EUROPEAN TELECOMMUNICATION STANDARD

ETS 300 399-1

March 1995

Source: ETSI TC-NA

Reference: DE/NA-023216-1

ICS: 33.080

Key words: ISDN, frame relay, stage 1

Frame relay services;
Part 1: General description

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

New presentation - see History box

Contents

Blank page

Foreword

This European Telecommunication Standard (ETS) has been produced by the Network Aspects (NA) Technical Committee of the European Telecommunications Standards Institute (ETSI).

The content of this ETS is adapted from the CCITT Recommendation I.233.1 [2].

This ETS consists of 4 parts as follows:

Part 1: "Part 1: General description".

Part 2: "Part 2: Integrated Services Digital Network (ISDN); Frame relay bearer service; Service definition".

Part 3: "Part 3: Integrated Services Digital Network (ISDN); Frame relay data transmission service; Service definition".

Part 4: "Part 4: Broadband Integrated Services Digital Network (B-ISDN); Frame relay bearer service; Service definition".

Transposition dates	
Date of latest announcement of this ETS (doa):	30 June 1995
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	31 December 1995
Date of withdrawal of any conflicting National Standard (dow):	31 December 1995

Introduction

The purpose of this ETS is to describe the frame relay service. The definition and description of this service forms the basis to define the network capabilities required for the support of the service. The prose description begins with clause 5, the static description begins with clause 11. No dynamic description is provided.

Blank page

1 Scope

This European Telecommunication Standard (ETS) specifies the general aspects of the frame relay service that is common to all frame relay services independent of the network on which the service is offered.

This ETS is applicable for all network-specific frame relay service definitions.

This ETS should be complemented with standards for the network-specific part of the frame relay service.

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] CCITT Recommendation E.164: "Numbering plan for the ISDN era".

[2] CCITT Recommendation I.233.1: "ISDN frame relaying bearer service".

[3] ITU-T Recommendation I.500: "General structure of the ISDN Interworking Recommendations".

[4] CCITT Recommendation Q.922: "ISDN data link layer specification for frame mode bearer services".

[5] ITU-T Recommendation Q.933: "Layer 3 signalling specification for frame mode bearer service".

[6] ITU-T Recommendation X.25: "Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit".

[7] ITU-T Recommendation X.31: "Support of packet mode terminal equipment by an ISDN".

[8] CCITT Recommendation X.121: "International numbering plan for public data networks".

[9] ITU-T Recommendation X.134: "Portion boundaries and packet layer reference events: basis for defining packet-switched performance parameters".

[10] ITU-T Recommendation X.140: "General quality of service parameters for communication via public data networks".

[11] CCITT Recommendation X.200: "Reference Model of Open Systems Interconnection for CCITT applications".

[12] ITU-T Recommendation X.210: "Open Systems Interconnection layer service definition conventions".

[13] ITU-T Recommendation X.213: "Information technology - Network service definition for Open Systems Interconnection".

[14] CCITT Recommendation X.300: "General principles for interworking between public networks and between public networks and other networks for the provision of data transmission services".

[15] Addendum 1 to ISO 8348 (1987): "Connectionless mode transmission".

[16] ISO 8473: "Information processing systems - Data communications - Protocol for providing the connectionless-mode network service".

3 Definitions

For the purposes of this ETS, the following definitions apply:

access rate: The data rate of the physical connection at the user-network interface. The speed of the physical connection determines how much data (maximum rate) the end-user can inject into the network.

Forward Explicit Congestion Notification (FECN): See CCITT Recommendation Q.922 [4] for the full definition.

Backward Explicit Congestion Notification (BECN): See CCITT Recommendation Q.922 [4] for the full definition.

Consolidated Link Layer Management Message (CLLM): See CCITT Recommendation Q.922 [4] for the full definition.

Committed Burst size (B_C): The maximum committed amount of data a user may offer to the network during a time interval T_C. B_C is negotiated at virtual circuit establishment.

Committed rate measurement interval (T_C): The time interval during which the user is allowed to send only the committed amount of data (B_C) and the excess amount of data (B_E). T_C is computed.

