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DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

PUBLIC DATA NETWORKS – TRANSMISSION, SIGNALLING AND SWITCHING

NETWORK-TO-NETWORK INTERFACE BETWEEN PUBLIC DATA NETWORKS PROVIDING THE FRAME RELAY DATA TRANSMISSION SERVICE

ITU-T Recommendation X.76

(Previously "CCITT Recommendation")

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.76 was prepared by ITU-T Study Group 7 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 10th of April 1995.

NOTE

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

ITU-T X-SERIES RECOMMENDATIONS

DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

(February 1994)

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SUMMARY

This Recommendation describes a frame relay network-to-network interface intended for the interconnection of public data networks offering the Frame Relay Data Transmission Service. Details of physical layer, data transfer and signalling procedures are provided. Procedures for the control of SVCs are for further study.

Recommendation X.76

NETWORK-TO-NETWORK INTERFACE BETWEEN PUBLIC DATA NETWORKS PROVIDING THE FRAME RELAY DATA TRANSMISSION SERVICE

(Geneva, 1995)

1 Scope

Recognizing that public networks are offering the frame relay data transmission service, there is a need for a standard network-to-network interface to enable interworking.

This Recommendation provides the structural details required to implement such an interface.

Procedures for PVC operation are provided. Procedures for control of SVCs are for further study.

2 References

The following Recommendations and other references contain provisions which, through reference in this text, constitute provision 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 currently valid ITU-T Recommendations is regularly published.

- CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces*.
- CCITT Recommendation G.704 (1991), *Synchronous frame structures used at primary and secondary hierarchical levels*.
- CCITT Recommendation I.122 (1988), *Framework for providing additional packet mode bearer services*.
- CCITT Recommendation I.233 (1991), *Frame mode bearer services*.
- CCITT Recommendation I.233.1 (1991), *ISDN frame relaying bearer service*.
- CCITT Recommendation I.370 (1991), *Congestion management for the ISDN frame relaying bearer service*.
- ITU-T Recommendation I.372 (1993), *Frame relaying bearer service network-to-network interface requirements*.
- ITU-T Recommendation I.430 (1993), *Basic user-network interface – Layer 1 specification*.
- ITU-T Recommendation I.431 (1993), *Primary rate user-network interface – Layer 1 specification*.
- CCITT Recommendation Q.920 (1988), *ISDN user-network interface data link layer – General aspects*.
- ITU-T Recommendation Q.921 (1993), *ISDN user-network interface – Data link layer specification*.
- CCITT Recommendation Q.922 (1992), *ISDN data link layer specification for frame mode bearer services*.
- CCITT Recommendation Q.931 (1988), *ISDN user-network interface layer 3 specification for basic call control*.
- ITU-T Recommendation Q.933 (1993), *ISDN Digital Subscriber Signalling System No. 1 (DSS1) – Signalling specification for frame mode basic call control*.
- ITU-T Recommendation X.37 (1995), *Encapsulation in X.25 packets of various protocols including frame relay*.
- CCITT Recommendation X.92 (1988), *Hypothetical reference connections for public synchronous data networks*.

- CCITT Recommendation X.212 (1988), *Data link service definition for Open Systems Interconnection for CCITT applications*.
- CCITT Recommendation X.213 (1988), *Network service definition for Open Systems Interconnection for CCITT applications*.

3 Terms and definitions

For the purpose of this Recommendation, the following definitions apply:

a) Committed Information Rate (CIR) as in 8.2.4;

b) Committed Burst Size (Bc) as in 8.2.2;

c) Excess Burst Size (Be) as in 8.2.3;

d) Committed Rate Measurement Interval (Tc) as in 8.2.5;

e) Access Rate (AR) as in 8.2.1;

f) N391 as in 11.4 and Table 17;

g) N392 as in 11.4 and Table 17;

h) N393 as in 11.4 and Table 17;

i) T391 as in 11.4 and Table 18;

j) T392 as in 11.4 and Table 18.

NOTE – The names of the timers and counters in items f) to j) are aligned with Annex A/Q.933 terminology.

4 Abbreviations

For the purpose of this Recommendation, the following abbreviations are used:

AR	Access Rate
Bc	Committed Burst Size
Be	Excess Burst Size
BECN	Backward Explicit Congestion Notification
CIR	Committed Information Rate
C/R	Command/Response
D/C	DLCI Extension/Control Indication Bit
DCE	Data Circuit-terminating Equipment
DE	Discard Eligibility indicator
DLCI	Data Link Connection Identifier
DTE	Data Terminal Equipment
EA	Address Field Extension
FCS	Frame Check Sequence
FECN	Forward Explicit Congestion Notification
FRDTS	Frame Relay Data Transmission Service
PDN	Public Data Network
PVC	Permanent Virtual Circuit
STE	Signalling Terminal
SVC	Switched Virtual Circuit
Tc	Committed Rate Measurement Interval

5 Conventions

No special conventions are employed within this Recommendation.

6 Physical Layer

The characteristics of the network-to-network interface, defined as the physical layer element, shall be in accordance with Recommendation G.703. When used, the frame structure conforms to Recommendation G.704. In the case of 2 Mbit/s, time slot 0 is used to perform fault detection (see Recommendation G.732). Time slot 16 may either be used or not used, resulting in an access rate of 1984 Kbit/s or 1920 Kbit/s respectively.

Other recognized rates may also be used, in which case the signalling terminal/physical circuit interface shall be in accordance with the appropriate V-Series or X-Series Recommendation, for example:

- V.24;
- V.35;
- V.36;
- X.21.

Each physical circuit must be able to support duplex operation.

In the case of international interworking between public data networks providing FRDTS, the link is assumed to be data link A1 and/or data link G1 in terms of the hypothetical reference connections defined in Recommendation X.92.

7 Reference Configuration

Figure 1 illustrates the possible locations of the network-to-network interface. The interfaces connect public data networks providing FRDTS.

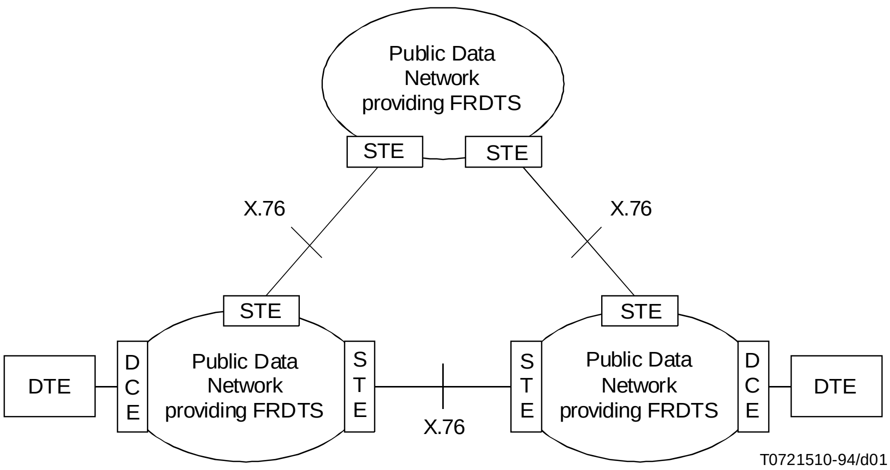


FIGURE 1/X.76

Locations of Network-to-network interface

8 Service parameters and Service quality

8.1 Scope

This clause describes the service parameters needed to define the necessary service requirements and control management for handling congestion during the data transmission phase in a Public Data Network providing frame relay data transmission services.

