted. The number of octets it contains must be an integer. The maximum length of the data field of *data* packets for a given transmission direction is determined at subscription time for permanent virtual circuits, at call set-up for switched virtual circuits.

In all cases and for each direction of data transmission, the maximum length of the data field:

- is a power of $2 \leq 64$ (in octets);
- does not exceed the maximum number of segments of PDU as negotiated during link set-up for this direction (see 10.6.5).

For switched virtual circuits, for each direction of data transmission, the largest maximum length that complies with the above is the default packet size (see 14.3 on packet size negotiation facility for the use of other values).

10.13.1 Segmentation

An SDU the data contents of which exceeds the maximum data field length for an interface is transmitted on this interface as a complete sequence.

When a data SDU is transmitted over a virtual circuit across a DTE/DCE interface with a data contents which exceeds the maximum data field length of *data* packets for this virtual circuit at this interface, it is transmitted as a sequence of *data* packets. The Beginnning bits and the End bits in packets of a packet sequence are set according to Table 10-5.

The last *data* packet of a complete packet sequence may have a data field length which is less than or equal to the maximum for the virtual circuit. Any *data* packets prior to the last in a complete sequence of packets, shall have a data field length equal to the maximum for the virtual circuit.

TABLE 10-5/X.45

Beginning and End bit coding

Type of data packet	Beginning bit value	End bit value
Beginning of the SDU	1	0
Continuation of the SDU	0	0
End of the SDU	0	1
Single packet SDU (Note)	1	1
NOTE – In this case, no segmentation occurs.		

10.13.2 SDU abort on non-assured virtual circuits

If a transmitting entity receives a negative acknowledgement for the last *data* packet it has sent and if it has no data packet belonging to the next SDU to transmit, then the transmitting entity shall transmit an *abort* packet. This packet indicates to the receiving entity that the current SDU will not be terminated and that some credits can be recovered.

The *abort* packet contains in the NNi(S) field, the VC-sequence number of the next packet to be transmitted.

If an *abort* packet is lost and no other *data* packet has been sent after the *abort* packet, and there is no new *data* packet to transmit, then the abort *packet* is retransmitted.

10.13.3 Reassembly on assured virtual circuits

On assured virtual circuits, reassembly based on the Beginning and End bits takes place when received *data* packets can be reordered using their VC-sequence number values.

10.13.4 Reassembly on non-assured virtual circuits

On non-assured virtual circuits, reassembly based on the Beginning and End bits is processed on received data packets as long as no discontinuity in the VC-sequence number is detected.

A receiving entity, when it receives a *data* packet with a VC-sequence number which is not the expected one, discards the *data* packet and the following ones, as long as they are not the first packet of a new SDU (i.e. as long as the Beginning bit is set to 0).

On a non-assured virtual circuit, a sequence of *data* packets is either a complete sequence or a partial sequence. A partial sequence consists in the first packet(s) of a complete sequence followed by either an abort packet or the first data packet of a following packet sequence.

A sequence of *data* packets which is received by the network from a DTE is, at the remote DTE/DCE interface, either:

– completely absent;

– transmitted as a sequence of *data* packets with the same amount of data or shorter.

The probability of a complete sequence of *data* packets being not delivered at all or being only delivered as a partial packet sequence, must be kept by the network at a similar order of magnitude as the probability of error transmissions on DTE/DCE links.

10.13.5 Qualification of data

This mechanism is only used by a DTE. It permits differentiation of two types of information (for instance, real user data and command data) and is based on the use of the Qualifier bit present in *data* packets.

The value of the Q-bit is only significant in the first *data* packet of a complete sequence. When not used and not significant the Qualifier bit is set to 0. This means that the DTE may set the Qualifier bit to one only in the first *data* packet of a complete sequence. In all other cases the Qualifier bit is set to 0.

This mechanism does not affect the numbering of *data* packets at the VC level.

The Qualifier bit of the first *data* packet of a complete sequence is carried transparently by the network.

10.14 Interrupt procedure

The interrupt procedure enables a DTE to transmit data to the remote DTE, without being subject to VC-flow control procedure.

This data whose length is limited to 32 octets is transmitted using *interrupt* packet. Such *interrupt* packets pass any *data* packet caught up within the network or at the remote DTE/DCE interface.

The remote DTE acknowledges the reception of the *interrupt* packet by sending an *interrupt confirmation* packet. The *interrupt confirmation* packet is in turn delivered by the network to the initial DTE.

The DTE must wait for the *interrupt confirmation* packet, before sending another *interrupt* packet on the same virtual circuit.

Interrupt and *interrupt confirmation* packets must be retransmitted upon losses.

In order to guarantee that the *interrupt* packet is delivered at or before the point in the stream of *data* packets at which the *interrupt* packet was generated by the DTE, an entity increments the count modulo 2 of transmitted interrupt, and places its current value in any sent *data* packet (including packet being retransmitted). Retransmission of *interrupt* packet does not affect the value of the interrupt count bit.

When an *interrupt* packet is received, the entity increments its counter modulo 2 of received interrupt. *Data* packets received with a count of interrupt not equal to the counter modulo 2 of received interrupt, must not be delivered until reception and delivery of the *interrupt* packet (which has been lost and will be retransmitted).

At initialisation time (i.e. VC set-up or reset) counters of received and transmitted interrupt are set to 0.

10.15 Reset of a virtual circuit

This procedure is used to re-initialise a virtual circuit.

All *data* and *interrupt* packets generated by a DTE (or the network) before initiation by the DTE or the DCE of a reset 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.

After completion of the reset procedure, the VC-sequence number in each transmission direction is set to 0, the upper bound of the window relative to each transmission direction is set to the exchanged VC-layer bound values, and counters of received and transmitted interrupt are set to 0.

The reset procedure uses *reset request* and *reset confirmation* packets exchanged between the DTE and the DCE.

10.15.1 Normal reset

An entity which wishes to re-initialise a virtual circuit transmits a *reset request* packet to the peer entity.

The *reset request* packet contains the following information:

- the value of the VC-layer bound allocated by the resetting entity;
- cause and diagnostic fields to explain the reset.

The *reset request* packet is the very last packet sent over the virtual circuit before the reset takes effect and must be retransmitted upon loss notification reception.

An entity which receives a *reset request* packet, must not retransmit negatively acknowledged packet, nor send any new packet over the concerned virtual circuit, but has to confirm reset by sending a *reset confirmation* packet.

The *reset confirmation* packet contains the following information:

- The value of the VC-layer bound allocated to the resetting entity.

The *reset confirmation* packet is the very last packet sent over the virtual circuit before the reset takes effect and must be retransmitted upon loss notification reception. The entity must wait for the link level acknowledgement of the *reset confirmation* packet it has sent to consider that the virtual circuit is definitely reset.

The resetting entity must wait for the reception of a *reset confirmation* packet to consider that the virtual circuit is definitely reset. The *reset confirmation* packet has local significance.

While waiting for the *reset confirmation* packet, the resetting entity must not retransmit negatively acknowledged packet (except the *reset request* packet) nor send any new packets.

When the virtual circuit is reset, new *data* packets may be sent on the virtual circuit as follows: for both transmission directions, the VC-sequence number is set to 0 and the upper bound of the window is set to the VC credit received either in the *reset request* packet or in the *reset confirmation* packet.

When the virtual circuit is reset, new *Interrupt* packets may be sent on the virtual circuit.

When a *reset request* packet is received by the DCE, the network transmits a *reset request* packet to the remote DTE.

When a *reset request* packet is sent by the DCE, it discards received *data* packets.

10.15.2 Reset collision

A reset collision occurs when both entities transmit a *reset request* packet for the same virtual circuit at the same time. Each entity considers that the reset procedure is completed when it receives the link level acknowledgement of the sent *reset request* packet. Neither waits for nor sends a *reset confirmation* packet.

11 Signalling coding

11.1 Message functional definitions and contents

11.1.1 List of the messages

Table 11-1 gives the function and the abbreviations of the defined messages.

TABLE 11-1/X.45

List of messages

Description	Function	Abbreviations	References
Call request message	Virtual circuit set-up	CR	11.1.2
Call confirmation message	Virtual circuit set-up	CC	11.1.3
Call abort message	Virtual circuit clearing	CA	11.1.4
Disconnect request message	Virtual circuit clearing	DR	11.1.5
Disconnect confirmation message	Virtual circuit clearing	DC	11.1.6
Restart request message	Signalling (re)initialisation	RQ	11.1.7
Restart confirmation message	Signalling (re)initialisation	RN	11.1.8

11.1.2 Call request message

The *call request* message is used to request the setting-up of a virtual circuit between two DTEs. It contains the virtual circuit identifier to be used by the peer entity in the transmission direction, an initial VC credit allocated to that peer entity and set-up data (addresses, parameters, user data, etc.). See Table 11-2.

The encapsulation of the *call request* message in data packet(s) makes possible to carry out a flow control on the calls by re-using the underlying flow control mechanisms of the signalling virtual circuit.

TABLE 11-2/X.45

Call request message content

Message type: *Call request*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
My VC identifier	11.2.4.4	Both	M	5
End-to-end transit delay	11.2.4.22	Both	O (Note 1)	4-11
Transit delay selection and indication	11.2.4.19	Both	O	5
Packet layer binary parameters	11.2.4.13	Both	O (Note 2)	3
Packet size	11.2.4.9	Both	O (Note 2)	4
Closed user group	11.2.4.11	Both	O	4-7
Reverse Charging / Charging information	11.2.4.12	Both	O	3
VC-layer bound	11.2.4.6	Both	M	6
Throughput	11.2.4.10	Both	O (Notes 1 and 2)	2-12
Protection	11.2.4.24	Both	O (Note 1)	3-255
X.213 priority	11.2.4.23	Both	O (Note 1)	3-8
Called party number	11.2.4.3	Both	O (Note 2)	2-*
Called party subaddress	11.2.4.20	Both	O (Note 1)	2-23
Called party number	11.2.4.2	Both	O (Note 3)	2-*
Called party subaddress	11.2.4.21	Both	O (Note 1)	2-23
NUI selection	11.2.4.14	DTE→DCE	O	2-*
Redirecting number	11.2.4.17	Both	O	6-*
Transit network selection	11.2.4.15	DTE→DCE	O	2-*
User-user	11.2.4.8	Both	O	3-131

NOTE 1 – Included in the DTE-to-DCE direction when the calling DTE wants to provide OSI network service requirements. Included in the DCE-to-DTE direction if the calling DTE included such information element in the corresponding *call request* message.

NOTE 2 – Optional in the DTE → DCE direction, Mandatory in the DCE → DTE direction.

NOTE 3 – Mandatory in the DTE → DCE direction, optional in the DCE → DTE direction.

11.1.3 Call confirmation message

The *call confirmation* message is used to accept the setting-up of a virtual circuit requested by the peer entity. It contains the value of the YI field (received in the *call request* message), the virtual circuit identifier to be used by the peer entity in the transmission direction, an initial VC credit allocated to that peer entity and set-up data (addresses, parameters, user data, etc.). See Table 11-3.

TABLE 11-3/X.45

Call confirmation message content

Message type: *Call confirmation*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
My VC identifier	11.2.4.4	Both	M	5
Your VC identifier	11.2.4.5	Both	M	5
End-to-end transit delay	11.2.4.22	Both	O (Note 1)	4-11
Transit delay selection and indication	11.2.4.19	DCE→DTE	O	5
Packet layer binary parameters	11.2.4.13	Both	O (Note 2)	3
Packet size	11.2.4.9	Both	O (Note 3)	4
Reverse charging / Charging information	11.2.4.12	DTE→DCE	O	3
VC-layer bound	11.2.4.6	Both	M	6
Throughput	11.2.4.10	Both	O (Note 2)	2-12
Protection	11.2.4.24	Both	O (Note 1)	3-255
X.213 priority	11.2.4.23	Both	O (Note 1)	3-8
Called party number	11.2.4.2	Both	O (Note 4)	2-*
Called party subaddress	11.2.4.21	Both	O (Note 1)	2-23
Called line address modified notification	11.2.4.18	Both	O	3-4
User-user	11.2.4.8	Both	O	3-131

NOTE 1 – Included in the DCE-to-DTE direction if the called DTE included such information element in the corresponding *call confirmation* message.

NOTE 2 – Optional in the DTE → DCE direction, Mandatory in the DCE → DTE direction.

NOTE 3 – See 14.3.

NOTE 4 – Mandatory when the called line address modified notification information element is present.

11.1.4 Call abort message

The *call abort* message is used to abort the setting-up of a virtual circuit. It contains the virtual circuit identifier to be used by the peer entity in the transmission direction, cause and diagnostic to explain the abort. See Table 11-4.

TABLE 11-4/X.45

Call abort message content

Message type: *Call abort*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
Cause	11.2.4.7	Both	M	4-32
My VC identifier	11.2.4.4	Both	M	5

11.1.5 Disconnect request message

The *disconnect request* message is used to reject the setting-up of a virtual circuit requested by the peer entity, or to request the clearing of a virtual circuit between two entities. It contains the value of the YI field of the virtual circuit, cause and diagnostic fields to explain the clearing and clearing data (addresses, parameters, user data, etc.). See Table 11-5.

TABLE 11-5/X.45

Disconnect request message content

Message type: *Disconnect request*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
Cause	11.2.4.7	Both	M	4-32
Your VC identifier	11.2.4.5	Both	M	5
End-to-end transit delay	11.2.4.22	DTE→DCE	O (Note 1)	4-11
Packet layer binary parameters	11.2.4.13	DTE→DCE	O (Note 1)	3
Reverse Charging / Charging information	11.2.4.12	DCE→DTE	O	3-*
Throughput	11.2.4.10	DTE→DCE	O (Note 1)	2-12
Protection	11.2.4.24	DTE→DCE	O (Note 1)	3-255
X.213 protection	11.2.4.23	DTE→DCE	O (Note 1)	3-8
Calling party subaddress	11.2.4.20	DTE→DCE	O (Note 1)	2-23
Called party number	11.2.4.2	Both	O (Notes 1 and 2)	2-*
Called party subaddress	11.2.4.21	Both	O	2-23
Called line address modified notification	11.2.4.18	Both	O	3-4
Call deflection selection	11.2.4.16	DTE→DCE	O	5-*
User-user	11.2.4.8	Both	O	3-131
NOTE 1 – May be included only when the call deflection selection facility/service is used. NOTE 2 – Mandatory when the called line address modified notification information element is present.				

11.1.6 Disconnect confirmation message

The *disconnect confirmation* message is used to confirm clearing of a virtual circuit. It contains the value of the YI field of the virtual circuit. See Table 11-6.

TABLE 11-6/X.45

Disconnect confirmation message content

Message type: *Disconnect confirmation*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
Your VC identifier	11.2.4.5	Both	M	5
Reverse charging / Charging information	11.2.4.12	DCE→DTE	O	3-*

11.1.7 Message de demande de redémarrage

Le message *demande de redémarrage* est utilisé pour demander la réinitialisation de l'itinéraire de signalisation entre deux entités. Il contient un champ motif et diagnostic donnant une explication au sujet du redémarrage. Voir le Tableau 11-7.