Committed Information Rate (CIR): The information transfer rate which the network is committed to transfer under normal conditions. The rate is averaged over a minimum increment of time T_C. CIR is negotiated at virtual circuit establishment.

congestion management: This includes: network engineering; Operation, Administration and Maintenance (OAM) procedures to detect the onset of congestion; and real time mechanisms to prevent or recover from congestion. Congestion management includes, but is not limited to; congestion control, congestion avoidance and congestion recovery, as defined below:

- **congestion control:** this refers to real-time mechanisms to prevent and recover from congestion during periods of coincidental peak traffic demands or network overload conditions (e.g. resource failures). Congestion control includes both congestion avoidance and congestion recovery mechanisms;

- **congestion avoidance:** congestion avoidance procedures refer to procedures initiated at or prior to the onset of mild congestion in order to prevent congestion from becoming severe. Congestion avoidance procedures operate around and within the regions of mild congestion and severe congestion;

- **congestion recovery:** congestion recovery procedures refer to procedures initiated to prevent congestion from severely degrading the end-user perceived Quality of Service (QoS) delivered by the network. These procedures are typically initiated when the network has begun to discard frames due to congestion. Congestion recovery procedures operate around and within the region of severe congestion.

core service: See CCITT Recommendation Q.922 [4], annex A for the full definition.

C-plane: The C-plane refers to the data exchanged across a user-network interface for establishment, release, monitoring, etc. of virtual circuits that are carried out outside the virtual circuits' data transmission.

delivered duplicated frames: A frame D received by a particular destination user is defined to be a duplicated frame if both of the following conditions are true:

- frame D was not generated by the source user;

- frame D is exactly the same as a frame that was previously delivered to that destination.

delivered errored frames: A delivered frame is defined to be an errored frame when the values of one or more of the bits in the frame is in error, or when some, but not all, bits in the frame are lost bits or extra bits (i.e. bits which were not present in the original signal) have been inserted (see ITU-T Recommendation X.140 [10]).

delivered out-of-sequence frames: Consider a sequence of frames F_1, F_2, F_3, ... , F_n and assume that F_1 is transmitted first, F_2 second, ... , F_n last.

A delivered frame F_i is defined to be out-of-sequence if it arrives at the destination after any of the frames $F_{(i+1)}$, $F_{(i+2)}$, ... , F_n.

discard eligibility indicator: This indicates that a frame should be discarded in preference to other frames in a congestion situation, when frames need to be discarded to ensure safe network operation and to maintain the committed level of service within the network.

egress node: The node that supports the destination user-network interface.

Excess Burst size (B_E): The maximum allowed amount of data by which a user can exceed B_C during a time interval T_C. This data (B_E) is delivered in general with a lower probability than B_C. B_E is negotiated at virtual circuit establishment.

fairness: An attempt by the network to maintain the committed call parameters which the end-user negotiated at call set-up time. An example of this would be first discarding the frames in excess of the CIR and refusing to allow new call set-ups to occur prior to discarding committed data traffic.

information integrity: Information integrity is preserved when for all frames delivered by the network no transmission errors have been detected.

ingress node: The node that supports the source user-network interface.

lost frames: A transmitted frame is declared to be a lost frame when the frame is not delivered to the intended destination user within a specified timeout period, and the network is responsible for the non-delivery (see ITU-T Recommendation X.140 [10]).

misdelivered frames: A misdelivered frame is a frame transferred from a source to a destination user other than the intended destination user. It is considered inconsequential whether the information is correct or incorrect in content (see ITU-T Recommendation X.140 [10]).

offered load: Refers to the frames offered to the network, by an end-user, to be delivered to the selected destination. The information rate offered to the network could exceed the negotiated class of service parameters.

residual error rate: The residual error rate is defined for frame relay services and the corresponding layer services. The layer services corresponding to the frame relay services are characterized by the exchange of Service Data Units (SDUs). For frame relay, SDUs are exchanged at the functional boundary between the core functions of CCITT Recommendation Q.922 [4] and the end-to-end protocol implemented above them. The network participates in this exchange by means of FPDUs.

The residual error rate for the frame relay layer service is defined as:

$$R_{fr} = 1 - \frac{\text{Total correct SDUs delivered}}{\text{Total offered SDUs}}$$

The residual error rate for frame relay is defined as:

$$R_{fr} = 1 - \frac{\text{Total correct SDUs delivered}}{\text{Total offered FPDUs}}$$

statistical guarantee on traffic parameters: The QoS level for committed traffic characterized by the CIR, B_C, and T_C parameters may be guaranteed with a certain probability. The QoS level for excess traffic characterized by the supplementary parameter B_E may also be guaranteed with a certain probability.