8.2 Service parameters

8.2.1 Access Rate (AR)

The access rate is the maximum data rate at which data can be injected into or extracted from the network. It is determined by the speed of the access channel. The access rate is bilaterally agreed between the two connecting networks for a period of time. The access rate parameter is provisioned once per STE.

8.2.2 Committed Burst Size (Bc)

The committed burst size is the amount of data for a particular virtual circuit that the network agrees to transfer under normal conditions during interval Tc [see 8.2.5 (Tc)]. The values used for this parameter are bilaterally agreed between the two connecting networks for a period of time. The values used at each STE should be chosen to provide the desired end-to-end service. This service parameter is provisioned once for each PVC at an STE. The value of this parameter can be different for each direction of transmission. That is, each STE on a network-to-network interface can support a different value of this parameter for a particular PVC.

8.2.3 Excess Burst Size (Be)

The excess burst size is the amount of uncommitted data that the network shall endeavour to deliver in addition to the Committed Burst Size (Bc) for a particular virtual circuit during interval Tc [see 8.2.5 (Tc)]. The values used for this parameter are bilaterally agreed between the two connecting networks for a period of time. The values used at each STE should be chosen to provide the desired end-to-end service. This service parameter is provisioned once for each PVC at an STE. The value of this parameter can be different for each direction of transmission. That is, each STE on a network-to-network interface can support a different value of this parameter for a particular PVC.

8.2.4 Committed Information Rate (CIR)

The information transfer rate which the network is committed to transfer for a particular virtual circuit under normal conditions. The rate is the average committed burst size over the time interval of Tc. The values used for this parameter are bilaterally agreed between the two connecting networks for a period of time. The values used at each STE should be chosen to provide the desired end-to-end service. This service parameter is provisioned once for each PVC at an STE. The value of this parameter can be different for each direction of transmission. That is, each STE on a network-to-network interface can support a different value of this parameter for a particular PVC.

8.2.5 Committed Rate Measurement Interval (Tc)

The Committed Rate Measurement Interval (Tc) is the time interval during which the network may expect committed burst size and excess burst size data. It is calculated according to the following formula:

1) if CIR > 0, Tc = Bc/CIR;

2) if CIR = 0, Tc is set to a network dependent value. The values used for this parameter are bilaterally agreed between the two connecting networks for a period of time. The values used at each STE should be chosen to provide the desired end-to-end service. This service parameter is provisioned once for each PVC at an STE.

The value of this parameter can be different for each direction of transmission. That is, each STE on a network-to-network interface can support a different value of this parameter for a particular PVC.

8.2.6 Maximum octet length of frame relay information field (N203)

The maximum octet length of the frame relay information field is the maximum supportable number of user octets. Octets are counted from the octet immediately following the address field to the octet immediately preceding the FCS field inclusive (see Figure 2). The count is done prior to zero-bit insertion on the transmitting side and following zero-bit extraction at the receiving side. This parameter is determined at subscription time. All networks shall support at least a value of 1600 octets. In addition, maximum information field sizes less than or greater than 1600 octets may be agreed to between networks during PVC provisioning. The value of N203 is bilaterally agreed between the two connecting networks for a period of time. This service parameter is provisioned once for each PVC at an STE. The value of this parameter can be different for each direction of transmission. That is, each STE on a network-to-network interface can support a different value of this parameter for a particular PVC.

8.3 Service Quality

The QOS level for committed traffic characterized by the CIR, Bc and Tc parameters may be delivered within a certain probability. The QOS level excess traffic characterized by the parameter Be may also be delivered within a certain probability. (More detail on this aspect can be found in Recommendation X.144.)

9 Data link transfer control

9.1 General

This clause describes the frame structure, elements of procedure, format of fields and procedures for the operation of the Frame Relay Data Transmission Service at layer 2 on the network-to-network interface. The core attributes of LAPF (as described in Annex A/Q.922) used to support the Frame Relay Data Transmission Service are:

- frame delimiting, alignment and transparency;
- frame multiplexing/demultiplexing using the address field;
- inspection of the frame to ensure that it consists of an integral number of octets prior to zero-bit insertion or following zero-bit extraction;
- inspection of the frame to ensure that it is neither too long nor too short;
- detection of (but not recovery from) transmission errors;
- congestion control functions.

9.2 Frame format

The frame format used for individual frame is shown in Figure 2.

8 7 6 5 4 3 2 1	
Flag	Octet 1
Address field first octet (Note)	Octet 2
Address field second octet	Octet 3
Information field (N – 6) Octet	Octet 4 Octet N – 3
Frame Check Sequence first octet	Octet N – 2
Frame Check Sequence second octet	Octet N – 1
Flag	Octet N

NOTE – The default address field length is 2 octets. It may be extended to either 3 or 4 octets.

FIGURE 2/X.76

Frame format with 2 octet address

9.2.1 Flag sequence

All frames shall start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The flag preceding the address field is defined as the opening flag. The flag following the Frame Check Sequence (FCS) field is defined as the closing flag. The closing flag may also serve as the opening flag of the following frame.

9.2.2 Address field

The address field shall consist of at least two octets and may optionally be extended up to four octets by bilateral agreement. The format of the address field is defined in 9.3.2 .

9.2.3 Information field

The information field of a frame follows the address field (see 9.3.2) and precedes the frame check sequence field (see 9.2.4). The contents of the frame relay information field shall consist of an integral number of octets. The maximum length of the frame relay information field is defined in 8.2.6.

9.2.4 Frame Check Sequence (FCS) field

The FCS field shall be a 16-bit sequence. It shall be the ones complement of the sum (modulo 2) of:

1) the remainder of $x^k (x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$ divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency; and

2) the remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the product of x^{16} by the content of the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

9.3 Addressing

9.3.1 General

This subclause describes the field format and procedures used by FRDTS services for data link transfer. Data link connection is governed by the address field elements which support optional procedures such as congestion management which are found in clause 12. The field information is set in accordance with the address field defined by the FRDTS frame format (see Figure 3).

9.3.2 Address field format

The address field format shown in Figure 3 contains the address field extension bits, a command/response indication, 3 bits reserved for explicit congestion notification and discard eligibility indication and a Data Link Connection Identifier (DLCI). The support of 2-octet address field is mandatory. A bit is also included to indicate whether the final octet of a 3- or 4-octet address field is the low order part of the DLCI or control information.