TABLE 11-7/X.45

Restart request message content

Message type: *Restart request*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1
Cause	11.2.4.7	Both	M	4-32

11.1.8 Restart confirmation message

The *restart confirmation* message is used to confirm re-initialisation of the signalling path. See Table 11-8.

TABLE 11-8/X.45

Restart confirmation message content

Message type: *Restart confirmation*				
Information element	References	Direction	Type	Length
Protocol discriminator	11.2.2	Both	M	1
Message type	11.2.3	Both	M	1

11.2 General message format and information elements coding

11.2.1 Overview

Every message shall consist of the following parts:

a) protocol discriminator;

b) message type;

c) other information elements as required by each message type.

This organisation is illustrated in the example shown in Figure 11-1.

Bits 8	7	6	5	4	3	2	1	Octets
Protocol discriminator								1
0	Message type							2
Other information elements as required								3, etc.

FIGURE 11-1/X.45

General message organisation example

A particular message may contain more than a particular DTE or DCE needs or can understand. All equipment should be able to ignore any extra information, present in a message, which is not required for the proper operation of that equipment. For example a DTE may ignore the calling party number if that number is of no interest to the DTE when a *call request* message is received.

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

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

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

11.2.2 Protocol discriminator

The purpose of the protocol discriminator is to distinguish messages for DTE/DCE signalling defined in this Recommendation from those in other ITU-T Recommendations and other standards.

The protocol discriminator is the first octet of every message. It is coded as shown in Figure 11-2.

Bits 8	7	6	5	4	3	2	1	Octets
X.45 DTE-DCE signalling messages								
0	0	1	1	0	0	1	0	1
Protocol discriminator								

FIGURE 11-2/X.45

Protocol discriminator

11.2.3 Message type

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

The message type is the first part of every message. The message type is coded as shown in Figure 11-3 and Table 11-9. Bit 8 is reserved for possible future use as an extension bit.

Bits								
8	7	6	5	4	3	2	1	Octets
0	Message type							1

FIGURE 11-3/X.45

Message type

TABLE 11-9/X.45

Message types

Bits 8765 4321	
000- - - - -	Virtual circuit set-up
0 0111	*Call confirmation*
0 0101	*Call request*
010- - - - -	Virtual circuit clearing
0 0101	*Disconnect request*
0 1101	*Disconnect confirmation*
1 1010	*Call abort*
0 0110	*Restart request*
0 1110	*Restart confirmation*

11.2.4 Information elements

11.2.4.1 Coding rules

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

Two categories of information element are defined:

a) single octet information elements [see diagrams a) and b)] of Figure 11-4;

b) variable length information elements [see diagram c)] of Figure 11-4.

Bits								
8	7	6	5	4	3	2	1	Octets
1	Information element identifier			Contents of information element				1

a) Single octet information element format (type 1)

Bits								
8	7	6	5	4	3	2	1	Octets
1	Information element identifier							1

b) Single octet information element format (type 2)

Bits								
8	7	6	5	4	3	2	1	Octets
0	Information element identifier							1
Length of contents of information element (octets)								2
Contents of information element								3, etc.

c) Variable length information element format

FIGURE 11-4/X.45

Formats of information elements

For the information elements listed below, the coding of the information element identifier bits is summarised in Table 11-10.

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

Single octet information elements may appear at any point in the message. Two types of single octet have been defined. Type 1 elements provide the information element identification in bit positions 7, 6, 5. The value "010" in these bit positions is reserved for Type 2 single octet elements.

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

TABLE 11-10/X.45

Information element identifier coding

8765 4321		References	Max length (octets) (Note 1)
0 : : : : : : :	*Variable length information elements*		
000 1000	Cause (Note 2)	11.2.4.7	32
001 1010	My VC identifier	11.2.4.4	5
001 1011	Your VC identifier	11.2.4.5	5
100 0010	End-to-end transit delay	11.2.4.22	11
100 0011	Transit delay selection and indication	11.2.4.19	5
100 0100	Packet layer binary parameters	11.2.4.13	3
100 0110	Packet size	11.2.4.9	4
100 0111	Closed user group	11.2.4.11	7
100 1010	Reverse charging / Charging information	11.2.4.12	(Note 3)
100 1011	VC-layer bound	11.2.4.6	6
100 1110	Throughput	11.2.4.10	12
100 1111	Protection	11.2.4.24	255
101 0000	X.213 priority	11.2.4.23	8
110 1100	Calling party number	11.2.4.3	(Note 3)
110 1101	Calling party subaddress	11.2.4.20	23
111 0000	Called party number	11.2.4.2	(Note 3)
111 0001	Called party subaddress	11.2.4.21	23
111 0010	NUI selection	11.2.4.14	(Note 3)
111 0100	Redirecting number	11.2.4.17	(Note 3)
111 0101	Called line address modified notification	11.2.4.18	4
111 0111	Call deflection selection	11.2.4.16	(Note 3)
111 1000	Transit network selection (Note 2)	11.2.4.15	(Note 3)
111 1110	User-user	11.2.4.8	131
	All other values are reserved.		

NOTE 1 – The length limits described for the variable length information elements below take into account only the present ITU-T standardised coding values (Future enhancements and expansions to this Recommendation may not be restricted to these limits).

NOTE 2 – This information element may be repeated.

NOTE 3 – The maximum length is network dependent.

The second octet of a variable length information element indicates the total length of the contents of that information element regardless of the coding of the first octet (i.e. the length starting with octet 3). It is the binary coding of the number of octets of the contents, with bit 1 as the least significant bit (2^0).

An optional variable-length information element may be present, but empty. For example a *call request* message may contain a called party number information element, the content of which is of zero length. This should be interpreted by the receiver as equivalent to that information element being absent. Similarly, an absent information element should be interpreted by the receiver as equivalent to that information element being empty.

The following rules apply to the coding of variable length information elements (octets 3, etc.):

a) The first digit in the octet number identifies one octet or a group of octets.

b) Each octet group is a self contained entity. The internal structure of an octet group may be defined in alternative ways.

c) An octet group is formed by using some extension mechanism. The preferred extension mechanism is to extend an octet (N) through the next octet(s) (Na, Nb, etc.) by using bit 8 in each octet as an extension bit. The bit value "0" indicates that the octet continues through the next octet. The bit value “1”, indicates that this octet is the last octet. If one octet (Nb) is present, also the preceding octets (N and Na) must be present.

In the format description appearing in 11.2.4.2 etc., bit 8 is marked “0/1 ext.”, if another octet follows. Bit 8 is marked “1 ext.”, if this is the last octet of the extension domain.

Additional octets may be defined later (“1 ext.” changed to “0/1 ext.”) and equipments shall be prepared to receive such additional octets although the equipment need not be able to interpret or act upon the content of these octets.

d) In addition to the extension mechanism defined above, an octet (N) may be extended through the next octet(s) (N1, N2 etc.) by indications in bits 7-1 (of octet N).

e) The mechanisms in c) and d) may be combined. Mechanism c) shall take priority in the ordering, such that all octets Na, Nb, etc. shall occur before octets N1, N2, etc. This rule shall apply even where the extension to octets N1, N2, etc., is indicated in one of the octet Na, Nb, etc.

f) Similar conventions even when mechanism d) is being repeated, i.e. octets N.1 shall occur before octets N.1.1, N.1.2, etc.

g) Optional octets are marked with asterisks (*).

NOTE 1 – It is not possible to use mechanism c) repeatedly, i.e. it is not possible to construct an octet 4a as this would become octet 4b.

NOTE 2 – Protocol designers should exercise care in using multiple extension mechanism to ensure that a unique interpretation of the resultant is possible.

NOTE 3 – For a number of information elements there is a field that defines the coding standard. When the coding standard defines a national standard, it is recommended that the national standard be structured similar to the information element defined in this Recommendation.

11.2.4.2 Called party number

The purpose of the called party number information element is to identify the called party of a call.

The called party number information element is coded as shown in Figure 11-5 and Table 11-11.

The maximum length of this information element is network dependent.

Bits

8	7	6	5	4	3	2	1	Octets
Called party number								
0	1	1	1	0		0	0	1
Information element identifier								
Length of called party number contents								2
1 ext.	Type of number			Numbering plan identification				3
0 spare	Number digits (T50 characters)							4, etc.

FIGURE 11-5/X.45

Called party number information element

TABLE 11-11/X.45

Called party number information element

Type of number (octet 3)	
Bits	
7 6 5	
0 0 0	Unknown => network dependent number
0 0 1	International number
0 1 0	National number
0 1 1	Network specific number (for private use only)
1 0 0	Complementary address without main address/subscriber number
1 0 1	Alternative address
1 1 1	Reserved for extension
Other values	Reserved
Numbering plan (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Unknown => network dependent number
0 0 0 1	Recommendation E.164 (digital)
0 0 1 0	Recommendation E.164 (analogue)
0 0 1 1	Recommendation X.121
0 1 0 0	Recommendation F.69 (Telex numbering plan)
1 0 0 1	Private numbering plan (for private use only)
1 1 1 1	Reserved for extension
Other values	Reserved
Numbering plan when interpreted as the alternative address coding authority (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Mnemonic address coded as per Recommendation T.50 (IA5)
0 0 0 1	OSI NSAP address as per ITU-T Rec. X.213 | ISO/IEC 8348
0 0 1 0	MAC address as per ISO/IEC 8802
0 0 1 1	Internet address coded per RFC 1166
Other values	Reserved
Number digits (octets 4, etc.)	
This field is coded with T50 characters, according to the format specified in the appropriate numbering plan.	

11.2.4.3 Calling party number

The purpose of the calling party number information element is to identify the origin of a call.

The calling party number information element is coded as shown in Figure 11-6 and Table 11-12.

The maximum length of this information element is network dependent

Bits 8	7	6	5	4	3	2	1	Octets
Calling party number 0	1	1	0	1	1	0	0 Information element identifier	1
Length of calling party number contents								2
1 ext.	Type of number			Numbering plan identification				3
0 spare	Number digits (T50 characters)							4*, etc.

FIGURE 11-6/X.45

Calling party number information element

TABLE 11-12/X.45

Calling party number information element

Type of number (octet 3)	
Bits	
7 6 5	
0 0 0	Unknown => network dependent number
0 0 1	International number
0 1 0	National number
0 1 1	Network specific number (for private use only)
1 0 0	Complementary address without main address/subscriber number
1 1 1	Reserved for extension
Other values	Reserved
Numbering plan (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Unknown => network dependent number
0 0 0 1	Recommendation E.164 (digital)
0 0 1 0	Recommendation E.164 (analogue)
0 0 1 1	Recommendation X.121
0 1 0 0	Recommendation F.69 (Telex numbering plan)
1 0 0 1	Private numbering plan (private use only)
1 1 1 1	Reserved for extension
Other values	Reserved
Number digits (octets 4, etc.)	
This field is coded with T50 characters, according to the format specified in the appropriate numbering plan.	

11.2.4.4 My VC identifier

The purpose of the My VC-identifier information element is to convey to the peer entity the virtual circuit identifier that the peer entity has to use in the transmission direction.

The My VC-identifier information element is coded as shown in Figure 11-7 and Table 11-13. The maximum length of this information element is 5 octets.

<table>
<tr><th colspan="8">Bits</th><th></th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>Octets</th></tr>
<tr><td colspan="8">My VC identifier</td><td rowspan="3">1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td colspan="8">Information element identifier</td></tr>
<tr><td colspan="8">Length of My VC-identifier contents</td><td>2</td></tr>
<tr><td colspan="8">My VC identifier
(Most significant 8 bits)</td><td>3</td></tr>
<tr><td colspan="8">My VC identifier
(Second most significant 8 bits)</td><td>4</td></tr>
<tr><td colspan="8">My VC identifier
(Third most significant 8 bits)</td><td>5</td></tr>
</table>

FIGURE 11-7/X.45

My VC-identifier information element

TABLE 11-13/X.45

My VC-identifier information element

My VC identifier (octets 3, 4 and 5) My VC-identifier is coded in binary.

11.2.4.5 Your VC identifier

The purpose of the Your VC-identifier information element is to convey to the peer entiy the virtual circuit identifier that the entity has to use in the transmission direction.

The Your VC-identifier information element is coded as shown in Figure 11-8 and Table 11-14. The maximum length of this information element is 5 octets.

Bits

8	7	6	5	4	3	2	1	Octets
Your VC identifier								
0	0	0	1	1	0	1	1	1
Information element identifier								
Length of Your VC-identifier contents								2
Your VC identifier (Most significant 8 bits)								3
Your VC identifier (Second most significant 8 bits)								4
Your VC identifier (Third most significant 8 bits)								5

FIGURE 11-8/X.45

Your VC-identifier information element

TABLE 11-14/X.45

Your VC-identifier information element

Your VC identifier (octets 3, 4 and 5) Your VC identifier is coded in binary.

11.2.4.6 VC-layer bound

The purpose of the VC-layer bound information element is to convey to the peer entity the rank of the first segment that the entity is not ready to accept in reception for this virtual circuit.

The VC-layer bound information element is coded as shown in Figure 11-9 and Table 11-15. The maximum length of this information element is 6 octets.

Bits 8	7	6	5	4	3	2	1	Octets
VC-layer bound 0	1	0	0	1	0	1	1 Information element identifier	1
Length of VC-layer bound contents								2
VC-layer bound (Most significant 8 bits)								3
VC-layer bound (Second most significant 8 bits)								4
VC-layer bound (Third most significant 8 bits)								5* (Note)
VC-layer bound (Least significant or second most significant 8 bits)								6* (Note)

NOTE – Octet 5* and 6* are both included when the extended format is used.

FIGURE 11-9/X.45

VC-layer bound information element

TABLE 11-15/X.45

VC-layer bound information element

VC-layer bound (octets 3, 4, 5 and 6*)*
VC-layer bound is coded in binary.

11.2.4.7 Cause

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

The Cause information element is coded as shown in Figure 11-10 and Table 11-16. The maximum length of this information element is 32 octets.