The values of these probabilities are network dependent.

These statistical guarantees may only be verified over an observation period which is:

- sufficiently long with respect to T_C;
- constraining for the network; and
- significant for the user.

As an example, the "busy hour" (in terms of traffic load) of the network may be used for this purpose.

throughput: Throughput for a virtual circuit (see ITU-T Recommendation X.134 [9], figure 1/X.139) is the number of data bits contained in the SDU of the frame successfully transferred in one direction across the virtual circuit per unit time. Successful transfer means that, for each frame, no transmission errors have been detected.

transit delay: Transit delay is defined only between pairs of section boundaries. Transit delay of a Frame relay Protocol Data Unit (FPDU) starts at the time t_1 at which the first bit of the FPDU crosses the first boundary, and ends at the time t_2 at which the last bit of the FPDU crosses the second boundary:

$$\textbf{transit delay} = t_2 - t_1.$$

Transit delay for a virtual circuit is equal to the summation of the section delays.

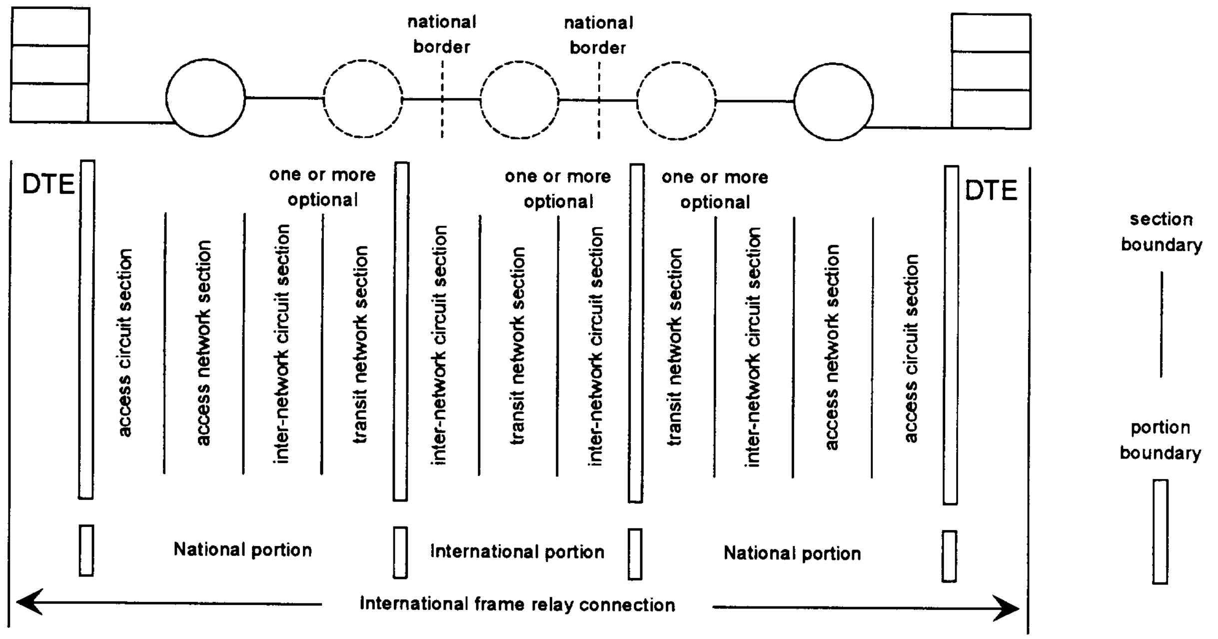


Figure 1: International reference frame relay connection

U-plane: The U-plane refers to the data exchanged across a user-network interface for the data transfer on one or more virtual circuits.

virtual circuit: The term "virtual circuit" refers to a layer 2 virtual circuit, i.e. a frame relay virtual circuit.