9.3.3 The address field elements

9.3.3.1 Address field extension bit (EA bit)

The address field range is extended by reserving bit 1 of the address field octets to indicate the final octet of the address field. The presence of a 0 in bit 1 of an address field octet signals that another octet of the address field follows this one. The presence of a 1 in bit 1 of an address field octet signals that it is the final octet of the address field.

9.3.3.2 Command/Response bit (C/R bit)

The C/R bit is conveyed transparently across network-to-network interfaces.

9.3.3.3 Forward Explicit Congestion Notification bit (FECN bit)

This bit should be set by an STE to indicate to the remote STE that the frame it receives has encountered congested resources. No STE shall ever clear (reset to 0) this bit.

Default address field format (2 octets)

8	7	6	5	4	3	2	1
Upper DLCI (6 bits)						C/R	EA 0
Lower DLCI (4 bits)				FECN	BECN	DE	EA 1

or

3-Octet address field format

8	7	6	5	4	3	2	1
Upper DLCI (6 bits)						C/R	EA 0
DLCI (4 bits)				FECN	BECN	DE	EA 0
Lower DLCI (6 bits) or control						D/C	EA 1

or

4-Octet address field format

8	7	6	5	4	3	2	1
Upper DLCI (6 bits)						C/R	EA 0
DLCI (4 bits)				FECN	BECN	DE	EA 0
DLCI (7 bits)							EA 0
Lower DLCI (6 bits) or control						D/C	EA 1

EA Address Field Extension bit
C/R Command/Response bit
FECN Forward Explicit Congestion Notification
BECN Backward Explicit Congestion Notification
DLCI Data Link Connection Identifier
DE Discard Eligibility Indicator
D/C DLCI extension/Control indicator bit

FIGURE 3/X.76

Address field format

NOTE – There are currently no functions defined that require the use of control information.

9.3.3.4 Backward Explicit Congestion Notification bit (BECN bit)

This bit should be set by an STE to indicate to the remote STE that the frame it transmits may encounter congested resources. No STE shall ever clear (reset to 0) this bit.

9.3.3.5 Discard Eligibility indicator bit (DE bit)

This bit, if used, is set to 1 to indicate a request that a frame should be discarded in preference to other frames in a congestion situation. Setting of this bit by the network is optional. No network shall ever clear (reset to 0) this bit. Networks are not constrained to discard only frames with DE = 1 in the presence of congestion.

9.3.3.6 Data Link Connection Identifier (DLCI)

Depending on the length of the address field, the DLCI can be 10 bits, 16 bits or 23 bits. When the length of the address field is 2 octets, the DLCI is 10 bits and appears in octets 1 and 2. When the length of the address field is 3 octets, the DLCI is 16 bits and appears in octets 1, 2 and 3. When the length of the address field is 4 octets, the DLCI is 23 bits and appears in octets 1, 2, 3 and 4. See Figure 3.

The DLCI identifies a virtual circuit at the network-to-network interface. Its value is determined either at subscription time for permanent virtual circuits or at call set-up time for switched virtual circuits. The maximum number of virtual circuits supported for a network-to-network interface is dependent on a bilateral agreement between the two networks involved.

Specific values of the DLCI are also used for:

– the signalling for switched virtual circuits (see clause 10);

– the additional procedures for permanent virtual circuits(see clause 11);

– layer 2 management.

The various values for DLCI are specified in Table 1.

TABLE 1 (a)/X.76

DLCI value range when 2-octet address field is used

DLCI range (10 bits)	Function
0	Signalling
1-15	Reserved
16-991	Virtual Circuit Identification
992-1007	Layer 2 Management
1008-1022	Reserved
1023	Reserved for in Channel Layer 2 Management, if Required

TABLE 1 (b)/X.76

DLCI value range when 3-octet address field is used with D/C bit = 0

DLCI range (16 bits)	Function
0	Signalling
1-1023	Reserved
1024-63 487	Virtual Circuit Identification
63 488-64 511	Layer 2 Management
64 512-65 534	Reserved
65 535	Reserved for in Channel Layer 2 Management, if Required

TABLE 1 (c)/X.76

DLCI value range when 4-octet address field is used with D/C bit = 0

DLCI range (23 bits)	Function
0	Signalling
1-131 071	Reserved
131 072-8 126 463	Virtual Circuit Identification
8 126 464-8 257 535	Layer 2 Management
8 257 536-8 388 606	Reserved
8 388 607	Reserved for in Channel Layer 2 Management, if Required

9.3.3.7 DLCI extension/Control indication bit (D/C bit)

The D/C bit is bit 2 of the last octet of the address field when a 3-octet or 4-octet format is used. This bit indicates whether the remaining six usable bits of the octet are to be interpreted as the lower DLCI bits or as control bits. The bit is set to "0" to indicate that the octet contains DLCI information. When the bit is set to "1", bits 3 to 8 of the last octet are no longer interpreted as DLCI bits and their use is for further study. For the purposes of this Recommendation, this bit should be always set to "0"

9.4 Transmission considerations

9.4.1 Order of bit transmission

The bits are grouped into octets. The bits of an octet are shown horizontally and are numbered from 1 to 8. Multiple octets are shown vertically and are numbered from 1 to n. See Figure 4.

The octets are transmitted in ascending numerical order. For each octet, bit 1, which is the least significant bit, is transmitted first and bit 8, which is the most significant bit, is transmitted last.

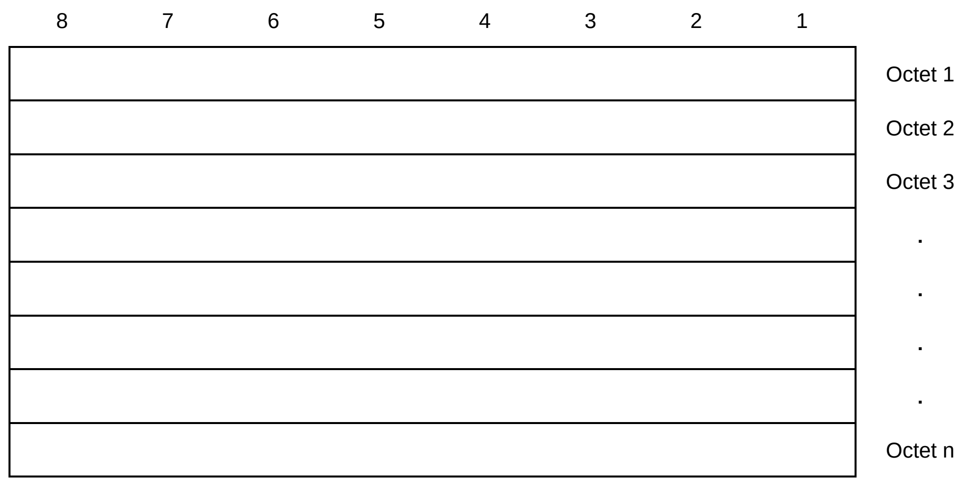


FIGURE 4/X.76

Format Convention

9.4.2 Order of bits in frame fields

When a field is contained within a single octet, the lowest bit number of the field represents the lowest order value.