<table>
<tr><th colspan="8">Bits</th><th></th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>Octets</th></tr>
<tr><td colspan="8">Cause</td><td rowspan="3">1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="8">Information element identifier</td></tr>
<tr><td colspan="8">Length of cause contents</td><td>2</td></tr>
<tr><td>0/1
ext.</td><td colspan="2">Coding
standard</td><td>0
Spare</td><td colspan="4">Location</td><td>3</td></tr>
<tr><td>1 ext.</td><td colspan="7">Recommendation</td><td>3a</td></tr>
<tr><td>1 ext.</td><td colspan="7">Cause value</td><td>4</td></tr>
<tr><td colspan="8">Diagnostic if any</td><td>5*</td></tr>
</table>

FIGURE 11-10/X.45

Cause information element

TABLE 11-16/X.45

Cause information element

Coding standard (octet 3) Bits 7 6 0 0 ITU-T-standardised coding, as described below 0 1 ISO/IEC standard (see Note 1) 1 0 National standard (see Note 1) 1 1 Standard specific to identified location (see Note 1)
NOTE 1 – These other coding standards should be used only when the desired cause value cannot be represented with the ITU-T-standardised coding.
Location (octet 3) Bits 4 3 2 1 0 0 0 0 DTE 0 0 0 1 Private network serving the local DTE 0 0 1 0 Public network serving the local DTE 0 0 1 1 Transit network 0 1 0 0 Public network serving the remote DTE 0 1 0 1 Private network serving the remote DTE 0 1 1 1 International network 1 0 1 0 Network beyond interworking point All other values are reserved.
NOTE 2 – In case the same public (respectively private) network is serving both local and remote DTEs, then the network use only public (respectively private) network serving the local DTE value.
Recommendation (octet 3a) Bits 7 6 5 4 3 2 1 0 0 0 0 0 0 0 Q.931 0 0 0 0 0 1 1 X.21 0 0 0 0 1 0 0 X.25 0 0 0 0 1 0 1 Public land mobile networks, Recommendations Q.1031 and Q.1051 0 0 0 0 1 1 0 X.45 All other values are reserved.
NOTE 3 – When required, this octet may be generated/processed at the interworking point if call clearing is initiated by/propagated to a "non-X.45" entity.
Cause value (octet 4) When in Recommendation (octet 3a) either Recommendation X.25 or Recommendation X.45 is referred to, it implies that bits 7 to 1 are coded as bit 7 to 1 in Table 5-6/X.25.
Diagnostics (octet 5) When in Recommendation (octet 3a), Recommendation X.25 is referred to, this field is coded as described in Annex E/X.25. When in Recommendation (octet 3a), Recommendation X.45 is referred to, this field is coded as follows : 8 7 6 5 4 3 2 1 0 0 0 0 0 0 0 0 No additional information All other values are reserved and their use is for further study.

11.2.4.8 User-user

The purpose of the user-user information element is to convey information between DTEs. This information is not interpreted by the network but is rather carried transparently and delivered to the remote DTE.

The user-user information element is coded as shown in Figure 11-11 and Table 11-17. There are no restrictions on the content of the user information field.

The maximum length of this information element is 131 octets.

Bits 8	7	6	5	4	3	2	1	Octets
User-user								
0	1	1	0	1	1	0	1	1
Information element identifier								
Length of user-user contents								2
Protocol discriminator								3
User information								4, etc.

FIGURE 11-11/X.45

User-user information element

TABLE 11-17/X.45

User-user information element

Protocol discriminator (octet 3)	
Bits	
8 7 6 5 4 3 2 1	
0 0 0 0 0 0 0 0	User-specific protocol
Other values	Reserved

11.2.4.9 Packet size

The purpose of the packet size information element is to indicate requested packet size values to be used for the virtual circuit. The values are encoded log 2. The packet size must be greater or equal to 64 octets.

The packet size information element is coded as shown in Figure 11-12.

The length of this information element is 4 octets.

Bits

8	7	6	5	4	3	2	1	Octets
Packet size Information element identifier								
0	1	0	0	0	1	1	0	1
Length of packet size contents								2
1 ext.	Forward value (Notes 1 and 2)							3
1 ext.	Backward value (Notes 1 and 2)							4

NOTE 1 – 000 0000 is reserved.

NOTE 2 – The term “forward” is defined in the direction from calling DTE to called DTE. The term “backward” is defined in the direction from called DTE to calling DTE.

FIGURE 11-12/X.45

Packet size information element

11.2.4.10 Throughput

The purpose of the throughput information element is to indicate requested throughput for the virtual circuit.

The throughput information element is coded as shown in Figure 11-13 and Table 11-18. The maximum length of this information element is 12 octets.

Bits 8	7	6	5	4	3	2	1	Octets
Throughput 0	1	0	0	1	1	1	0 Information element identifier	1 (Note 1)
Length of throughput contents								2
0 ext.	Throughput 0	0	0	1	0	1	0	3* (Note 2)
0 ext.	Outgoing magnitude				Outgoing multiplier			3a*
0/1 ext.	Outgoing multiplier (cont.)							3b*
0 ext.	Incoming magnitude				Incoming multiplier			3c*
1 ext.	Incoming multiplier (cont.)							3d*
0 ext.	Minimum acceptable throughput 0	0	0	1	0	1	1	4* (Notes 3 and 4)
0 ext.	Outgoing magnitude				Outgoing multiplier			4a* (Note 4)
0/1 ext.	Outgoing multiplier (cont.)							4b* (Note 4)
0 ext.	Incoming magnitude				Incoming multiplier			4c* (Note 4)
1 ext.	Incoming multiplier (cont.)							4d* (Note 4)

NOTE 1 – The throughput and minimal acceptable throughput are optional. When the throughput is not included, network default value will be used. The term "outgoing" is defined in the direction from calling DTE to called DTE. The term "incoming" is defined in the direction from called DTE to calling DTE.

NOTE 2 – When octet 3 is present, octets 3a and 3b shall also be present. Additionally, octet groups 3c and 3d may also be included.

NOTE 3 – When octets 4 is present, octets 4a and 4b shall also be present. Additionally octet groups 4c and 4d may also be included.

NOTE 4 – Included only in the *call request* message.

FIGURE 11-13/X.45

Throughput information element

TABLE 11-18/X.45

Throughput information element

Throughput (octets 3, 3a, 3b, 3c and 3d)

The purpose of the throughput field is to negotiate the throughput for the call.

This field, when present in the call request message, indicates requested throughput, which is the lesser of the throughput requested by the calling DTE and throughput available from the network(s), but is not less than the minimum acceptable throughput. When present in the call confirmation message, it indicates the agreed throughput, which is the throughput acceptable to the calling DTE, the called DTE and the network(s).

If the throughput is asymmetrical (i.e. the values in the incoming and outgoing directions are different), octets 4a and 4b indicate throughput in the outgoing direction (from the calling DTE) and octets 4c and 4d indicate throughput in the incoming direction (to the calling DTE). If the throughput is symmetrical, octets 4a and 4b indicate throughput in both directions, and octets 4c and 4d are absent.

Throughput is expressed as an order of magnitude (in powers of 10) and a three significant digit multiplier, the value of which is between 0.100 and 0.999. For example, a rate of 1920 kbit/s is expressed as 0.192×10^7.

Magnitude (octets 3a and 3c)

This field indicates the magnitude of the throughput. This is expressed as a power of 10.

Bits 7 6 5 4	
0 0 0 0	10^0
0 0 0 1	10^1
0 0 1 0	10^2
0 0 1 1	10^3
0 1 0 0	10^4
0 1 0 1	10^5
0 1 1 0	10^6
0 1 1 1	10^7
1 0 0 0	10^8
1 0 0 1	10^9
1 0 1 0	10^{10}
1 0 1 1	10^{11}
1 1 0 0	10^{12}
1 1 0 1	10^{13}
1 1 1 0	10^{14}

All other values are reserved.

Multiplier (octets 3a, 3b, 3c and 3d)

This field encodes in binary the equivalent integer to the first three significant digits of the multiplier expressed as a floating number. This means that value of the multiplier is between 0.100 and 0.999, but is coded as 100 up to 999 (hexadecimal: 64 up to 3E7). As an example 1920 kbit/s will be coded as 0.192×10^7, magnitude: hexadecimal 7, multiplier: hexadecimal C0.

Minimum acceptable throughput

The purpose of the minimum acceptable throughput field is to negotiate the throughput for the call. Minimum acceptable throughput is the lowest throughput value that the calling user is willing to accept for the call. If the network or the called user is unable to support this throughput, the call shall be cleared.

This field which is present only in the call request message, is carried unchanged through the network(s). Its value may not be greater than the requested throughput.

If the minimum acceptable throughput is asymmetrical (i.e. the values in the incoming and outgoing directions are different) octets 4a and 4b indicate minimum acceptable throughput in the outgoing direction (from the calling DTE) and octets 4c and 4d indicate minimum acceptable throughput in the incoming direction (to the calling DTE). If the minimum acceptable throughput is symmetrical, octets 4a and 4b indicate throughput in both directions, and octets 4c and 4d are absent.

Minimum acceptable throughput is expressed as an order of magnitude (in powers of 10) and a three significant digits multiplier, the value of which is between 0.100 and 0.999. For example, a rate of 1920 kbit/s is expressed as 0.192×10^7.

Magnitude (octets 4a and 4c)

Same as octets 3a and 3c coding.

Multiplier (octets 4a, 4b, 4c and 4d)

Same as octets 3a, 3b, 3c and 3d coding.

11.2.4.11 Closed user group

The purpose of the closed user group information element is to indicate the closed user group to be used for that virtual circuit.

The closed user group information element is coded as shown in Figure 11-14 and Table 11-19.

The maximum length of this information element is 7 octets.

Bits 8	7	6	5	4	3	2	1	Octets
Closed user group 0	1	0	0	0	1	1	1 Information element identifier	1
Length of closed user group contents								2
1 ext.	0 Spare	0	0	0	CUG indication			3
0 spare	CUG index code (T50 characters)							4, etc.

FIGURE 11-14/X.45

Closed user group information element

TABLE 11-19/X.45

Closed user group information element

CUG indication (octet 3)	
Bits	
3 2 1	
0 0 1	Closed user group
0 1 0	Closed user group with outgoing access
All other values are reserved.	
CUG index code (octet 4 etc.)	
Bits	
7 6 5 4 3 2 1	
0 1 1 0 0 0 0	0
0 1 1 0 0 0 1	1
0 1 1 0 0 1 0	2
0 1 1 0 0 1 1	3
0 1 1 0 1 0 0	4
0 1 1 0 1 0 1	5
0 1 1 0 1 1 0	6
0 1 1 0 1 1 1	7
0 1 1 1 0 0 0	8
0 1 1 1 0 0 1	9
The CUG index code should represented by up to four T50 characters.	

11.2.4.12 Reverse charging / Charging information

The purpose of the reverse charging / Charging information information element is to indicate that reverse charging and/or charging information have been requested for that virtual circuit, and to provide charging information for that virtual circuit being cleared.

The reverse charging / charging information information element is coded as shown in Figure 11-15 and Table 11-20.

The maximum length of this information element is network dependent.

Bits 8	7	6	5	4	3	2	1	Octets
Reverse charging / Charging information								
0	1	0	0	1	0	1	0	1
Information element identifier								
Length of reverse charging / Charging information contents								2
1 ext.	0 Réservé	0	0	Charg. inf.	Reverse charging Indication			3
Monetary unit								
1	1	0	0	0	1	0	1	4*
Length of charging								5*
Charging								6*, etc.
Charging segment count								
1	1	0	0	0	0	1	0	l*
Length of charging segment counts								l + 1*
Charging segment counts								l + 2*, etc.
Call duration								
1	1	0	0	0	0	0	1	m*
Length of call duration								m + 1*
Call durations								m + 2*, etc.

FIGURE 11-15/X.45

Reverse charging / Charging information information element

TABLE 11-20/X.45

Reverse charging / Charging information information element

Charging information (octet 3)

Bit
4
0 Charging information not requested / no meaning
1 Charging information requested

Reverse charging indication (octet 3)

Bits
3 2 1
0 0 0 Reverse charging not requested/no meaning
0 0 1 Reverse charging requested
All other values are reserved.

Charging (octets 6, etc.)

The coding of this parameter is for further study.

Charging segment counts [octets (l + 2), etc.]

This parameter has a length of n × 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 indicate the number of charging segments sent to the DTE. The following four octets indicate the number of charging 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 charging segment count.

Charging 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 1 – 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.

Call durations [octets (m + 2), etc.]

This parameter has a length of n × 4 where n is the different tariff periods managed by the network.

For each tariff period, the first octet of the parameter 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 2 – 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.

11.2.4.13 Packet layer binary parameters

The purpose of the packet layer binary parameters information element is to indicate requested layer 3 parameter values to be used for that virtual circuit.

The packet layer binary parameters information element is coded as shown in Figure 11-16 and Table 11-21.

The length of this information element is 3 octets.

Bits 8	7	6	5	4	3	2	1	Octets
Packet layer binary parameters								
0	1	0	0	0	1	0	0	1
Information element identifier								
Length of packet layer binary parameters contents								2
1 ext.	0 spare	n. ass. Data	Fast selection		Exp. Data	0 (not used)	0 (not used)	3

FIGURE 11-16/X.45

Packet layer binary parameters element

TABLE 11-21/X.45

Packet layer binary parameters information element

Non-assured data (octet 3)	
Bit 6	
0	No request/request denied
1	Request indicated/request accepted
Fast select (octet 3)	
Bits 5 4	
0 0	Fast select not requested
0 1	Fast select not requested
1 0	Fast select requested with no restriction on response
1 1	Fast select requested with restriction on response
Expedited data (octet 3)	
Bit 3	
0	No request/request denied
1	Request indicated/request accepted

11.2.4.14 NUI selection

The purpose of the NUI selection information element is to indicate to the network which network user identifier is to be used for the virtual circuit.

The NUI selection information element is coded as shown in Figure 11-17 and Table 11-22. The maximum length of this information element is network dependent.

Bits

8	7	6	5	4	3	2	1	Octets
NUI selection								
0	1	1	1	0	0	1	0	1
Information element identifier								
Length of NUI selection contents								2
NUI format		V	0	NUI subfld. for.		Verifying entity		3
Remaining octets of NUI ...								4, etc.
Type				0	0	0	0	i
Subfield length								i + 1
Subfield information								i + 2 i + j
...								

FIGURE 11-17/X.45

NUI selection information element

TABLE 11-22/X.45

NUI selection element

NUI format (octet 3)	
Bits	
8 7	
1 1	The remaining bits of octet 3 and the remaining octets of NUI are specified below [alternative (a)].
Other values	Neither the remaining bits of octet 3 nor the remaining octets of the NUI are constrained by this Recommendation [alternative (b)].
V(octet 3)	
Bit	
6	
0	Only this value may be passed over an X.45 interface in the DTE to DCE direction.
1	Left for further study.
NUI subfield format (octet 3)	
Bits	
4 3	
0 0	First subfield conforms to Recommendation E.118 and ISO 7812 (Note)
0 1	No constraints on remaining octets of NUI
1 0	Subfield format; no subfield information constraints (Note)
1 1	Reserved
NOTE – The remaining octets of NUI are divided into *m* subfields (*m* greater or equal to 1), where each subfield is defined as described in Figure 11-17 from octet (i) to octet (i + j).	
Verifying entity (octet 3)	
Bits	
2 1	
0 0	Originating network, i.e. the network in which the call request phase is initiated
0 1	Destination network, i.e. the network in which the call confirmation phase is initiated
1 0	First transit network
1 1	Other/not specified
Type (octet i)	
Bits	
8 7 6 5	
1 1 0 1	BCD semi octet
1 1 0 0	IA5 (T50) with bit 8 = 0
1 1 1 0	Reserved for national use
1 1 1 1	Network specific format
Other values	For future definition
Subfield length (octet i + 1)	
Subfield length is the number of semi-octets of information in the subfield, and is encoded in binary.	
For Type = 1101 (BCD), subfield length may be even or odd value.	
Subfield information (octet i + 2 to octet i + j)	
For Type = 1101 (BCD), an integral number of octets will be assured by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the subfield when necessary.	