4 Symbols and abbreviations

For the purpose of this ETS, the following symbols and abbreviations apply:

BECN	Backward Explicit Congestion Notification
B-ISDN	Broadband Integrated Services Digital Network
B_C	Committed Burst size
B_E	Excess Burst size
CEI	Connection Endpoint Identifier
CIR	Committed Information Rate
CLLM	Consolidated Link Layer Management Message
CONS	OSI Connection Oriented Network layer Service
CPDU	Core Protocol Data Unit
CSAP	Core Service Access Point
CSDU	Core Service Data Unit
DLCI	Data Link Connection Identifier
ECN	Explicit Congestion Notification
FECN	Forward Explicit Congestion Notification
FPDU	Frame relay Protocol Data Unit
ISDN	Integrated Services Digital Network
LAN	Local Area Network
NSAP	OSI Network Service Access Point
OAM	Operation, Administration and Maintenance
OSI-NS	OSI Network layer Service
PSPDN	Packet Switched Public Data Network
QoS	Quality of Service
SDU	Service Data Unit
T_C	Committed rate measurement interval
X.25 DTP	ITU-T Recommendation X.25 [6] Data Transfer Protocol

5 General definition

The frame relay service provides the bi-directional transfer of data units (Core-Service Data Unit (CSDU)) from one user-network interface to another. The data units are routed through the network on the basis of an attached label. This label is a logical identifier with local significance (termed Data Link Connection Identifier (DLCI) in the protocol description). Per DLCI, the order of the data units is preserved from one user-network interface to another.

The user-network interface allows for the establishment of multiple on-demand and/or permanent virtual circuits to many destinations.

This service description shows how the OSI network layer service can be supported (see annex A).

6 Description of the frame relay service

6.1 General description

6.1.1 Characteristics of the frame relay service

The frame relay service has the following characteristics:

1) all C-plane procedures, if needed, are performed in a logically separate manner using protocol procedures that are network dependent and are specified in the network specific frame relay service definition (e.g. in ETS 300 399-2);

2) the U-plane procedures at layer 1 are network dependent. Layer 2 procedures are based on the core functions as defined in annex B (see also subclause 6.1.2). These layer 2 core functions allow for the statistical multiplexing of user information flows immediately above layer 1 functions.

The frame relay service:

a) preserves the order of SDUs transmitted at one user-network interface when they are delivered at the other end;

NOTE: Since the network does not support any procedure above the core functions, the network cannot use information in the frame to preserve the order of SDUs. Nevertheless, networks are implemented in such a way that the frame order is preserved.

b) detects transmission, format, and operational errors (e.g. frames with an unknown label);

c) transports frames transparently, only the label and, hence, the bit error detection information may be modified by the network;

d) does not acknowledge frames.

The functions above are based on the core functions. It provides service quality that is characterized by the values of the following parameters:

- throughput;
- access rate;
- CIR;
- committed burst size;
- excess burst size;
- transit delay;
- residual error rate;
- delivered errored frames;
- delivered duplicated frames;
- delivered out-of-sequence frames;
- lost frames;
- misdelivered frames.

6.1.2 Core functions

The core functions are:

- frame delimiting, alignment and transparency;
- frame multiplexing/demultiplexing using the label (DLCI);
- inspection of the frame to ensure that it consists of an integer number of octets;
- inspection of the frame to ensure that it is neither too long nor too short;
- detection of transmission errors;
- congestion control functions.

6.2 Applications

The frame relay service specified in this ETS aims to support a wide range of data applications and rates from very low to high (including Broadband Integrated Services Digital Network (B-ISDN)). A typical application may be the interconnection of Local Area Networks (LANs).

7 Service classes

The service classes are defined per physical connection; not all service classes may be offered simultaneously on a single physical connection. If a network provides at the user-network interface more than one physical connection (e.g. more than one B-channel in an Integrated Services Digital Network (ISDN)), several service classes per physical connection may co-exist at a user-network interface. Not all service classes are supported on all networks.

The service classes are summarized in table 1.

Table 1: Frame relay service classes

Class			Characteristic	References
P			Layer 2 permanent (permanent virtual call)	subclause 7.1.1
	1		Layer 1 permanent	subclause 7.2.1
		a	with Q.933, annex A connection monitoring	
		b	with Q.933, annex B connection monitoring	
	2		Layer 1 on-demand	subclause 7.2.2
		a	with Q.933, annex A connection monitoring	
		b	with Q.933, annex B connection monitoring	
A			On-demand case A	subclause 7.1.2
	1		Layer 1 permanent	subclause 7.2.1
	2		Layer 1 on-demand	subclause 7.2.2
B			On-demand case B	subclause 7.1.3
	1		Layer 1 permanent	subclause 7.2.1
	2		Layer 1 on-demand	subclause 7.2.2
Q.933 = ITU-T Recommendation Q.933 [5].				