When a field spans more than one octet, the order of bit values progressively decreases as the octet number increases within each octet. The lowest bit number associated with the field represents the lowest order value.

For example, in an address field with length of two octets, the order of the values of the DLCI bits is as shown in Figure 5.

8	7	6	5	4	3	2	1	
Upper DLCI (6 bits) 2^9	2^8	2^7	2^6	2^5	2^4	C/R	EA 0	1st octet
Lower DLCI (4 bits) 2^3	2^2	2^1	2^0	FECN	BECN	DE	EA 1	2nd octet

FIGURE 5/X.76

Order of values of the DLCI bits

There are two exceptions to the preceding convention:

1) The order of the values of the bits within the information field is not specified in this Recommendation.

2) The order of the values of FCS bits is as follows: bit 1 of the first octet is the high-order bit and bit 8 of the second octet is the low-order bit. See Figure 6.

8	7	6	5	4	3	2	1	
2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	1st octet
2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2nd octet

FIGURE 6/X.76

Order of values of the FCS bits

9.4.3 Transparency

Each transmitting data link entity shall examine the frame content between the opening and closing flag sequences, (address, information, and FCS fields) and shall insert a ‘0’ bit after all sequences of five contiguous ‘1’ bits (including the last five bits of the FCS) to ensure that a flag or an abort sequence is not simulated within the frame. The receiving data link entity shall examine the frame contents between the opening and closing flag sequences and shall discard any ‘0’ bit which directly follows five contiguous ‘1’ bits.

9.4.4 Inter frame fill

For inter frame fill flag sequence must also be used.

9.4.5 Invalid frame

An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than two octets between the address field and the closing flag; or

c) does not consist of an integral number of octets prior to a “0” bit insertion or following “0” bit extraction; or

d) contains a frame check sequence error; or

e) contains a single octet address field; or

f) contains a DLCI which is not supported by the receiver; or

g) contains seven or more continuous bits set to 1 after “0” bit insertion or before “0” bit extraction (“transparency violation ” or “frame abort”); or

h) has an information field longer than N203 (see 8.2.6).

NOTE – Item b) above means that frames with an information field length equal to 0 are valid frames. In case there is no traffic in a given transmission direction, the STE may use such frames to send information about congestion in the opposite direction by means of the BECN bit. For backward compatibility reasons, an STE may consider such frames as invalid, and consequently discard them without notification.

In case h) above, the network may send part of the frame toward the remote DTE, then abort the frame.

Invalid frames shall be discarded without notification to the transmitting STE.

9.4.6 Frame Abortion

Aborting a frame is performed by transmitting at least seven contiguous 1 bits (with no inserted 0 bits). The receipt of seven or more contiguous 1 bits by an STE is interpreted as an abort and the STE ignores the frame currently being received.

10 Call connection control

Call connection control is for further study.

11 Additional Procedures for PVCs using Unnumbered Information Frames

11.1 Overview

These procedures described in 11.2 to 11.7 provide the following functionality:

– link integrity verification;

– notification of the addition of a PVC;

– detection of the deletion of a PVC;

– notification of the status of a PVC (active or inactive).

These procedures are based on the periodic exchange of STATUS ENQUIRY and STATUS messages over the network-to-network interface.

11.2 Message definition

Messages are transferred on DLCI = 0 with bits C/R, DE, BECN and FECN set to 0 upon transmission. Bits C/R, DE, BECN and FECN are not interpreted upon reception.

The 3 octets following the address field have fixed values:

– the first octet is the control field of a UI frame with the Poll bit set to 0;

– the 2nd octet is the protocol discriminator information element of the message;

– the 3rd octet is the dummy call reference information element of the message.

Consequently, the first octets of the frame are as described in Figure 7.

The other information elements are described in 11.2.1 and 11.2.2 below.

Octet	8	7	6	5	4	3	2	1	
1	Flag								
2	0	0	0	0	0	0	0	0	Address field DLCI = 0
3	0	0	0	0	0	0	0	1	
4	0	0	0	0	0	0	1	1	UI, Poll bit = 0
5	0	0	0	0	1	0	0	0	Protocol discriminator
6	0	0	0	0	0	0	0	0	Dummy call reference
	Message specific information elements								See 11.2.1 and 11.2.2
	FCS								
	FCS								
	Flag								

FIGURE 7/X.76

PVC management frame format (for 2-octet address)

11.2.1 STATUS ENQUIRY message

This message is sent to request the status of PVCs or to verify link integrity. Message specific information elements for this message are described in Table 2, and must appear in the order indicated in this table.

TABLE 2/X.76

Message specific information elements in STATUS ENQUIRY message

Message type: STATUS ENQUIRY Significance: Local		
Information element	Type	Length
Message type	Mandatory	1
Report type	Mandatory	3
Link integrity verification	Mandatory	4

11.2.2 STATUS message

This message is sent in response to a STATUS ENQUIRY message to indicate the status of permanent virtual circuits or for a link integrity verification. Optionally, it may be sent at any time to indicate the status of a single PVC. Message specific information elements for this message are described in Table 3, and are in the order indicated in this table. The PVC status information element may occur several times in this message.

TABLE 3/X.76

Message specific information elements in STATUS message

Message type: STATUS Significance: Local		
Information element	Type	Length
Message type	Mandatory	1
Report type	Mandatory	3
Link integrity verification	Optional/Mandatory (Note 1)	4
PVC status (Note 2)	Optional/Mandatory (Note 3)	5-7

NOTES

1 Mandatory if the type of report is “full status” or “link integrity verification only”. Not included in the optional asynchronous status message (report type equal to “single asynchronous PVC status”).

2 Included in the case of a full status message. This is a STATUS message that contains the status of all PVCs on the interface. There is one PVC status information element for each PVC configured. The PVC status information elements are arranged in the messages in ascending order of DLCIs; the PVC with the lowest DLCI is first, the second lowest DLCI is second, and so on. The maximum number of PVCs that can be indicated in a message is limited by the maximum frame size. The optional asynchronous STATUS message contains a single PVC status information element.

3 Mandatory if the Report type information element indicated “full status” or “single asynchronous PVC status” and there are PVCs configured.

11.3 Message specific information elements

11.3.1 Message type

The coding of message type is defined in Table 4.

TABLE 4/X.76

Message type coding

```
Message type coding for PVC management

        Bits
        8765 4321
        011- ----
           1 0101 STATUS  ENQUIRY
           1 1101 STATUS
```

11.3.2 Report type

The purpose of the Report type information element is to indicate the type of enquiry requested when included in a STATUS ENQUIRY message or the contents of the STATUS message. The length of this information element is 3 octets. The format and encoding of the Report type information element is defined in Figure 8.