The DCE must be able to recognise and distinguish between the two format alternatives [(a) and (b)] specified above, but the network need not support both alternatives nor all of the format options specified for alternative (a) (if that alternative is supported). Support refers to the ability to accept and/or verify/use the NUI format alternative or option in question.

A network may change the value of the V-bit received from a DTE to 1 only if it is the verifying entity. A network receiving a NUI value with the verifying entity bits set to "11" (other/not specified) may change the value of the verifying entity bits to one of the three specified values (and, depending on the value inserted, designate itself as the verifying entity). Other changes to the received value of the verifying entity bits are not permitted.

11.2.4.15 Transit network selection

The purpose of the Transit network selection information element is to identify one requested transit network. The Transit network selection information element may be repeated in a message to select a sequence of transit networks through which a virtual circuit must pass.

The transit network selection information element is coded as shown in Figure 11-18 and Table 11-23. The maximum length of this information element is network dependent.

Bits 8	7	6	5	4	3	2	1	Octets
Transit network selection 0	1	1	1	1	0	0	0 Information element identifier	1
Length of transit network selection contents								2
1 ext.	Type of network identification			Network identification plan				3
0 spare	Network identification (T50 characters)							4, etc.

FIGURE 11-18/X.45

Transit network selection information element

TABLE 11-23/X.45

Transit network selection information element

Type of network identification (octet 3)	
Bits	
7 6 5	
0 1 1	International network identification
Other values	Reserved
Network identification plan (octet 3)	
Bits	
4 3 2 1	
0 0 0 1	ISDN Network identification code (Recommendation E.164)
0 0 1 1	Data network identification code (Recommendation X.121)
Other values	Reserved
Network identification (octets 4, etc.)	
These T50 characters are organised according to the network identification plan specified in octet 3.	

11.2.4.16 Call deflection selection

The call deflection selection information element is used by the called DTE in the *disconnect request* message only in direct response to a *call request* message to specify the alternate DTE address to which the call is to be deflected.

The call deflection selection information element is coded as shown in Figure 11-19 and Table 11-24. The maximum length of this information element is network dependent.

<table>
<tr><td colspan="8" align="center">Bits</td><td></td></tr>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>Octets</td></tr>
<tr><td colspan="8" align="center">Call deflection selection
0 1 1 1 0 1 1 1
Information element identifier</td><td>1</td></tr>
<tr><td colspan="8" align="center">Length of call deflection selection contents</td><td>2</td></tr>
<tr><td>1 ext.</td><td colspan="3">Type of number</td><td colspan="4">Numbering plan identification</td><td>3</td></tr>
<tr><td>1
ext.</td><td>0
spare</td><td colspan="6">Reason for deflection</td><td>4</td></tr>
<tr><td>0 spare</td><td colspan="7">Number digits (T50 characters)</td><td>5, etc.</td></tr>
</table>

FIGURE 11-19/X.45

Call deflection selection information element

TABLE 11-24/X.45

Call deflection selection information element

Type of number (octet 3)	
Bits	
7 6 5	
0 0 0	Unknown => network dependent number
0 0 1	International number
0 1 0	National number
0 1 1	Network specific number (for private use only)
1 0 0	Complementary address without main address/subscriber number
1 0 1	Alternative address
1 1 1	Reserved for extension
Other values	Reserved
Numbering plan (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Unknown => network dependent number
0 0 0 1	Recommendation E.164 (digital)
0 0 1 0	Recommendation E.164 (analogue)
0 0 1 1	Recommendation X.121
0 1 0 0	Recommendation F.69 (Telex numbering plan)
1 0 0 1	Private numbering plan (for private use only)
1 1 1 1	Reserved for extension
Other values	Reserved
Numbering plan when interpreted as the alternative address coding authority (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Mnemonic address coded as per Recommendation T.50 (IA5)
0 0 0 1	OSI-NSAP address as per ITU-T Rec. X.213 | ISO/IEC 8348
0 0 1 0	MAC address as per ISO/IEC 8802
0 0 1 1	Internet address coded per RFC 1166
Other values	Reserved
Reason for deflection (octet 4)	
Bits	
6 5 4 3 2 1	
x x x x x x	Each x may be independently set to 0 or 1 by the called DTE and is passed transparently to the DTE to which the call is deflected.
Number digits (octets 5, etc.)	
This field is coded with T50 characters, according to the format specified in the appropriate numbering plan.	

11.2.4.17 Redirecting number

The purpose of the redirecting number information element is to identify the originally called DTE and to indicate the reason for the call redirection or call deflection.

The redirection number information element is coded as shown in Figure 11-20 and Table 11-25. The maximum length of this information element is network dependent.

Bits 8	7	6	5	4	3	2	1	Octets
Redirecting number								
0	1	1	1	0	1	0	0	1
Information element identifier								
Length of redirecting number contents								
0 ext.	Type of number			Numbering plan identification				3
0 ext.	Presentation indicator		0 Spare	0	0	Screening indicator		3a
0 ext.	0 Spare	0	0	Reason for redirection				3b
1 ext.	0 spare		Reason extension					3c*
0 spare	Number digits (T50 characters)							4, etc.

FIGURE 11-20/X.45

Redirecting number information element

TABLE 11-25/X.45

Redirecting number information element

Type of number (octet 3)	
Bits	
7 6 5	
0 0 0	Unknown => network dependent number
0 0 1	International number
0 1 0	National number
0 1 1	Network specific number
1 0 0	Complementary address without main address/subscriber number
1 0 1	Alternative address
1 1 1	Reserved for extension
Other values	Reserved
Numbering plan (octet 3)	
Bits	
4 3 2 1	
0 0 0 0	Unknown => network dependent number
0 0 0 1	Recommendation E.164 (digital)
0 0 1 0	Recommendation E.164 (analogue)
0 0 1 1	Recommendation X.121
0 1 0 0	Recommendation F.69 (Telex numbering plan)
1 0 0 1	Private numbering plan (for private use only)
1 1 1 1	Reserved for extension
Other values	Reserved
Presentation indicator (octet 3a)	
Its value is coded to binary 00 meaning Presentation allowed. Other defined code points are not used in this Recommendation.	
Screening indicator (octet 3a)	
Its value is coded to binary 01 meaning DTE provided verified and passed. Other defined code points are not used in this Recommendation.	
Reason for redirection (octet 3b)	
Bits	
4 3 2 1	
0 0 0 1	Call forwarding busy or called DTE busy
0 1 1 0	Calling DTE originated
0 1 1 1	Call distribution within a hunt group
1 0 0 1	Originally called DTE out of order
1 0 1 0	Call forwarding by the originally called DTE
1 1 1 1	Systematic call redirection
Reason extension (octet 3c)	
Bits	
6 5 4 3 2 1	
x x x x x x	When reason for redirection is calling DTE originated, each x may be independently set to 0 or 1 by the calling DTE and is passed transparently to the called DTE. When reason for redirection is call forwarding by the originally called DTE, the xs are those set by the originally called DTE in the call deflection selection information element
Number digits (octets 4, etc.)	
This field is coded with T50 characters, according to the format specified in the appropriate numbering plan.	

11.2.4.18 Called line address modified notification

The purpose of the called line address modified notification information element is to indicate to the calling DTE the reason of call redirection or call deflection.

The called line address modified notification information element is coded as shown in Figure 11-21 and Table 11-26. The maximum length of this information element is 4 octets.

Bits

8	7	6	5	4	3	2	1	Octets
Called line address modified notification								
0	1	1	1	0	1	0	1	1
Information element identifier								
Length of called line address modified notification contents								2
0 ext.	0	0	0	Reason for redirection				3
	Spare							
1 ext.	0 spare	Reason extension						3a*

FIGURE 11-21/X.45

Called line address modified notification information element

TABLE 11-26/X.45

Called line address modified notification information element

Reason for redirection (octet 3)	
Bits	
4 3 2 1	
0 0 0 1	Call redirection due to originally called DTE busy
0 1 1 0	Called DTE originated
0 1 1 1	Call distribution within a hunt group
1 0 0 1	Call redirection due to originally called DTE out of order
1 0 1 0	Call deflection by the originally called DTE
1 1 1 1	Call redirection due to prior request from originally called DTE for systematic call redirection
Reason extension (octet 3a)	
Bits	
6 5 4 3 2 1	
x x x x x x	When reason for redirection is called DTE originated, each x may be independently set to 0 or 1 by the called DTE and is passed transparently to the calling DTE. When reason for redirection is call deflection by the originally called DTE, the xs are those set by the originally called DTE in the call deflection selection information element.

11.2.4.19 Transit delay selection and indication

The purpose of the transit delay selection and indication information element is to request the nominal maximum permissible transit delay applicable on a per call basis for that virtual circuit.

The transit delay selection and indication information element is coded as shown in Figure 11-22 and Table 11-27. The maximum length of this information element is 5 octets.

<table>
<tr><th colspan="8">Bits</th><th></th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>Octets</th></tr>
<tr><td colspan="8">Transit delay selection and indication</td><td></td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="8">Information element identifier</td><td></td></tr>
<tr><td colspan="8">Length of transit delay selection and indication contents</td><td>2</td></tr>
<tr><td>0
ext.</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td colspan="2" rowspan="2">Transit delay selection.
and indication value</td><td>3</td></tr>
<tr><td></td><td colspan="5">Spare</td><td></td></tr>
<tr><td>0 ext.</td><td colspan="7">Transit delay selection and indication value (cont.)</td><td>3a</td></tr>
<tr><td>1 ext.</td><td colspan="7">Transit delay selection and indication value (cont.)</td><td>3b</td></tr>
</table>

FIGURE 11-22/X.45

Transit delay selection and indication information element

TABLE 11-27/X.45

Transit delay selection and indication information element

Transit delay selection and indication [octet 3 (bits 1-2), octets 3a and 3b]
Transit delay value binary encoded in milliseconds. Bit 2 of octet 3 is the highest order bit and bit 1 of octet 3b is the lowest order bit. The transit delay value occupies 16 bits total.

11.2.4.20 Calling part subaddress

The purpose of the calling party subaddress information element is to identify a subaddress associated with the origin of a call.

The calling part subaddress information element is coded as shown in Figure 11-23 and Table 11-28.

The maximum length of this information element is 23 octets.

Bits 8	7	6	5	4	3	2	1	Octets
Calling party subaddress 0	1	1	0	1	1	0	1 Information element identifier	1
Length of calling party subaddress contents								2
1 ext.	Type of subaddress			Odd/even indicator	0	0 Spare	0	3
Subaddress information								4, etc.

FIGURE 11-23/X.45

Calling party subaddress information element

TABLE 11-28/X.45

Calling party subaddress information element

Type of subaddress (octet 3)	
Bits 7 6 5	
0 0 0	NSAP (ITU-T Rec. X.213 | ISO/IEC 8348 AD2)
0 1 0	DTE specified
Other values	Reserved
Odd/even indicator (octet 3)	
Bit 4	
0	Even number of address signals
1	Odd number of address signals
NOTE – The odd/even indicator is used when the type of subaddress is "DTE specified" and the coding is BCD.	
Subaddress information (octets 4, etc.)	
The NSAP X.213 | ISO/IEC 8348 AD2 address, shall be formatted as specified by octet 4 which contains the Authority and Format Identifier (AFI). The encoding is made according to the "preferred binary encoding" as defined in ITU-T Rec. X.213 | ISO/IEC 8348 AD2.	
For the DTE specified subaddress, each digit is coded in a semi-octet in binary coded decimal.	

11.2.4.21 Called party subaddress

The purpose of the called party subaddress information element is to identify the subaddress of the called party of the call. The network does not interpret this information.

The called party subaddress information element is coded as shown in Figure 11-24 and Table 11-29.

The maximum length of this information element is 23 octets.

Bits								
8	7	6	5	4	3	2	1	Octets
Called party subaddress								
0	1	1	1	0	0	0	1	1
Information element identifier								
Length of called party subaddress contents								2
1 ext.	Type of subaddress			Odd/even indicator	0	0	0	3
					Spare			
Subaddress information								4, etc.

FIGURE 11-24/X.45

Called party subaddress information element

TABLE 11-29/X.45

Called party subaddress information element

Type of subaddress (octet 3)	
Bits	
7 6 5	
0 0 0	NSAP (ITU-T Rec. X.213 | ISO/CEI 8348 AD2)
0 1 0	DTE specified
Others values	Reserved
Odd/even indicator (octet 3)	
Bit	
4	
0	Even number of address signals
1	Odd number of address signals
NOTE – The odd/even indicator is used when the type of subaddress is "DTE specified" and the coding is BCD.	
Subaddress information (octets 4, etc.)	
The NSAP X.213 | ISO/IEC 8348 AD2 address, shall be formatted as specified by octet 4 which contains the Authority and Format Identifier (AFI). The encoding is made according to the "preferred binary encoding" as defined in ITU-T Rec. X.213 | ISO/IEC 8348 AD 2.	
For the DTE specified subaddress, each digit is coded in a semi-octet in binary coded decimal.	

11.2.4.22 End-to-end transit delay

The purpose of the end-to-end transit information element is to request and indicate the nominal maximum permissible transit delay applicable on a per call basis for that virtual circuit.

The end-to-end transit delay information element is coded as shown in Figure 11-25 and Table 11-30. The maximum length of this information element is 11 octets.

Bits 8	7	6	5	4	3	2	1	Octets
End-to-end transit delay 0	1	0	0	0	0	1	0	1
Information element identifier								
Length of end-to-end transit delay contents								2
0 ext.	0	0	0 Spare	0	0	Cumulative transit delay value		3
0 ext.	Cumulative transit delay value (cont.)							3a
1 ext.	Cumulative transit delay value (cont.)							3b
0 ext.	0	0	0 Spare	0	0	Requested end-to-end transit delay value		4* (Note 1)
0 ext.	Requested end-to-end transit delay value (cont.)							4a*
1 ext.	Requested end-to-end transit delay value (cont.)							4b*
0 ext.	0	0	0 Spare	0	0	Maximum end-to-end transit delay value		5* (Note 2)
0 ext.	Maximum end-to-end transit delay value (cont.)							5a*
1 ext.	Maximum end-to-end transit delay value (cont.)							5b*

NOTE 1 – Octets 4, 4a, 4b are optional. If present, these octets are always interpreted as requested end-to-end transit delay.

NOTE 2 – Octets 5, 5a, 5b are optional. If present, octets 4, 4a, 4b must also be present.

FIGURE 11-25/X.45

End-to-end transit delay information element

TABLE 11-30/X.45

End-to-end transit delay information element

Cumulative transit delay value [octets 3 (bits 1-2), octets 3a and 3b]
Cumulative transit delay value binary encoded in milliseconds. Bit 2 of octet 3 is the highest order bit and bit 1 of octet 3b is the lowest order bit. The cumulative transit delay value occupies 16 bits total.
Requested end-to-end transit delay value [octets 4 (bits 1-2), octets 4a and 4b]
Requested end-to-end transit delay value binary encoded in milliseconds. Bit 2 of octet 4 is the highest order bit and bit 1 of octet 4b is the lowest order bit. The requested end-to-end transit delay value occupies 16 bits total.
Maximum end-to-end transit delay value [octets 5 (bits 1-2), octets 5a and 5b]
Maximum end-to-end transit delay value binary encoded in milliseconds. Bit 2 of octet 5 is the highest order bit and bit 1 of octet 5b is the lowest order bit. The maximum end-to-end transit delay value occupies 16 bits total.