8	7	6	5	4	3	2	1	Octet
0	1	0	1	0	0	0	1	1
Length of report type contents = 1								2
Type of report								3

Type of report (octet 3)
Bits
87654321
00000000 Full status (status of all PVCs at the interface)
00000001 Link integrity verification only
00000010 Single PVC asynchronous status

All other values are reserved.

FIGURE 8/X.76

Report type information element

11.3.3 Link integrity verification

The purpose of the Link integrity verification information element is to exchange sequence numbers across the network-to-network interface on a periodic basis. The length of this information element is 4 octets. It is binary encoded.

The format of the Link integrity verification information element is defined in the Figure 9, where send sequence number in octet 3 indicates the current send sequence number of the originator of the message, and receive sequence number in octet 4 indicates the send sequence number received in the last received message. The send sequence number is binary encoded in octet 3. The receive sequence number is binary encoded in octet 4.

8	7	6	5	4	3	2	1	Octet
0	1	0	1	0	0	1	1	1
Lenght of link integrity verification contents = 2								2
Send sequence number								3
Receive sequence number								4

FIGURE 9/X.76

Link integrity verification information element

11.3.4 PVC status

The purpose of the PVC status information element is to indicate the status of existing PVCs at the interface. The information element can be repeated, as necessary, in a message to indicate the status of all PVCs on the network-to-network interface. The length of this information element depends on the length of the DLCIs being used on the network-to-network interface. The length of this information element is 5 octets when a default address format (2 octet) is used. The format of the PVC status information element is defined in Figure 10, where a default address format is used. Bit 6 of octet 3 is the most significant bit in the data link connection identifier.

The format of the PVC status information element is defined in Figure 10 (b) and 10 (c), where a 3-octet address format and a 4-octet address format are used respectively.

Bit 2 of the last octet for each PVC status information element is the Active bit which is coded 1 to indicate the PVC is active, and coded 0 to indicate the PVC is inactive. An active indication means that the PVC is available to be used for data transfer. An inactive indication means that the PVC is configured but is not available for data transfer.

Bit 4 of the last octet for each PVC status information element is the New bit which is coded 1 to indicate the PVC is newly configured, and coded 0 to indicate the PVC is already configured.

Bit 3 of the last octet for each PVC status information element is the Delete bit which is coded 1 to indicate the PVC is deleted, and coded 0 to indicate the PVC is configured.

The PVC status information elements are arranged in the messages in ascending order of DLCIs; the PVC with the lowest DLCI is first, the second lowest DLCI is second, and so on. The maximum number of PVCs that can be indicated in a message is limited by the frame size.

The Delete bit is only applicable for timely notification using the optional single PVC asynchronous status report. When the bit is set to 1, the New and Active bits have no significance and shall be set to 0 upon transmission and not interpreted upon reception. When the New or Active bits have significance, the Delete bit shall be set to 0 upon transmission and not interpreted upon reception.

8	7	6	5	4	3	2	1	Octet
0	1	0	1	0	1	1	1	1
Length of PVC status contents = 3								2
0 ext	0 spare	Data Link Connection identifier (Most significant 6 bits)						3
1 ext	Data Link Connection identifier (2nd most significant 4 bits)				0 spare	0	0	3a
1 ext	0 spare	0	0	New	Delete	Active	0 reserved	4

FIGURE 10 (a)/X.76

PVC status information element with 2-octet address format

8	7	6	5	4	3	2	1	Octet
0	1	0	1	0	1	1	1	1
Length of PVC status contents = 4								2
0 ext	0 spare	Data Link Connection identifier (most significant 6 bits)						3
0 ext	Data Link Connection identifier (2nd most significant 4 bits)				0 spare	0	0	3a
1 ext	Data Link Connection identifier (3rd most significant 6 bits)						0 spare	3b
1 ext	0 spare	0	0	New	Delete	Active	0 reserved	4

FIGURE 10 (b)/X.76

PVC status information element with 3-octet address format

8	7	6	5	4	3	2	1	Octet
0	1	0	1	0	1	1	1	1
Length of PVC status contents = 5								2
0 ext	0 spare	Data Link Connection identifier (most significant 6 bits)						3
0 ext	Data Link Connection identifier (2nd most significant 4 bits)				0 spare	0	0	3a
0 ext	Data Link Connection identifier (3rd most significant 7 bits)							3b
1 ext	Data Link Connection identifier (4th most significant 6 bits)						0 spare	3c
1 ext	0 spare	0	0	New	Delete	Active	0 reserved	4

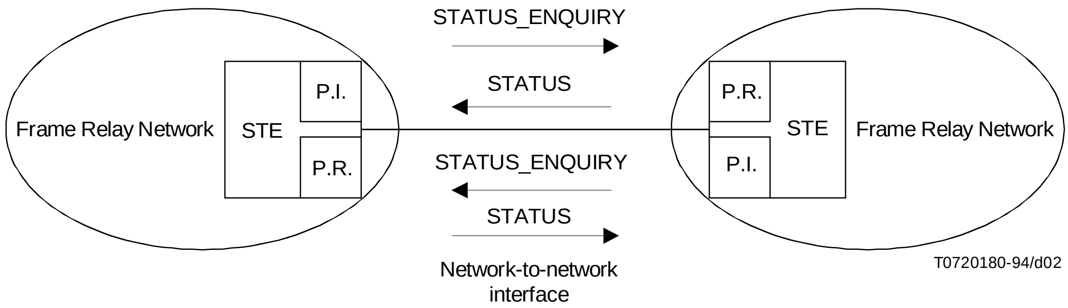
FIGURE 10 (c)/X.76

PVC status information element with 4-octet address format

11.4 Description of procedures

These procedures use periodic polling, as described in 11.4.1 to verify the integrity of the link (see 11.4.2) and to report the status of PVCs (see 11.4.3, 11.4.4 and 11.4.5).

Bidirectional signalling procedures are employed at the network-to-network interface. Each Signalling Terminal (STE) on either side of the network-to-network interface employs procedures for both polling initiation and polling response (see Figure 11).



STE Signalling Terminal

P.I. Polling Initiation procedure

P.R. Polling Response procedure

FIGURE 11/X.76

Bidirectional Signalling Procedures

11.4.1 Periodic Polling

Polling is initiated as described below:

1) A STATUS ENQUIRY message is sent and the polling timer T391 started. When T391 expires, this action is repeated. The T391 interval between such messages is called the polling interval. This STATUS ENQUIRY message typically requests a link integrity verification exchange only (report type equal “0000 0001”). However, every N391 polling cycles, the polling initiation procedures, request full status of all PVCs (report type equal “0000 0000”).