11.2.4.23 X.213 priority

The purpose of the X.213 priority information element is to allow the optional negotiation of priority for call in support of the OSI network service.

The X.213 priority information element is coded as shown in Figure 11-26 and Table 11-31. The maximum length of this information element is 8 octets.

Bits 8	7	6	5	4	3	2	1	Octets
X.213 priority 0	1	0	1	0	0	0	0 Information element identifier	1
Length of the X.213 priority contents								2
0/1 ext.	0 Spare	0	0	Priority of data on a connection				3
1 ext.	0 Spare	0	0	Lowest acceptable priority of data on a connection				3a*
0/1 ext.	0 Spare	0	0	Priority to gain a connection				4* (Notes 1 and 3)
1 ext.	0 Spare	0	0	Lowest acceptable priority to gain a connection				4a*
0/1 ext.	0 Spare	0	0	Priority to keep a connection				5* (Notes 2 and 3)
1 ext.	0 Spare	0	0	Lowest acceptable priority to keep a connection				5a*

NOTE 1 – Octets 4 and 4a are optional. If present, octet 3 must also be present.

NOTE 2 – Octets 5 and 5a are optional. If present, octets 3 and 4 must also be present.

NOTE 3 – Specification of a value in a particular octet requires that all preceding 0/1ext. octets be present although they may be considered optional; in such a case, the preceding octets would carry the value "unspecified". A missing octet is equivalent to the value "unspecified".

FIGURE 11-26/X.45

X.213 priority information element

TABLE 11-31/X.45

X.213 priority information element

All priority parameters take a value in the range of 0 (lowest priority) to 14 (highest priority). The value 15 is to be used to indicate an "unspecified" priority value. If the subparameter(s) for all priority parameters are unspecified, then the information element is not transmitted. If the lowest acceptable is not specified, then (a) octet is omitted. All parameters are encoded as binary encoded values between 0 and 15.

11.2.4.24 Protection

The purpose of the protection information element is to convey security related informations including level of protection, authentification information and key information.

The protection information element is coded as shown in Figure 11-27 and Table 11-32. The maximum length of this information element is 255 octets.

Bits 8	7	6	5	4	3	2	1	Octets
Protection 0	1	0	0	1	1	1	1 Information element identifier	1
Length of protection contents								2
Protection format		0	0	0	0	0	0 Spare	3
Length of level of protection contents (n)								4
Level of protection								5, etc.
Length of lowest acceptable protection level contents (m)								n + 6
Lowest acceptable protection level								(n + 7), etc.

FIGURE 11-27/X.45

Protection information element

TABLE 11-32/X.45

Protection information element

Protection format (octet 3)	
Bits	
8 7	
0 0	Reserved
0 1	Source address specific
1 0	Destination address specific
1 1	Globally unique
Level protection (octet 5 to n + 5)	
The precise field format is for further study.	
Lowest acceptable protection level (octet n + 7 to n + m + 7).	
The precise field format is for further study.	

11.3 Addressing

Table 11-33 describes the possible types of address for calling party number, called party number and redirecting number information elements in *call request* message.

TABLE 11-33/X.45

Type of address in call request message

Information element	Calling DTE interface	Called DTE interface
Calling party number	All defined values except alternative address	All defined values except alternative address and complementary address without main address
Called party number	All defined values except complementary address without main address	All defined values except alternative address
Redirecting number	All defined values except alternative address	All defined values except alternative address and complementary address without main address

Table 11-34 describes the possible types of address for called party number information element in *call confirmation* message.

TABLE 11-34/X.45

Type of address in call confirmation message

Information element	Calling DTE interface	Called DTE interface
Called party number	All defined values except alternative address and complementary address without main address	All defined values except alternative address

Table 11-35 describes the possible types of address for called party number and call deflection selection information elements in *disconnect request* message.

TABLE 11-35/X.45

Type of address in disconnect request message

Information element	Calling DTE interface	Called DTE interface
Called party number	All defined values except alternative address and complementary address without main address	All defined values except alternative address
Call deflection selection	Not applicable	All defined values except complementary address without main address

For called party number, calling party number, call deflection selection and redirecting number information elements, the possible combinations between type of address and numbering plan fields as well as the format of the address digits are given in Table 11-36.

TABLE 11-36/X.45

TOA/NP combinations / Format of address digits

Type of Address	Numbering Plan	Format	Comments
Unknown => network dependent number	Unknown => network dependent number	–	The address digits are organised according to network numbering plan.
International number	E.164 digital	CC + National Significant Number	Notes 1 and 2
	E.164 analogue	CC + National Significant Number	Notes 1 and 3
	X.121	DNIC + Network Terminal Number	Note 1
	F.69 (Telex Plan)	TDC + National Telex Number	Note 1
National number	E.164 digital	National Significant Number	Notes 1 and 2
	E.164 analogue	National Significant Number	Notes 1 and 3
	X.121	National Number (starting with 4th digit of DNIC) or Network Terminal Number	Note 1
	F.69 (Telex plan)	National Telex Number	Note 1
Network specific number (for use in private network)	Private numbering plan	–	This combination is provided for private use only
Complementary address without main address	Unknown => network dependent number	–	
Alternative address	All code points defined when numbering plan is interpreted as the alternative address coding authority can be used	–	The address is organised according to the alternative address coding authority.

NOTE 1 – Escape and prefix code shall not be present.

NOTE 2 – E.164 digital is used when a digital interface on the destination network (ISDN or integrated ISDN/PSTN) is requested and as the default when it is not required to differentiate the service type or when the service type is unknown.

NOTE 3 – E.164 analogue is used when an analogue interface on the destination network (PSTN or integrated ISDN/PSTN) is requested.

11.4 Handling of coding errors

11.4.1 Protocol discrimination error

When a message is received with a protocol discriminator coded other than "(number to be provided)", that message shall be ignored as if the message had never been received.

11.4.2 Message too short

When a message is received that is too short to contain a complete message type information element, that message shall be ignored as if the message had never been received.

11.4.3 General information element errors

11.4.3.1 Information element out of sequence

A variable length information element which has a code value lower than the code value of the variable length information element preceding it shall be considered as an out of sequence information element.

If an entity receives a message containing an out of sequence information element, it may ignore this information element and continue to process the message. If this information element is mandatory and the entity chooses to ignore this out of sequence information element, then the error handling procedure for missing mandatory information elements as specified in 11.4.4.1 shall be followed. If the ignored information element is non-mandatory, the receiving entity continues to process the message.

11.4.3.2 Duplicated information elements

If an information element is repeated in a message in which repetition of the information element is not permitted, only the contents of information element appearing first, shall be handled and all subsequent repetitions of the information element shall be ignored. When repetition of information elements is permitted, only the contents of permitted information elements shall be handled. If the limit on repetition of information elements is exceeded, the contents of information elements appearing first up to the limit of repetitions shall be handled and all subsequent repetitions of the information element shall be ignored.

11.4.4 Mandatory information element errors

11.4.4.1 Mandatory information element missing

When a message is received with My VC identifier and/or Your VC-identifier information element missing, so that the receiving entity is not able to relate that message to a particular virtual circuit, then that message shall be ignored as if it had never been received.

When a *call request* message is received which has one or more mandatory information element missing, a *disconnect request* message with cause "mandatory information element is missing" shall be returned.

When a *disconnect request* or *call abort* message is received with the cause information element missing, the actions taken shall be the same as if a *disconnect request* or *call abort* message with cause "normal/no additional information" was received.

In all other cases, the received message shall be ignored as it had never been received.

11.4.4.2 Mandatory information element content error

When a *call request* message is received which has one or more mandatory information elements with invalid content, a *disconnect request* message with cause "invalid information element contents" shall be returned.

When a *disconnect request* or *call abort* message is received with invalid content of the cause information element, the actions taken shall be the same as if a *disconnect request* or *call abort* message with cause "normal/no additional information" was received.

Information elements with a length exceeding the maximum length shall be treated as if the length was equal to the maximum length (i.e. octets up to the maximum length are processed, following octet up to the actual length shall be ignored). This mechanism allows upward compatibility with future upgrades that will supersede the present maximum length.

11.4.5 Non-mandatory information element errors

11.4.5.1 Unrecognised information element

Any unrecognised information element shall be ignored as if it had never been included in the received message. Following information elements, if any, shall be normally processed.

This procedure allows for upgrades and ensures upward compatibility.

11.4.5.2 Non-mandatory information element content error

When a message is received which has one or more non-mandatory information elements with invalid content, action shall be taken on the message and those information elements which are recognised and have valid content.

Information elements with a length exceeding the maximum length shall be treated as if the length was equal to the maximum length (i.e. octets up to the maximum length are processed, following octet up to the actual length shall be ignored). This mechanism allows upward compatibility with future upgrades that will supersede the present maximum length.

11.4.5.3 Unexpected recognised information element

When a message is received with a recognised information element that is not defined to be contained in that message, the receiving entity shall ignore that information element as if it had never been included in the received message. Following information elements, if any, shall be normally processed.

12 Procedures for permanent virtual circuit service

For permanent virtual circuits there is no call set-up or clearing. The pairs of virtual circuit identifiers are assigned in agreement with the Network at the time of subscription to the service.

The procedures for the control of packets between DTE and DCE while in the data transfer state are contained in clause 10.

If a momentary failure occurs within the network, the DCE will reset the permanent virtual circuit as described in 10.15 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".

13 Signalling procedures for switched virtual circuits

13.1 Set-up and clearing procedures

The set-up and clearing procedures use signalling messages which are exchanged between the DTE and the DCE through the signalling virtual circuit (see 10.9.2).

The encapsulation of the signalling messages in *data* packet(s) makes possible to carry out a flow control on the amount of signalling data (in particular *call request* message) that an entity receives by re-using the underlying flow control mechanisms of the signalling virtual circuit.

13.1.1 Request of a virtual circuit set-up

The procedure for setting up a virtual circuit is used to create a new connection in the packet mode between the DTE and a remote DTE.

To request a virtual circuit set-up, the calling entity sends a *call request* message to the called entity. At the DTE/DCE interface of the calling DTE, the calling entity is on the DTE side, whereas at the DTE/DCE interface of the called DTE, the calling entity is on the DCE side.

The *call request* message contains the following information:

- Included in My VC-identifier information element, the virtual circuit identifier which will be used by the called entity to send packets to the calling entity. This virtual circuit identifier has local significance and may take any value which is not used.
- The initial value of the VC credit allocated by the calling entity.
- Other information pertaining to addressing, facilities and user data (see 11.1.2).

If the calling entity indicates a zero value of its initial VC-credit allocation, then after receiving a *call confirmation* message from the called entity it has to send a *VC-flow control* packet with non-zero credit allocation. Then the called entity may transmit data across the interface.

On the other hand, by indicating a non-zero value in its initial VC-credit allocation, the calling entity may authorise the called entity to transmit data across the interface as soon as it knows the call has been accepted. Thus, the time before first data cross the interface, may be reduced by one round trip across the DTE/DCE link. In this case the calling entity must be prepared to receive data before it has received the *call confirmation* message. This may occur in particular if the *call confirmation* message, although initially sent before data, has been hit by a transmission error and has to be retransmitted. In called entities, it is not necessary to guarantee that the *call confirmation* message always crosses the interface before the first data packets of the newly established virtual circuit.

13.1.2 Acceptance of virtual circuit set-up

The called entity indicates that the incoming call has been accepted by sending the calling entity a *call confirmation* message.

The *call confirmation* message contains the following information:

- Included in Your VC-identifier information element, the virtual circuit identifier received in the corresponding *call request* message sent by the calling entity.
- Included in My VC-identifier information element, the virtual circuit identifier which will be used by the calling entity to send packets to the called entity. This virtual circuit identifier has local significance and may take any value which is not used.
- The initial value of the VC credit allocated by the called entity.
- Other information pertaining to addressing, facilities, and user data (see 11.1.3).

After having sent the *call confirmation* message, the called DTE must be ready to receive data on the virtual circuit according to the number of VC credit it has allocated.

13.1.3 Rejection of virtual circuit set-up

The procedure for rejecting a virtual circuit set-up is used by the called entity to refuse a connection in response to a *call request* message.

The called entity which wishes to reject virtual circuit set-up sends to the peer entity a *disconnect request* message and a *signalling synchronisation* packet.

The *disconnect request* message contains the following information:

- included in Your VC-identifier information element, the virtual circuit identifier received in the corresponding *call request* message;
- other information pertaining to cause, diagnostic, addressing, facilities and user data (see 11.1.5).

The *signalling synchronisation* packet is sent by the rejecting entity with the virtual circuit identifier received in the *call request* message. The NNi(S) field of this *signalling synchronisation* packet is set to 0.

The calling entity, after it has received both the *disconnect request* message and the corresponding *signalling synchronisation* packet (not necessarily in this order), may re-use the virtual circuit identifier which they contain.

13.1.4 Abort of virtual circuit set-up

To abort a virtual circuit set-up in progress, the calling entity sends a *call abort* message to the peer entity.

The *call abort* message contains the following information:

- included in My VC-identifier information element, the virtual circuit identifier as previously sent in the corresponding *call request* message;
- cause and diagnostic fields to explain the abort.

If the entity which sent the *call abort* message receives a *call confirmation* message (a collision between call acceptance and call abortion having occurred), it ignores it and waits for the continuation of the abort procedure.

The entity which receives the *call abort* message must confirm the call abort by sending a *disconnect confirmation* message and a *signalling synchronisation* packet.

The *disconnect confirmation* message contains the following information:

- Included in Your VC-identifier information element, the virtual circuit identifier received in the corresponding *call request* message.

The *signalling synchronisation* packet is sent by the entity which receives the *call abort* message with the virtual circuit identifier received in the *call request* message. The NNi(S) field of this *signalling synchronisation* packet is set to 0.

The calling entity, after it has received both the *disconnect confirmation* message and the corresponding *signalling synchronisation* packet (not necessarily in this order), may re-use the virtual circuit identifier which they contain.

13.1.5 Normal clearing of a virtual circuit

At any time, after virtual circuit set-up, i.e. after complete reception of a *call confirmation* message if the considered entity was the calling one or after sending the *call confirmation* message if the entity is the called one, an entity may indicate virtual circuit clearing by sending a *disconnect request* message and a *signalling synchronisation* packet to the peer entity.

The *disconnect request* message contains the following information:

- included in Your VC-identifier information element, the virtual circuit identifier of the virtual circuit being cleared (virtual circuit identifier received either in a *call request* message or in a *call confirmation* message);
- other information pertaining to cause, diagnostic, addressing, facilities and user data (see 11.1.5).