2) The polling response procedure responds to each STATUS ENQUIRY message with a STATUS message and (re) starts the polling verification timer T392. The STATUS message sent in response to a STATUS ENQUIRY contains the link integrity verification and report type information elements. If the content of the report type information element specifies full status, then the STATUS message must contain one PVC status information element for each PVC configured on the interface.

3) The polling initiation procedure shall interpret the STATUS message based on the type of report contained in this STATUS message. The polling response procedure may respond to any poll with a full status message in case of a PVC status change or to report the addition or deletion of a PVC on the interface. If it is a full status message, the STE should update the status of each configured PVC as reported by the remote STE.

11.4.2 Link integrity verification

The purpose of the Link integrity verification information element is to allow the connected STEs to determine the status of the signalling link (DLCI 0). This is necessary since these procedures use Unnumbered Information (UI) frames.

An STE maintains the following internal counters:

- The send sequence counter maintains the value of the send sequence number field of the last link integrity verification information element sent.
- The receive sequence counter maintains the value of the last received send sequence number field in the link integrity verification information element. This represents the value to be placed in the next transmitted received sequence number field.

A separate pair of counters (send sequence counter and receive sequence counter) is kept for the polling initiation procedure and the polling response procedure. These two sets of procedures co-exist within a single STE.

The polling initiation procedure consists of those procedures which generate STATUS ENQUIRY messages and process the received, corresponding STATUS messages.

The polling response procedure consists of those procedures which process STATUS ENQUIRY messages and generate the required STATUS messages.

The following procedure is used:

1) Before any messages are exchanged, an STE must set both pairs of send sequence counters and receive sequence counters to zero.

2) Each time the polling initiation procedure sends a STATUS ENQUIRY message, it increments the send sequence counter and places its value into the send sequence number field of the link integrity verification information element. It also places the current value of the receive sequence counter into the receive sequence number field of the link integrity verification information element. The polling initiation procedure increments the send sequence counter using modulo 256. The value zero is skipped.

3) When the STE receives a STATUS ENQUIRY, the polling response procedure of the STE checks the receive sequence number sent by the remote STE against its send sequence counter. The handling of error conditions is described in 11.4.6.

   The received send sequence number is stored in the receive sequence counter. The polling response procedure then increments its send sequence counter and places its current value in the send sequence number field and the value of the receive sequence counter (the last received send sequence number) into the receive sequence number field of the outgoing link integrity verification information element. The polling response procedure then transmits the completed STATUS message back to the remote STE which performed the polling initiation. The polling response procedure increments the send sequence counter using modulo 256. The value zero is skipped.

4) When the polling initiation procedure receives a STATUS from the remote STE in response to a STATUS ENQUIRY, it checks the receive sequence number received from the remote STE against its send sequence counter. The handling of error conditions is described in 11.4.6. The received send sequence number from the STATUS message is stored in the receive sequence counter.

NOTE – The value zero in the receive sequence number indicates that the field contents are undefined; this value is normally used after initialization. The value zero shall not be sent in the send sequence number field so that the receive sequence number shall never contain the value zero to differentiate the undefined condition from the normal modulo round off.

11.4.3 Signalling of the presence or absence of a PVC

The STE will signal the presence of a PVC by including a PVC STATUS information element with the appropriate DLCI in a STATUS message with full status report. A PVC should be considered as present when it is configured in the network in which the STE is located. Note that this presence indication does not have an end-to-end significance in the case of a multi-network PVC. An STE shall interpret the omission of a previously reported PVC from the full STATUS message as an indication that the PVC is no longer provisioned for the interface in the remote network.

11.4.4 Signalling that a PVC is New

One of the functions of periodic polling is to notify the remote STE of newly added permanent virtual circuits using a full status message. The PVC reporting procedure using a full status message ensures that a permanent virtual circuit cannot be deleted and another added using the same DLCI without the remote STE detecting the change. The PVC reporting procedures are defined as follows:

1) When a new permanent virtual circuit has been added, the STE sets the New bit to 1 in the PVC status information element for that PVC in a full STATUS message.

2) The STE shall not clear the New bit in the PVC status information element until it receives a STATUS ENQUIRY message containing a receive sequence number equal to the send sequence counter (i.e. the send sequence number transmitted in the last STATUS message).

Note that when the New bit is set to 1, the Delete bit must be set to 0 on transmission. On reception, the Delete bit is not interpreted when the New bit is set to 1.

For a given PVC, when the New bit is received set to 1 at an STE, this means that the PVC has been newly added or re-configured in the adjacent network or in a subsequent network beyond the adjacent network. This information shall be propagated across the network on which this STE exists to the other end of the PVC segment (i.e. X.76 or X.36 interface).

NOTE – This procedure ensures the DTE does not miss the fact that a transit network deleted a PVC and then quickly used the same DLCI for a new PVC to a new destination.

11.4.5 Signalling the active/inactive status of PVCs

In response to a STATUS ENQUIRY message sent by an STE containing a Report type information element set to “full status”, the polling response procedures of the remote STE report in a STATUS message the activity status of each PVC configured on the interface with PVC status information elements (one per PVC).

The Report type information element in this STATUS message is set to “full status”. Also, in response to a STATUS ENQUIRY message containing a Report type information element set to “link integrity verification only”, the STE may respond with a STATUS message containing a Report type information element set to “full status” in case of a PVC status change. Each PVC status information element contains an Active bit indicating whether that PVC is active (set to 1) or inactive (set to 0).

The action that an STE takes based on the value of the Active bit is independent of the action based on the New bit. An STE could receive a PVC status information element with the New bit set to 1 and the Active bit set to 0.

If an STE receives a PVC status information element with the Active bit set to 0, the STE shall stop transmitting frames on the PVC until it receives a PVC status information element for that PVC with the Active bit set to 1. When the Active bit is set to 1, the Delete bit must be set to 0 on transmission. The Delete bit is not interpreted in the full status reporting STATUS message. When the Delete bit is set to 1 in the optional asynchronous status message, the Active bit has no significance. Other action taken by the STE is implementation dependent.

Since there is a delay between the time the network makes a PVC active and the time the STE transmits a PVC status information element notifying the remote STE, there is a possibility of an STE receiving frames on a PVC marked as inactive. The action the STE takes on receipt of frames on an inactive PVC is implementation dependent.

Since there is a delay between the time the network detects that a PVC has become inactive and the time the STE transmits a PVC status information element notifying the remote STE, there is a possibility of an STE receiving frames on an inactive PVC. The action an STE takes on receipt of frames for an inactive PVC is network dependent and may include the dropping of frames on the inactive PVC.

An STE indicates that a PVC is active if the following criteria are met:

– The PVC is configured and available for data transfer in the network on which the STE exists.

– There is no service affecting condition at the STE (see 11.4.6) or at the other STE (or DCE) traversed by this PVC on the network on which the STE exists.