The *signalling synchronisation* packet is sent by the clearing entity with the virtual circuit identifier of the virtual circuit being cleared.

The *signalling synchronisation* packet is the very last packet sent over the virtual circuit and must be re-transmitted if lost.

The entity which receives the *disconnect request* message, must stop sending any packet over the concerned virtual circuit and confirm clearing by sending a *disconnect confirmation* message and a *signalling synchronisation* packet.

The *disconnect confirmation* message contains the following information:

- Included in Your VC-identifier information element, the virtual circuit identifier of the virtual circuit being cleared (virtual circuit identifier received either in a *call request* message or in a *call confirmation* message).

The *signalling synchronisation* packet is sent by the cleared entity with the virtual circuit identifier of the virtual circuit being cleared. The *signalling synchronisation* packet is the very last packet sent over the virtual circuit and must be re-transmitted if lost. The cleared entity, after reception of both the *disconnect request* message and the corresponding *signalling synchronisation* packet (not necessarily in this order) may re-use the virtual circuit identifier they contain.

The clearing entity, after reception of both the *disconnect confirmation* message and the corresponding *signalling synchronisation* packet (not necessarily in this order), may re-use the virtual circuit identifier they contain.

13.1.6 Clear collision on a virtual circuit

A clear collision occurs when both entities transmit *disconnect request* messages and *signalling synchronisation* packets, or when an entity sends a *call abort* message and the peer entity a *disconnect request* message and a *signalling synchronisation* packet (call abort on a virtual circuit which was going to be cleared).

In both cases each entity does as though the message it has received in place of the expected *disconnect confirmation* massage was a *disconnect confirmation* message.

13.2 Procedure for restart

The restart procedure is used to initialise or re-initialise the signalling path of the DTE/DCE interface. The restart procedure simultaneously clears all the switched virtual circuits at the DTE/DCE interface and overrides any pending signalling procedures such as set-up and clearing .

The restart procedure uses *restart request* and *restart confirmation* messages exchanged between DTE and DCE.

13.2.1 Normal restart

An entity which wishes to re-initialise the signalling path of the DTE/DCE interface transmits a *restart request* message to the peer entity.

The *restart request* message contains a cause information element to explain the restart.

An entity which receives a *restart request* message considers that all established and pending switched virtual circuits are cleared and must confirm the restart by sending a *restart confirmation* message to the restarting entity.

The restarting entity must wait for the reception of a *restart confirmation* message to consider that the signalling path of the DTE/DCE interface is definitely restarted.

When the signalling path is restarted, messages may be sent again across the DTE/DCE interface.

13.2.2 Restart collision

A restart collision occurs when both entities transmit a *restart request* message at the same time. Each entity considers that the restart procedure is completed. Neither waits nor sends a *restart confirmation* message.

13.3 Effects of clearing and restart procedures on 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 clearing 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.

14 Procedures for user facilities

14.1 Incoming calls barred

Incoming calls barred is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

This user facility, if subscribed to, prevents incoming virtual circuits from being presented to the DTE. The DTE may originate outgoing virtual circuits.

14.2 Outgoing calls barred

Outgoing calls barred is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

This user facility, if subscribed to, prevents the DCE from accepting outgoing virtual circuits from the DTE. The DTE may receive incoming virtual circuits.

14.3 Packet size negotiation facility

Packet size negotiation facility permits negotiation on a per call basis of the maximum data field length of *data* packets for each direction of data transmission.

The calling entity may request packet sizes for both directions of data transmission by including in the *call request* message the packet size information element (see 11.2.4.9). If particular packet sizes are not explicitly requested, the called entity will assume that the default packet sizes of that interface were requested for the concerned directions of data transmission.

Default packet sizes are specified in 10.13.

When the *call request* message includes a packet size information element, the called entity may select, for both directions of data transmission, packet sizes smaller or equal to those indicated in the packet size information element in the *call request* message, by including in the *call confirmation* message the packet size information element. In such a case the selected packet sizes are used on the virtual circuit. If the called entity does not include the packet size information element in the *call confirmation* message, it means that default packet sizes will be used for both directions of data transmission.

When the *call request* message does not include a packet size information element, it means that default packet sizes will be used for both directions of data transmission. In this case the called entity must not include the packet size information element in the *call confirmation* message.

14.4 Assured / non-assured data transfer negotiation facility

The assured/non-assured data transfer negotiation facility allows for a given virtual circuit, *data* packets to be transferred either in the assured mode (i.e. upon loss due to error transmission, *data* packets are retransmitted) or in the non-assured mode (i.e. upon loss due to error transmission, *data* packets are not retransmitted, see 10.13.4 in case lost *data* packet belongs to a complete sequence).

The non-assured data transfer mode may be chosen when a stable transit delay is preferred to a virtual circuit exempt from losses.

Regarding transfer of *data* packets, the default mode for a virtual circuit is assured data transfer.

14.4.1 Procedures for PVC

If required, the non-assured data transfer facility is configured at subscription time.

14.4.2 Procedures for SVC

During the virtual circuit set-up phase, the calling DTE may request non-assured data transfer facility by setting to 1 the non-assured data transfer bit of the packet layer binary parameters information element in the *call request* message.

If the network supports virtual circuits in the non-assured data transfer mode, this request is transparently transmitted to the called DTE. If not, the network forces to 0 the non-assured data transfer bit of the packet layer binary parameters information element in the *call request* message it delivers to the called DTE.

The called DTE which receives a request for non-assured data transfer in a *call request* message may accept the request (alternatively reject the request) by setting to 1 (alternatively forcing to 0) the non-assured data transfer bit of the packet layer binary parameters information element in the *call confirmation* message.

The called DTE which receives a *call request* message without request for non-assured data transfer, must set to 0 the non-assured data transfer bit if the packet layer binary parameters information element is included in the *call confirmation* message.

When the calling DTE receives a *call confirmation* packet with the non-assured data transfer bit set to 1 (alternatively set to 0), the virtual circuit is in the non-assured data transfer mode (alternatively assured data transfer mode). The calling DTE will receive the non-assured data transfer bit set to 1 only if the calling DTE has requested non-assured data transfer, the network supports it and the called DTE has accepted the request.

14.5 Throughput negotiation facilities

Throughput negotiation facility permits negotiation on a per call basis of the throughput of virtual circuit for each direction of data transmission.

The calling entity may request throughput for both directions of data transmission by including in the *call request* message the throughput information element (see 11.2.4.10). If particular throughputs are not explicitly requested, the called entity will assume that the default throughputs of that interface were requested for the concerned directions of data transmission.

For each direction of data transmission on the interface, default throughput is equal to the maximum throughput of the link in this direction.

When the *call request* message includes the throughput information element, the called entity may request, for both directions of data transmission, throughputs smaller or equal to those indicated explicitly (in the throughput information element) or implicitly (use of default values) in the *call request* message, by including in the *call confirmation* message the throughput information element. If the called entity does not include the throughput information element, the calling entity will assume that the called entity has accepted the throughputs for both directions of data transmission as proposed explicitly or implicitly in the *call request* message.

The DCE always indicates explicitly throughputs for both directions of data transmission by including in the *call request* message and in the *call confirmation* message the throughput information element. The throughputs indicated by the DCE to the called DTE are less than or equal to the one requested either explicitly or implicitly at the calling DTE/DCE interface. The throughputs indicated by the DCE to the calling DTE are equal to the one accepted explicitly or implicitly by the called DTE.

14.6 Closed user group related facilities

General

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. A DTE belonging only to one or several CUGs (i.e. not having the outgoing or incoming access described below) can only communicate with DTEs belonging also to one of these CUGs: the network will clear any call not fitting with this condition. On an administrative point of view, a DTE may subscribe to a given CUG only with the authorisation of the subscriber who is responsible for the CUG.

The access for a CUG may be restricted to incoming or outgoing calls. These options are called outgoing call barred into the CUG and incoming call barred into the CUG, respectively.

In addition to the CUGs, is defined the open part which is composed of all the DTEs which have not subscribed to any closed user group related facilities.

A DTE having subscribed to outgoing access, may call the open part and DTEs having subscribed to incoming access.

A DTE having subscribed to incoming access may be called by the open part and by DTEs having subscribed to the outgoing access.

Subscription-time facilities

The DTE may subscribe either to simple CUG facility or to CUG selection facility.

The simple CUG facility enables the DTE to belong to one CUG in a way that is completely transparent, i.e. without any specific signalling procedures.

The CUG selection facility enables the DTE to belong to one or several CUGs and for each virtual circuit to select or to receive the information to which CUG the particular virtual circuit belongs to.

For each CUG it belongs to, the DTE can subscribe to outgoing call barred into the CUG or to incoming call barred into the CUG options.

In addition, the DTE may subscribe to outgoing access and or incoming access.

Per call facilities

The CUG facilities defined on a per call basis are:

- No CUG: It is equivalent to a call with called DTE in the open part or having subscribed to incoming access.
- CUG specified.
- CUG specified with outgoing access.

14.6.1 Simple CUG

Simple CUG is an optional user facility agreed for a period of time and applies to the entire DTE/DCE interface for virtual circuits. This facility, if subscribed to enable the DTE to belong to a CUG in a way that is completely transparent. This facility is mutually exclusive of CUG selection facility.

At subscription time the user indicates its CUG profile:

- the CUG it wants to belong to (only one);
- if outgoing calls are barred into this CUG or not;
- if incoming calls are barred into this CUG or not;
- the outgoing access or not;
- the incoming access or not.

In all these combinations, no closed user group information element is needed nor permitted in the *call request* messages received and transmitted by the DTE.

14.6.1.1 Call request message from the DTE to the DCE

The *call request* message transmitted by the DTE does not contain any closed user group information element. If any closed user group information element is present in a *call request* message received from a DTE having subscribed to the simple CUG facility, the DCE must clear the virtual circuit.

To determine whether or not the call can proceed, and if it can, the type of the call regarding CUG possibilities, the DCE processes the CUG profile of the calling DTE as described in Table 14-1.

TABLE 14-1/X.45

DCE check on outgoing calls for simple CUG

CUG profile of the calling DTE	Type of the call regarding CUG possibilities
Simple CUG with outgoing calls barred	Call cleared
Simple CUG with outgoing calls not barred	CUG specified
Simple CUG with outgoing calls barred plus outgoing access	Call with no CUG
Simple CUG with outgoing calls not barred plus outgoing access	CUG specified + OA

14.6.1.2 Call request message from the DCE to the DTE

To determine whether the call can be presented to the called DTE or must be cleared, the DCE processes the type of the call regarding CUG possibilities and the CUG profile of the called DTE as described in Table 14-2.

The *call request* message transmitted by the DCE must not contain any closed user group information element.

TABLE 14-2/X.45

DCE check on incoming calls for simple CUG

CUG profile of the called DTE	Type of the call regarding CUG possibilities				
	No CUG	CUG specified		CUG specified with outgoing access	
		Matching	Wrong	Matching	Wrong
Simple CUG with incoming calls barred	Access barred	Access barred	Access barred	Access barred	Access barred
Simple CUG with incoming calls not barred	Access barred	Presented	Access barred	Presented	Access barred
Simple CUG with incoming calls barred plus incoming access	Presented	Access barred	Access barred	Access barred	Presented
Simple CUG with incoming calls not barred plus incoming access	Presented	Presented	Access barred	Presented	Presented

14.6.2 CUG selection

CUG selection is an optional user facility agreed for a period of time and applies for the entire DTE/DCE interface for virtual circuits. This facility, if subscribed to, enables the DTE to belong to one or several CUGs and for each virtual circuit to select or to receive the information to which CUG the particular virtual circuit belongs to. This facility is mutually exclusive of simple CUG facility.

At subscription, the user indicates its CUG profile:

- the CUGs it wants to belong to;
- for each CUG, if outgoing calls are barred or not;
- for each CUG, if incoming calls are barred or not;
- the outgoing access or not;
- the incoming access or not.

14.6.2.1 Call request message from the DTE to the DCE

The *call request* message transmitted by the DTE may contain or not the closed user group information element. To determine whether or not the call can proceed, and if it can, the type of the call regarding CUG possibilities, the DCE processes the content of the closed user group information element (if present) and the CUG profile of the calling DTE as described in Table 14-3.

TABLE 14-3/X.45

DCE check on outgoing calls for CUG selection

CUG profile of the calling DTE	Type of the call regarding CUG possibilities as encoded in the closed user group information element of the *call request* message				
	No CUG	CUG specified		CUG specified with outgoing access	
	(Note)	Matching	Wrong	Matching	Wrong
CUG selection with outgoing calls barred into CUG x	Call cleared	Call cleared	Call cleared	Call cleared	Call cleared
CUG selection with outgoing calls not barred into CUG x	Call cleared	Call with CUG specified	Call cleared	Call cleared	Call cleared
CUG selection with outgoing calls barred into CUG x plus outgoing access	Call with no CUG	Call cleared	Call cleared	Call cleared	Call with no CUG
CUG selection with outgoing calls not barred into CUG x plus outgoing access	Call with no CUG	Call with CUG specified	Call cleared	Call with CUG specified + OA	Call with no CUG
NOTE – The presence of the closed user group information element with an empty index field is interpreted identically as the absence of this information element.					

14.6.2.2 Call request message from the DCE to the DTE

To determine whether the call can be presented to the called DTE or must be cleared, the DCE processes the type of the call regarding CUG possibilities and the CUG profile of the called DTE as described in Table 14-4. When the call can be presented, Table 14-4 provides also the CUG signalling to the DTE.

14.6.3 No CUG

In case DTEs have subscribed neither to simple CUG nor to CUG selection facilities, this subclause describes DCE check and signalling on outgoing and incoming calls.

TABLE 14-4/X.45

DCE check and signalling on incoming calls for CUG selection

CUG profile of the called DTE	Type of the call regarding CUG possibilities				
	No CUG	CUG specified		CUG specified with outgoing access	
		Matching	Wrong	Matching	Wrong
CUG selection with incoming calls barred into CUG x	Access barred	Access barred	Access barred	Access barred	Access barred
CUG selection with incoming calls not barred into CUG x	Access barred	Call with CUG specified	Access barred	Call with CUG specified	Access barred
CUG selection with incoming calls barred into CUG x plus incoming access	Call with no CUG	Access barred	Access barred	Access barred	Call with no CUG
CUG selection with incoming calls not barred into CUG x plus incoming access	Call with no CUG	Call with CUG specified	Access barred	Call with CUG specified + OA	Call with no CUG

14.6.3.1 Call request message from the DTE to the DCE

The *call request* message transmitted by the DTE should not contain any closed user group information element. If any closed user group information element is present in a *call request* message received from a DTE having subscribed neither to simple CUG nor CUG selection facilities, the DCE must clear the virtual circuit.

The per call facility used by such a DTE is call with no CUG.

14.6.3.2 Call request message from the DCE to the DTE

To determine whether the call can be presented to the called DTE or must be cleared, the DCE processes the type of the call regarding CUG possibilities and the fact that the called DTE has not subscribed to any CUG facilities, as described in Table 14-5.

The *call request* message transmitted by the DCE must not contain any closed user group information element.