– The other STE (or DCE supporting bidirectional procedures) traversed by this PVC on the network on which the STE exists indicates that the PVC is present and active.

Note that the indication sent by an STE is independent of the indication received across the network-to-network interface from the remote STE.

See 11.4.6 for conditions under which the network sets the active bit to zero.

11.4.6 Error conditions

The polling initiation and polling response procedures use the information provided by periodic polling for error monitoring.

The polling initiation and polling response procedures detect the following error conditions:

– *Procedure errors* – Non-receipt of STATUS/STATUS ENQUIRY messages, or invalid receive sequence number in a link integrity verification information element.

– *Protocol errors* – Protocol discriminator, message type, call reference and mandatory information element errors.

In the case of protocol errors both the polling initiation and polling response procedures shall ignore such messages: no response shall be made, no error counted and no use shall be made of the content of the link integrity verification information.

11.4.6.1 Polling Response Procedure Actions

Several kinds of errors have to be taken into account by the polling response procedures within an STE:

1) *Errors within the network*

   The STE shall set the Active bit to 0 for a PVC if a service affecting condition occurs within the network (implementation dependent, e.g. switching node or internal link out of order, etc.).

2) *Errors at the network-to-network interface*

   For the purposes of determining a service affecting condition at the network-to-network interface, an event is defined as:

   – receipt of a STATUS ENQUIRY message with no protocol errors; or

   – expiration of timer T392.

The first type of event is considered as an error if the contents of the Link integrity verification information element is invalid. This consists of an invalid receive sequence number. The received receive sequence number is not valid when it is not equal to the last transmitted send sequence number.

NOTE – The polling response procedures continue with the periodic polling procedure regardless of the value of the received receive sequence number (i.e. the polling response procedures respond to every STATUS ENQUIRY message which does not contain a protocol error).

The second type of event is always considered as in error. Detecting that N392 of the last N393 events are in error indicates a service affecting condition. At the detection of a service affecting condition at the network-to-network interface by the STE, the STE should notify the remote STE for each PVC whose service is affected by setting the Active bit to 0 in a full status STATUS message or optionally in the single PVC asynchronous STATUS message.

11.4.6.2 Polling Initiation Procedure Actions

For the purpose of determining a service affecting condition at the network-to-network interface, an event is defined as the transmission of a STATUS ENQUIRY message.

This event is considered as in error in the following cases:

- Non-receipt of a STATUS message with no protocol errors with report type equal to “full status” or “link integrity verification only” before T391 expiry.

- Receipt of a STATUS message with no protocol errors and with report type equal to “full status” or “link integrity verification only”, with invalid contents of a link integrity verification information element. This consists of detecting an invalid receive sequence number. The received receive sequence number is not valid when it is not equal to the last transmitted send sequence number.

NOTE – When the polling initiation procedures receive a STATUS message with no protocol errors but with an invalid receive sequence number, this message (including its send sequence number) is ignored. Using the send sequence number of such a STATUS message may cause the polling initiation procedures to acknowledge a STATUS message with report type equal to “full status” that has, in fact, been ignored (this could cause the incorrect acknowledgement of a New and/or Delete indication).

Detecting that N392 of the last N393 events are in error indicates a service affecting condition. The STE also may use other methods for detecting service affecting conditions.

At the detection of a service affecting condition at the network-to-network interface, the STE should stop transmission of frames on all PVCs on the network-to-network interface. The STE should continue link integrity verification procedures to detect service restoration.

When the STE detects that the service affecting conditions is cleared, it resumes normal operation of active PVCs on the network-to-network interface. One method to detect service restoration is by detecting that N392 consecutive events have occurred without error.

If a PVC status information element is received for a PVC not currently defined and the New bit is set to 0, this is recorded as an error. Other actions taken are implementation dependent.

This procedure detects problems with the signalling link (DLCI = 0) and does not detect problems with individual PVCs.

11.5 Bidirectional aspects of operation

Bidirectional procedures mean that there is symmetrical operation on the network-to-network interface.

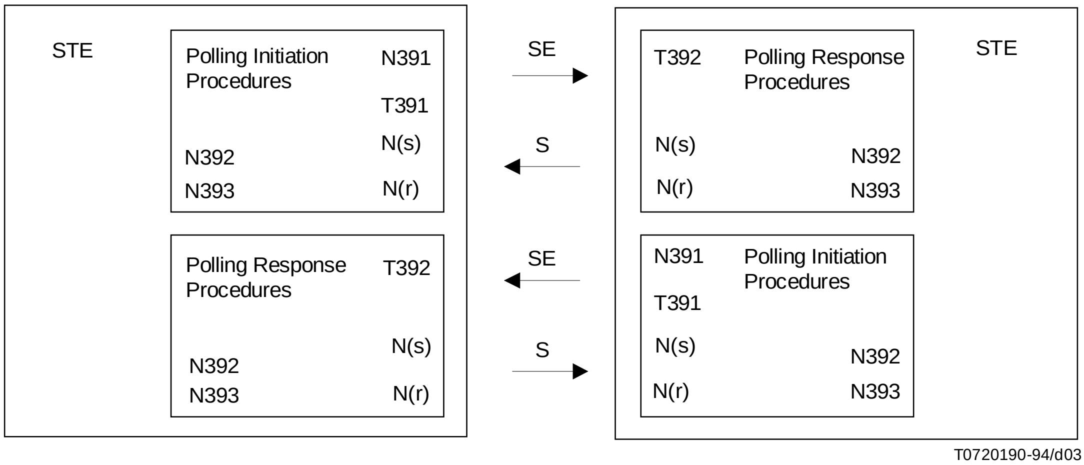
Two sets of signalling parameters are administered for each STE at a given network-to-network interface as shown below:

- polling initiation procedure – T391, N391;

- polling response procedure – T392.

One set of parameters is used when the STE is providing the “polling initiation procedure” which send the polling message (STATUS ENQUIRY). The other set of parameters is used when the STE is providing the “polling response procedure” which sends a response (STATUS) to each polling message.

The location of these system parameters is indicated in Figure 12 below.



S STATUS message
SE STATUS ENQUIRY message
N(s) Send Sequence Counter
N(r) Receive Sequence Counter

FIGURE 12/X.76

Location of System Parameters and Variables

Each side of the network-to-network interface is required to initiate polling using a STATUS ENQUIRY message based on its own T391 timer. A full status report is required every N391 (default 6) polling cycles. This periodic polling procedure is defined in 11.4.

When it is first activated, the STE shall consider the network-to-network interface to be non-operational. When the STE observes one of the following conditions on the network-to-network interface, it shall consider that network-to-network interface to be operational:

– N393 consecutive valid polling cycles occur. These polling cycles may be counted from: polling initiation cycles, polling response cycles or a combination of both.