TABLE 14-5/X.45

DCE check on incoming calls for no CUG

CUG profile of the called DTE	Type of the call regarding CUG possibilities		
	No CUG	CUG specified	CUG specified with outgoing access
No CUG	Call with no CUG	Access barred	Call with no CUG

14.7 Fast select

Fast select is a user facility used to request on a per call basis the no use or use with or no restriction on response of fast select.

The calling entity may request either no fast select, fast select with no restriction on response, or fast select with restriction on response by including in the *call request* message the packet layer binary parameters information element (see 11.2.4.13). If packet layer binary parameters information element is not included in the *call request* message, the called entity will assume that the default mode was requested.

The default mode is fast select not requested.

If the called entity is not able to support the requested mode, the call shall be cleared. When the DCE supports the mode requested by the calling DTE, the DCE will request the same mode to the called DTE.

If no fast select is requested in the *call request* message, it allows this message to contain a user-user information element of up to 16 octets in the user information field (see 11.2.4.8). C*all confirmation* or *disconnect request* messages transmitted in response by the called entity must contain no user-user information element.

If fast select with no restriction on response is requested in the *call request* message (explicitly or implicitly), it allows this message to contain a user-user information element of up to 128 octets in the user information field (see 11.2.4.8), authorises the called entity to transmit in response to the *call request* message a *call confirmation* message or a *disconnect request* message with a user-user information element respectively of up to 128 octets in the user information field and authorises both entities to transmit after the virtual circuit is set up, a *disconnect request* message with a user-user information element respectively of up to 128 octets in the user information field.

If fast select with restriction on response is requested in the *call request* message, it allows this message to contain a user-user information element of up to 128 octets in the user information field, authorises the called entity to transmit in response to the *call request* message a *disconnect request* message with a user-user information element of up to 128 octets in the user information field. The called entity would not be authorised to transmit a *call confirmation* message.

14.8 Reverse charging

Reverse charging is an optional user facility which may be requested by a called DTE for a given virtual circuit by including in the *call request* message reverse charging / charging information element with the reverse charging indication field set to reverse charging requested (see 11.2.4.12).

14.9 Reverse charging acceptance

Reverse charging acceptance is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

This user facility, if subscribed to, authorises the DCE to present 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 *call request* messages which request the reverse charging facility.

14.10 Local charging prevention

Local charging prevention is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

This user facility, when subscribed to, authorises the DCE to prevent the establishment of virtual calls which the subscriber must pay for by:

a) not transmitting to the DTE *call request* messages 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 a number of actions, both procedural and administrative. The procedural methods include:

   – the use of reverse charging;

   – identification of a third party using NUI subscription facility (see 14.11.1) and NUI selection facility (see 14.11.3).

When the party to be charged has not been established for a virtual circuit set-up, the DCE that receives the *call request* message will apply reverse charging to this call.

14.11 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 two optional user facilities, NUI subscription facility (see 14.11.1) and NUI override facility (see 14.11.2) may be agreed for a period of time for virtual circuits. 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 information element.

Network user identifier is never transmitted to the remote DTE. The calling DTE address transmitted to the remote DTE in the calling party number information element should not be inferred from the network user identifier transmitted by the DTE in the NUI selection information element in the *call request* message.

14.11.1 NUI subscription

NUI subscription is an optional user facility agreed for a period of time for virtual circuits. 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* message or in the *call confirmation* message by using the NUI selection facility (see 14.11.3). It may be used whether or not the DTE has also subscribed to the local charging prevention facility (see 14.10). If the DCE determines that the network user identifier is invalid or that the NUI selection information element is not present when required by the network, it will clear the call.

14.11.2 NUI override

NUI override is an optional user facility agreed for a period of time for virtual circuits. 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* message by means of the NUI selection facility (see 14.11.3), 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 virtual circuits or subsequent virtual circuits 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 identifier when the NUI override facility has been subscribed to are specified in Annex H/X.25. The optional user facilities which have been agreed for a period of time for the interface and which are not overridden by using the NUI override facility remain in effect.

14.11.3 NUI selection

NUI selection is an optional user facility which may be requested by a DTE for a given virtual circuit by using the NUI selection information element (see 11.2.4.14). This user facility may be requested by a DTE only if it has subscribed to the NUI subscription facility (see 14.11.1) and/or the NUI override facility (see 14.11.2). 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* message 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 confirmation* message, if the selected network user identifier has been agreed in conjunction with the NUI subscription facility.

If the network determines that the network user identifier is invalid or that any of the user facilities requested in the *call request* message are not allowed for the DTE, it will clear the virtual circuit.

14.11.4 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 circuit.

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 the reverse charging/charging information information element (see 11.2.4.12) in *call request* message or *call confirmation* message

If the DTE subscribes to the charging information 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* message or in *call confirmation* message.

By including the reverse charging/charging information information element in the *disconnect request* or *disconnect confirmation* message, the DCE will send to the DTE information about the charge for that virtual circuit and/or other information which makes it possible for the user to calculate the charge.

14.12 Transit network selection related facilities

The set of Transit network selection optional user facilities provides for the calling DTEs designation of a sequence of one or more transit network(s) within the originating country through which the virtual circuit is to be routed when more than one transit network exist at a sequence of one or more gateways. In the case of international calls, this capability includes the selection of an international transit network in the originating country.

14.12.1 Transit network subscription

Transit network subscription is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

This user facility, if subscribed to, applies (unless overridden for a single virtual circuit by the transit network selection facility) to all virtual circuits where more than one transit network exist at a sequence of one or more gateways. The transit network subscription facility provides a sequence of transit networks through which virtual circuits are to be routed. In the absence of both the transit network subscription facility and the transit network selection facility (see 14.12.2) no user designation of transit networks is in effect.

14.12.2 Transit network selection

Transit network selection is an optional user facility which may be requested by a DTE for a given virtual circuit when including transit network selection information element(s). It is not necessary to subscribe to the transit network subscription facility in order to use this facility. This facility when used for a given virtual circuit, applies for this virtual circuit only where more than one transit network exist at a sequence of one or more gateways. The transit network selection facility provides a sequence of transit networks through which virtual circuits are to be routed. The presence of the corresponding transit network selection information element(s) in a *call request* message completely overrides the sequence of transit networks that may have been specified by the transit network subscription facility (see 14.12.1).

14.13 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 call if there is at least one virtual circuit identifier available for virtual circuits on any of the DTE/DCE interfaces in the group. Once a call is assigned to a DTE/DCE interface, it is treated as a regular call.

When 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 *disconnect request* message (when no *call confirmation* message has been transmitted) or the *call confirmation* message transferred to the calling DTE may contain the called DTE address of the selected DTE/DCE interface and the called line address modified notification information element (see 11.2.4.18) indicating the reason why the called DTE address is different from the originally requested.

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 *call request* message 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 circuit 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.

14.14 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 "alternate DTE"). The call redirection facility (see 14.14.1) allows the DCE, in specific circumstances, to redirect calls destined to the originally called DTE; no *call request* message is transmitted to the originally called DTE when such a redirection is performed. The call deflection selection (see 14.14.2) allows the originally called DTE to deflect individual incoming calls after reception of the *call request* message by this originally called DTE.

When a virtual circuit 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.

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.

When the call is redirected or deflected, the *disconnect request* message, when no call confirmation message has been transmitted by any DTE, or the *call confirmation* message transferred to the calling DTE will contain the called address of the alternate DTE and the called line address modified notification information element (see 11.2.4.18), indicating the reason why the called address is different from the one originally requested.

When the call is redirected or deflected, some networks may indicate to the alternate DTE that the call was redirected or deflected, the reason for the redirection or deflection, and the address of the originally called DTE, using the call redirection or call deflection notification facility (see 14.14.3) in the *call request* message received by the alternate DTE.

In addition, some networks may allow a DTE to indicate in a *call request* message (see 14.14.3) that the call was redirected or deflected, the reason for the redirection or deflection, and the address of the originally called DTE, using the call redirection or call deflection notification facility.

14.14.1 Call redirection

Call redirection is an optional user facility agreed for a period of time. This facility applies to the entire DTE/DCE interface for virtual circuits.

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 1). Some networks may offer in addition:

3) systematic call redirection due to a prior request by the subscriber according to a 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 alternate DTEs (C1, C2, etc.) 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 virtual circuit 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 alternate 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.

14.14.2 Call deflection selection

Call deflection selection facility allows a DTE to deflect an incoming call to another DTE after reception of the corresponding *call request* message by this originally called DTE.

To use this facility the DTE includes the call deflection selection information element (see 11.2.4.16) in the *disconnect request* message only in direct response to a *call request* message to specify the alternate DTE address to which the call is to be deflected.

If the call deflection selection information element is used in the *disconnect request* message, then the DTE may also include some or all of end-to-end transit delay, packet layer binary parameters, throughput, protection, X.213 priority, calling and called party subaddress and user-user information elements to be sent to the alternate DTE. These information elements in the *disconnect request* message are not dependent on the contents of the original *call request* message. The *disconnect request* message may contain a user-user information element of up to 16 octets in the user information field if the original virtual circuit was established without fast select and up to 128 octets if it was established with fast select. If no information elements of the above list are included in the *disconnect request* message, then there will be none in the *call request* message to the alternate DTE.

When requested for a given virtual circuit, the network deflects the call to the alternate DTE and does not respond to the calling DTE as a result of the clearing of the called DTE/DCE interface. The information elements corresponding to facilities that are present in the *call request* message transmitted to the alternate DTE are those that would have been present in the *call request* packet if the call was a direct call from the calling DTE to the alternate DTE; moreover, the call redirection or call deflection notification facility (see 14.14.3) may also be used, if supported by the network.

If the network offers only the basic service and if a call redirection or call deflection has already been performed, the DCE clears the virtual circuit when the call deflection selection facility is used.

14.14.3 Call redirection or call deflection notification

Call redirection or call deflection notification is a user facility used by the DCE to inform the alternate 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 corresponding information element is the redirecting number information element (see 11.2.4.17).

When more than one address applies to a DTE/DCE interface, the call redirection or call deflection notification facility may also be used by the calling DTE to inform the called DTE that the call has been redirected or deflected in the calling DTE (which is supposed to be a packet switched private data network). When this facility is received from the DTE, the DCE will clear the virtual circuit if the contained address is not one of those applying to the interface.

The following reasons can be indicated in the redirecting number information element:

1) call redirection due to originally called DTE out of order:

   - use of code point "Originally called DTE out of order";

2) call redirection due to originally called DTE busy:

- use of code point "Call forwarding busy or called DTE busy";

3) call redirection due to prior request from the originally called DTE for systematic call redirection:

- use of code point "Systematic call redirection";

4) call deflection by the originally called DTE:

- use of code point "Call forwarding by the originally called DTE";

5) call redirection or call deflection in the calling DTE (which is supposed to be a packet switched private data network):

- use of code point "Calling DTE originated".

Some networks may also use the following reason in network-dependent cases not described in this Recommendation:

6) call distribution within a hunt group:

- use of code point "Call distribution within a hunt group".

14.15 Called line address modified notification

Called line address modified notification is an optional user facility used by the DCE in the *call confirmation* message or *disconnect request* message to inform the calling DTE why the called DTE address in the message is different from that specified in the *call request* message transmitted by the calling DTE. The corresponding information element is called line address modified notification (see 11.2.4.18).

When more than one address applies to a DTE/DCE interface, the called line address modified notification information element may be included by the called DTE in the *disconnect request* message (when no *call confirmation* message has been transmitted) or the *call confirmation* message, when the called DTE address is present in the message and different from that specified in the *call request* message. When this information element is received from the DTE, the DCE will clear the virtual circuit 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 without notification by the called line address modified notification facility, may cause the virtual circuit to be cleared.

The following reasons can be indicated with the use of the called line address modified notification information element in *call confirmation* or *disconnect request* messages 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 confirmation* or *disconnect request* messages received from the DTE, the reason indicated in conjunction with the use of the called line address modified notification information element should be "called DTE originated".

When several reasons could apply to the same virtual circuit, the reason to be indicated by the network in the *call confirmation* message 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 confirmation* or the *disconnect request* messages should correspond to the last DTE which has been reached or attempted.

14.16 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 circuit. This facility permits selection and indication, on a per virtual circuit basis, of the transit delay applicable to that virtual circuit.

A DTE wishing to specify a desired transit delay for a virtual circuit indicates the desired value in the transit delay selection and indication information element (see 11.2.4.19) of the *call request* message transmitted to the DCE.

The network when able to do so, should allocate resources and route the virtual circuit in a manner such that the transit delay applicable to that virtual circuit does not exceed the desired transit delay.

The *call request* message transmitted to the called DTE and the *call confirmation* message transmitted to the calling DTE, will both contain in the transit delay selection and indication information element the indication of the transit delay applicable to the virtual circuit. This transit delay may be smaller than, equal to or greater than the desired transit delay requested by the calling DTE in the *call request* message.

14.17 Alternative addressing facilities

The set of alternative addressing related facilities enables a calling DTE to use an alternative address to identify the called DTE in order to establish a virtual circuit. An alternative address is defined as one that does not conform to the format defined in Recommendations X.121 and X.301. In particular the following alternative addresses may be supported:

– a mnemonic address according to Recommendation T.50;

– an OSI-NSAP address according to ITU-T Rec. X.213 | ISO/IEC 8348;

– a LAN-MAC address according to ISO/IEC 8802;

– an Internet address according to RFC 1166.

When receiving a *call request* message containing an alternative address, the DCE shall translate the alternative address to the format defined in Recommendations X.121 and X.301 as the basis on which to route the virtual circuit. The translation of the address will depend on the rules determined at subscription time. A single alternative address could map to several X.121 addresses dependent on parameters such as time of day, etc. A single X.121 address could be reached by multiple alternative addresses.

NOTE – The use of directories to resolve the translation of the alternative address is a matter for further study.

When establishing a virtual circuit, an alternative address can only be present in the *call request* message transmitted by the DTE. The use of addresses in all other messages is unchanged by using an alternative address in the *call request* message. When an alternative address is used in a *call request* message transmitted by the DTE, the called DTE address of the call request and call confirmation messages, respectively received and transmitted by the called DTE, will conform to the format specified in Recommendations X.121 and X.301. However, it is a network option that the called DTE address of the *call confirmation* message received by the calling DTE can either conform to the format specified in Recommendations X.121 and X.301 or be absent.

14.17.1 Alternative address registration related facilities

The set of alternative address registration related facilities, when subscribed to, enables users to register alternative addresses. There are two facilities for registering an alternative address. Depending on which facility is subscribed to, the alternative address either will have global significance or will be interface specific.

14.17.1.1 Global alternative address registration

Global alternative address registration is an optional user facility agreed for a period of time. Any DTE (both inside and outside a specific network) can register alternative address translations with an Administration. All such alternative addresses would require uniqueness with the network of registration and thus have network wide (global) significance.

NOTE – It is envisaged that global translations will be registered for the benefit of any calling DTEs. In this case, the translation of the alternative address would be independent of the calling DTE. Organisations wishing the calling DTEs of a specific network to use the alternative address of a DTE rather than its X.121 number, will need to register such alternative addresses with the specific Administration.

14.17.1.2 Interface specific alternative address registration

Interface specific alternative address registration is an optional user facility agreed for a period of time. When subscribed to, alternative address translations that are specific to a DTE/DCE interface for use by a DTE when making a call, may be registered. In such cases, the rules for translation of the interface specific alternative addresses are given at registration time. The alternative address usage subscription facility (see 14.17.2) must also be subscribed to. When an interface specific alternative address is the same as a global alternative address, the interface specific alternative address takes precedence and the translation will be according to the rules defined for the specific DTE/DCE interface.

14.17.2 Alternative address usage subscription

Alternative address usage subscription is an optional user facility which, when subscribed to by a DTE, allows the DTE to use an alternative address in the *call request* message. The decision to use an alternative address is made on a per call basis.

Networks may support all or a sub-set of the formats listed in 14.17. The formats supported will be made known to subscribing DTEs. Which set is supported will determine how the alternative address may be carried in the call request message (see 14.17.3.1 and 14.17.3.2).

Two network options are allowed for use by DTEs. The first option permits a DTE to use the called party number information element to carry any of the alternative address formats (see 14.17.3.1). The second option allows the DTE to use the called party subaddress information element to carry an OSI-NSAP address (i.e. an address conforming to ITU-T Rec. X.213 | ISO/IEC 8348) as an alternative address (see 14.17.3.2). Either or both of these options can be supported by Administrations.

14.17.3 Alternative address selection

When the alternative address usage subscription facility (see 14.17.2) has been subscribed to, the DTE may identify a called DTE by using an alternative address in the *call request* message. In such cases the network would perform an analysis of the alternative address and derive an address conforming to the formats described in Recommendations X.121 and X.301 as the basis on which to route the virtual circuit.

14.17.3.1 Use of the called party number to carry an alternative address

If the first option of the alternative address usage subscription facility (see 14.17.2) applies to the DTE/DCE interface, then the alternative address is carried in the called party number information element (see 11.2.4.2) of the *call request* message.

Within this information element, the type of number bits are coded as “alternative address” and the numbering plan bits encode the alternative address coding authority (see Table 11-11).

14.17.3.2 Use of the called party subaddress to carry an alternative address

If the second option of the alternative address usage subscription facility (see 14.17.2) applies to the DTE/DCE interface, then the alternative address is carried in the called party subaddress information element (see 11.2.4.21) of the *call request* message.

The fact that the called party subaddress information element is being used to carry an alternative address is indicated by the absence of number digits in the called party number information element of the *call request* message transmitted by the calling DTE (i.e. the called party number information element length is three octets).

NOTE 1 – The preferred method for using the called party subaddress is described above. However, some networks may allow the use of the called party subaddress to carry an alternative address without having no number digits in the called party number information element of the *call request* message transmitted by the calling DTE. In this case, the translation will apply for every *call request* message.

The OSI-NSAP address carried in the called party subaddress information element would be passed unchanged between the two packet mode terminals involved.

NOTE 2 – In those cases where the network does not support the analysis and translation of the OSI-NSAP address carried in the called party subaddress information element, the semantics of an NSAP address can be used as an alternative address and carried in the called party number information element of the *call request* message transmitted by the calling DTE in accordance with the coding specified in Table 11-11 (see also 14.17.3.1). However, in such cases when this format is used and the called OSI-NSAP address is also required by the called DTE, then the called OSI-NSAP address must also be included in the called party subaddress information element by the calling DTE.

Annex A

Additional information for interworking between X.25 and X.45 protocols

This annex provides additional specifications to ensure exhaustively the interworking between X.25 and X.45 protocols.

A.1 Throughput mapping

In X.45 to X.25 direction, an X.45 throughput indicated in the throughput information element is mapped to the immediately inferior throughput class (i.e. the greater X.25 throughput class that is smaller than or equal to the X.45 throughput).

An X.45 throughput smaller than 75 bit/s, is mapped to the throughput class 75 bit/s.

A.2 Data transfer option

Procedures described in 14.4 are applicable taking into account that on the X.25 DTE/DCE interface, only the assured data transfer can be used.

A.3 Signalling coding mapping

This subclause describes the signalling coding mapping between X.25 and X.45 protocols.

A.3.1 Called DTE address – Called party number

When present, X.25 type of address subfield and X.25 numbering plan identification subfield are mapped to X.45 type of number and X.45 numbering plan identification.

X.25 called DTE address digits (BCD coding) are mapped to called party number digits (T50 characters).

A.3.2 Calling DTE address – Calling party number

When present, X.25 type of address subfield and X.25 numbering plan identification subfield are mapped to X.45 type of number and X.45 numbering plan identification.

X.25 calling DTE address digits (BCD coding) are mapped to calling party number digits (T50 characters).

A.3.3 Call user data, called user data, clear user data – User-user

X.25 call user data, called user data, clear user data are mapped to user information (octet 4, etc.) of X.45 user-user information element.

A.3.4 Cause, diagnostic – Cause

Table A.1 provides cause mapping specification X.25 to X.45 direction.

TABLE A.1/X.45

Cause mapping in X.25 to X.45 direction

X.25 cause	➡	X.45 cause	
		Location field	Cause value
0 XXX XXX (except all X set to 0)	➡	Public network serving the remote DTE	XXX XXXX
1 XXX XXXX	➡	Private network serving the remote DTE	XXX XXXX
0 000 0000	➡	DTE	000 0000

Table A.2 provides cause mapping specification X.45 to X.25 direction.

X.25 diagnostic are included in octet 5* of X.45 cause information element.

TABLE A.2/X.45

Cause mapping in X.45 to X.25 direction

X.45 cause		➡	X.25 cause
Location field	Cause value		
Public network	XXX XXXX	➡	0 XXX XXX (except all X set to 0)
Private network	XXX XXXX	➡	1 XXX XXXX
DTE	000 0000	➡	0 000 0000
DTE	XXX XXXX (except all X set to 0)	➡	1 XXX XXXX

A.3.5 Basic/extended throughput class negotiation – Throughput

X.25 throughput class from the called DTE is mapped to incoming throughput (octets 3c* and 3d*) of X.45 throughput information element.

X.25 throughput class from the calling DTE is mapped to outgoing throughput (octets 3a* and 3b*) of X.45 throughput information element.

Rules describe in A.1 are followed.

A.3.6 Closed user group selection basic/extended format, closed user group selection with outgoing access selection basic/extended format – Closed user group

X.25 closed user group selection basic/extended format corresponds to closed user group information element with CUG indication (octet 3) set to closed user group.

Closed user group selection with outgoing access selection basic/extended format corresponds to closed user group information element with CUG indication (octet 3) set to closed user group with outgoing access.

A.3.7 Reverse charging – Reverse charging / Charging information

X.25 reverse charging is mapped to reverse charging indication (octet 3) of X.45 reverse charging / charging information information element.

A.3.8 Fast select – Packet layer binary parameters

X.25 fast select is mapped to fast select (octets 3) of X.45 packet layer binary parameters information element.

A.3.9 NUI selection – NUI selection

The first octet of X.25 NUI selection facility parameter is mapped to octet 3 of X.45 NUI selection information element.

The remaining octets of X.25 NUI selection facility parameter are mapped to octet 4, etc. of X.45 NUI selection information element.

A.3.10 Charging information requesting service, Charging information receiving information: monetary unit, segment count, call duration – Reverse charging / Charging information

X.25 charging information requesting the service facility parameter is mapped to charging information (octet 3) of X.45 reverse charging / charging information information element.

X.25 monetary unit is mapped to charging (octets 6*, etc.) of X.45 reverse charging / charging information information element.

X.25 segment count is mapped to charging segment counts (octets l + 2, etc.) of X.45 reverse charging / charging information information element.

X.25 call duration is mapped to call duration (octets m + 2, etc.) of X.45 reverse charging / charging information information element.

A.3.11 ROA selection basic/extended format – Transit network selection

For each X.25 ROA transit network an X.45 transit network selection information element is coded. The network identification plan of X.45 transit network selection information element is set to data network identification code (see Recommendation X.121). Network identification (octet 4, etc.) of each X.45 transit network selection information element is set to the data network identification code of the particular ROA transit network.

A.3.12 Call deflection selection – Call deflection selection

The X.25 reason for deflection (bits 6 to 1 of the first octet of the facility parameter field) is mapped to reason for deflection (octet 4) of X.45 call deflection selection information element.

When present, X.25 type of address subfield and X.25 numbering plan identification subfield are mapped to X.45 type of number and X.45 numbering plan identification.

X.25 alternate DTE address digits (BCD coding) are mapped to alternate party number digits (T50 characters).

A.3.13 Call redirection or call deflection notification – Redirecting number

The X.25 reason for call redirection or call deflection notification (first octet of the facility parameter field) is mapped to reason for redirection (octet 3b) and when applicable to reason extension (octet 3c*) of X.45 call deflection selection information element.

When present, X.25 type of address subfield and X.25 numbering plan identification subfield are mapped to X.45 type of number and X.45 numbering plan identification.

X.25 originally called DTE address digits (BCD coding) are mapped to originally called party number digits (T50 characters).

A.3.14 Called line address modified notification – Called line address modified notification

X.25 reason for call redirection or call deflection (first octet if the facility parameter field) is mapped to reason for redirection (octet 3b) and when applicable to reason extension (octet 3c*) of X.45 called line address modified notification information element.

A.3.15 Transit delay selection and indication – Transit delay selection and indication

X.25 transit delay value (first and second octets of the facility parameter field) is mapped to transit delay selection and indication value (octets 3, 3a and 3b) of X.45 transit delay selection and indication information element.

A.3.16 Calling address extension facility – Calling party subaddress

Use of the calling address extension as coded in bits 8 and 7 in the first octet of the X.25 calling address extension facility parameter field is mapped to type of subaddress (octet 3) of X.45 calling party subaddress information element.

The number of semi octets as coded in bits 6 to 1 in the first octet of the X.25 calling address extension facility parameter field is mapped to the length of calling party subaddress contents (octet 2) and when applicable to the odd/even indicator (octet 3) of X.45 calling party subaddress information element.

Calling address extension digits are mapped to subaddress information (octets 4, etc.).

A.3.17 Called address extension facility – Called party subaddress

Use of the called address extension as coded in bits 8 and 7 in the first octet of the X.25 called address extension facility parameter field is mapped to type of subaddress (octet 3) of X.45 called party subaddress information element.

The number of semi octets as coded in bits 6 to 1 in the first octet of the X.25 called address extension facility parameter field is mapped to the length of called party subaddress contents (octet 2) and when applicable to the odd/even indicator (octet 3) of X.45 called party subaddress information element.

Called address extension digits are mapped to subaddress information (octets 4, etc.).

A.3.18 Minimum throughput class basic/extended format – Throughput

X.25 minimum throughput class from the called DTE is mapped to minimum acceptable incoming throughput (octets 4c* and 4d*) of X.45 throughput information element.

X.25 minimum throughput class from the calling DTE is mapped to minimum acceptable outgoing throughput (octets 4a* and 4b*) of X.45 throughput information element.

Rules described in A.1 are followed.

A.3.19 End-to-end transit delay – End-to-end transit delay

Cumulative transit delay (first and second octets) of X.25 end-to-end transit delay facility is mapped to cumulative transit delay value (octets 3, 3a and 3b) of X.45 end-to-end transit delay information element.

When present, requested end-to-end transit delay (third and fourth octets) of X.25 end-to-end transit delay facility is mapped to requested end-to-end transit delay value (octets 4*, 4a* and 4b*) of X.45 end-to-end transit delay information element.

When present, maximum acceptable end-to-end transit delay (5th and 6th octets) of X.25 end-to-end transit delay facility is mapped to maximum end-to-end transit delay value (octets 5*, 5a* and 5b*) of X.45 end-to-end transit delay information element.

A.3.20 Priority – X.213 priority

Priority of data on connection (first octet) of X.25 priority facility is mapped to priority of data on a connection (octet 3) of X.45 X.213 priority information element.

Priority to gain a connection (2nd octet) of X.25 priority facility is mapped to priority to gain a connection (octet 4*) of X.45 X.213 priority information element.

Priority to keep a connection (3rd octet) of X.25 priority facility is mapped to priority to keep a connection (octet 5*) of X.45 X.213 priority information element.

Lowest acceptable priority of data on connection (4th octet) of X.25 priority facility is mapped to lowest acceptable priority of data on a connection (octet 3a*) of X.45 X.213 priority information element.

Lowest acceptable priority to gain a connection (5th octet) of X.25 priority facility is mapped to lowest acceptable priority to gain a connection (octet 4a*) of X.45 X.213 priority information element.

Lowest acceptable priority to keep a connection (sixth octet) of X.25 priority facility is mapped to lowest acceptable priority to keep a connection (octet 5a*) of X.45 X.213 priority information element.

Unspecified value is identified by 255 in X.25 and by 15 in X.45 protocol.

A.3.21 Protection – Protection

Protection format code (bits 8 and 7 of first octet) of X.25 protection facility is mapped to protection format (octet 3) of X.45 protection information element.

Level of protection of X.25 protection facility is mapped to level of protection (octets 5 to n + 5) of X.45 protection information element.

Lowest acceptable level of protection of X.25 protection facility is mapped to lowest acceptable level of protection (octets n + 7 to m + n + 7) of X.45 protection information element.

A.3.22 Expedited data negotiation – Packet layer binary parameters

X.25 expedited data negotiation facility corresponds to expedited data (bit 3 of octet 3) in X.45 packet layer binary parameters information element.

Appendix I

Subscription parameters

This appendix provides a list of parameters that needs to be specified when services described in this Recommendation are supported and subscribed to. When the network does not support a particular service, or when a particular service is not subscribed to, the corresponding parameters need simply to be ignored.

I.1 Subscription parameters per interface

- Access rate(s);
- Incoming calls barred or not;
- Outgoing calls barred or not.
- If subscribed to simple CUG (may not be subscribed in conjunction with CUG selection):
  a) CUG identification (only one);
  b) with/without outgoing calls barred out;
  c) with/without incoming calls barred out;
  d) with/without outgoing access;
  e) with/without incoming access.

- If subscribed to CUG selection (may not be subscribed in conjunction with simple CUG):
  - a) CUG identification(s), and for each CUG:
    - i) with/without outgoing calls barred out;
    - ii) with/without incoming calls barred out;
  - b) with/without outgoing access;
  - c) with/without incoming access;
- Reverse charging acceptance;
- Local charging prevention;
- NUI subscription:
  - Network user identifier(s);
- NUI override:
  - Network user identifier(s);
- Charging information;
- Transit network subscription:
  - Transit network identification(s);
- Hunt group;
- Call redirection:
  - Condition(s) to redirect calls;
- Global alternative address registration;
- Interface specific alternative address registration;
- Alternative address usage subscription.

I.2 Subscription parameters per PVC

- Virtual circuit identifiers: one for each direction of data transmission;
- Maximum packet sizes: one for each direction of data transmission;
- Throughputs: one for each direction of data transmission;
- Assured / non-assured data transfer.

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