– As an alternative, one valid polling cycle occurs. That is, if the first polling cycle constitutes a valid exchange of sequence numbers, then the network-to-network interface shall be considered operational. If the first polling cycle results in an error, then the network-to-network interface shall be considered non-operational until N393 consecutive valid polling cycles occur at the network-to-network interface. These polling cycles may be counted from: polling initiation cycles, polling response cycles or a combination of both.

Later (after it has once been considered operational), the interface is considered non-operational following detection of a service affecting condition at the network-to-network interface, and it is considered operational following detection of service restoration.

An STE implements two sets of parameters N392 and N393 for monitoring errors and events respectively. One set is used by the polling initiation procedures and one set by the polling response procedures. It is recognized that, within an STE, the polling initiation procedures and the polling response procedures may detect different states. The determination of the state of the network-to-network interface from these states is implementation dependent.

11.6 Asynchronous PVC STATUS message

Whenever a PVC status has changed, optionally, a STATUS message with report type set to single PVC asynchronous status is sent to inform the remote STE of the new PVC status. If sent, this message is sent immediately after the occurrence of the PVC status change.

When a PVC is deleted, the STE may send an asynchronous PVC STATUS message to the STE that contains the Report type information element set to "single PVC asynchronous status" and the PVC status information element. In the PVC status information element, the Delete bit is set to 1. When the Delete bit is set to 1, the New bit and the Active bit have no significance. They must be set to 0 on transmission and should not be interpreted on reception.

The procedures for the reporting of new PVCs are not supported by asynchronous STATUS messages. In an asynchronous PVC STATUS message, the New bit has no significance. It must be set to 0 on transmission and should not be interpreted on reception. Asynchronous STATUS messages do not satisfy the requirements for a STATUS message in a given polling interval. STEs which are not able to interpret a STATUS message with report type set to single PVC asynchronous status must ignore this message.

11.7 System parameters

Tables 5 and 6 summarize the acceptable values for the configurable parameters described in these procedures. Parameter values other than the default values are a subscription option.

TABLE 5/X.76

System parameters – Counters

Counter	Description	Range	Default/threshold	Usage
N391	Full status (status of all PVCs) polling counter	1-255	6	Polling cycles
N392	Error/recovery counter	1-10 (Note 1)	3	Errored events/ Non-errored events
N393	Monitored events counter	1-10 (Note 2)	4	Events

NOTES

1 N392 should be less than or equal to N393.

2 If N393 is set to a value much less than N391, then the link could go in and out-of error condition without the user equipment or network being notified.

TABLE 6/X.76

System parameters – Timers

Timer	Description	Range	Default (seconds)	Started	Stopped	Action taken when expired
T391	Link integrity verification polling timer	5-30	10	Transmit STATUS ENQUIRY	–	Transmit STATUS ENQUIRY. Record error if STATUS message not received
T392	Polling verification timer	5-30 (Note)	15	Transmit STATUS	Receive STATUS ENQUIRY	Record error by incrementing N392. Restart T392.
NOTE – T392 should be greater than T391.						

12 Congestion control

As defined in Recommendation I.370, congestion states are classified as one of either mild or severe congestion. In times of mild congestion, the network must implement procedures to detect congestion, notify users, and control excess traffic so as to avoid as far as possible the actual discarding of frames. The network can send congestion notifying indications to adjacent networks via frame relay network-to-network interfaces if it has been determined that traffic with these networks is encountering congested resources.

Each network should generate Forward Explicit Congestion Notification (FECN), Backward Explicit Congestion Notification (BECN) and may support rate enforcement using the DE indicator in accordance with Recommendation I.370.

Each network is responsible for protecting itself against congestion scenarios at the network-to-network interface (e.g. a given network should not rely solely on the prior network's setting of the DE bit).

Under normal operating conditions, every effort should be made not to discard Bc committed data at the NNI. One method to assure this, is to set an upper limit to the sum of the subscribed CIRs (egress from the network) of all PVCs taking into account the NNI access rate. Each STE sets its own upper limit.

The Committed Information Rate (CIR), Committed Burst Size (Bc) and Excess Burst Size (Be) values are administratively coordinated at the network-to-network interface. The values of these parameters are chosen to provide a consistent service along the multi-network PVC. CIR, Bc and Be may be uniquely defined in the forward and backward directions.

The Access Rate (AR) of all NNIs involved in a multi-network PVC do not have to be equal. The access rate at one NNI may be substantially higher than at another NNI. Therefore, continuous input of Be frames at one NNI may lead to persistent congestion of the network buffers at another NNI, and a substantial amount of the input Be data may be discarded.

The generation and signalling of explicit congestion control information is further described in Appendix I.

Appendix I

Network Congestion Scenarios

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

In Figure I.1 a single PVC passing through three networks is shown. The PVC consists of three segments and traverses two separate NNI links. The PVC carries traffic between two end users; user X and user Y.

If network B becomes congested in a manner which reduces its capacity to carry traffic on this PVC in the direction X to Y, network B must signal this explicitly to users X and Y. Network B achieves this by setting the FECN bit in the address field in frames passing towards user Y and setting the BECN bit in the address field in frames passing towards user X. The responsibility of networks A and C in this case is to transport these congestion notification bits towards the UNIs unchanged.

In principle, on receiving congestion notification, end-user equipment should reduce the offered load on the indicated PVC. This may, in fact, result in an increase in the effective throughput available to the end-user under congestion conditions. However, as the behaviour of each end-user cannot be guaranteed, networks should have the ability to protect themselves and other users from congestion. In the case shown, network B may protect itself by the use of a rate enforcement mechanism at ingress from an NNI which would involve the discarding of frames, beginning with those marked discard eligible, in times of congestion.

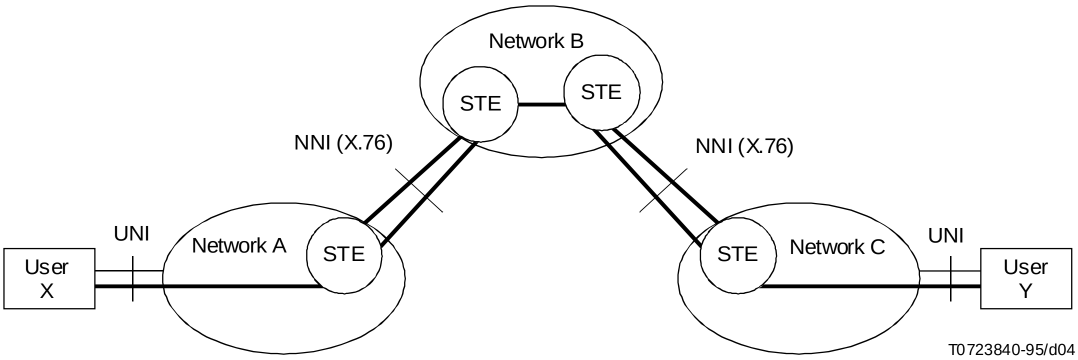


FIGURE I.1/X.76

Multi-segment PVC to illustrate congestion scenarios