7.1 Layer 2 characteristics

7.1.1 Layer 2 permanent

The layer 2 connection is established for a period of time. No change in the profile is possible. If the layer 1 characteristic is different from "permanent", the layer 2 connection may also be suspended.

7.1.2 Layer 2 on-demand case A

Case A is defined in ITU-T Recommendation Q.933 [5]. It implies a signalling link with a DLCI value "0" on the same physical connection. Signalling on this data link, defined according to ITU-T Recommendation Q.933 [5], is deployed to establish and release layer 2 connections.

7.1.3 Layer 2 on-demand case B

Case B is defined in ITU-T Recommendation Q.933 [5]. It implies signalling on a network dependent physical connection. The network dependent signalling procedures are deployed to establish and release layer 2 connections.

NOTE: The physical connection used for the case B signalling may also be used to carry frame relay traffic (e.g. D-channel in ISDN).

7.2 Layer 1 characteristics

7.2.1 Layer 1 permanent

The layer 1 connection is established for a period of time. The network shall ensure that the physical connection remains established.

7.2.2 Layer 1 on-demand

The physical connection can be released by the terminal equipment. In addition, the network releases the physical connection after a timer expiry after the release of the last virtual circuit on the physical connection; a signalling link, if it exists, is cleared before the release of the physical connection. The network may also release the physical connection in case of a severe error situation. The network does not attempt to (re-)establish the physical connection. The timer may be set to "infinity", i.e. it may never expire.

8 Procedures

8.1 Provision/withdrawal

The frame relay service is offered with several subscription options which apply separately to each network number (e.g. CCITT Recommendation E.164 [1] or CCITT Recommendation X.121 [8] number) or group of network numbers on the interface. For each subscription option, only one value can be selected. Subscription options for the interface are summarized below:

- general subscription to the frame relay service (some networks may not require specific subscription as the frame relay service may be offered as a default for general subscription);

- subscription to the frame relay service with a user defined profile (the DLCI length and convention is also agreed at subscription time - a single convention applies per user-network interface);

- subscription to the conveyance of subaddresses for terminal selection and/or conveyance of NSAP addresses for support of the OSI network layer service;

- subscription to supplementary services as may be required for terminal selection purposes.

In general, there will be a limit on the number of virtual circuits available at the user-network interface:

- maximum number of total virtual circuits present per user-network interface;

- maximum number of total virtual circuits present per physical connection.

8.2 Normal procedures, invocation and operation

All user-network signalling takes place using logically separate messages.

The layer 1 protocol for the U (user) and C (control) planes is network dependent. The C-plane uses either a separate physical connection dedicated to signalling. It may also share the physical connection with other virtual circuits; in such cases, C-plane messages are distinguishable from virtual circuits by a reserved DLCI (label). For permanent virtual circuits, no real time call establishment is necessary and any parameters are agreed upon at subscription time. Depending on the network, the U-plane may use different types of physical connections (e.g. D-channels, B-channels, or H-channels on ISDN) on which the user implements the core functions of annex B.

On-demand and permanent virtual circuit procedures can be invoked and operated concurrently by a given terminal. However, not all service classes can be supported concurrently on a single user-network interface.

8.2.1 On-demand virtual circuit procedures

Before procedures for originating the service are invoked, a physical connection and a reliable data link connection for signalling shall be established.

8.2.1.1 Originating the service (call set-up)

The call is originated by the subscriber requesting from the network the required service with this request including a number identifying the called user. Other information required for the service and additional information (e.g. calling line identification) may also be included.

There are two possible physical channel access arrangements:

- on-demand establishment of the physical connection;

- permanent establishment of the physical connection or use of an already existing physical connection.

In the first arrangement, if a physical connection is not established, or already established channels have no free capacity, another physical connection (if available) is established using the network dependent signalling procedures. Depending on the signalling capabilities of the network, the physical connection may be requested simultaneously with the establishment of the first virtual circuit.

NOTE: Some networks may only provide for one physical connection per user-network interface.

In the second arrangement, no dynamic establishment procedure is required.

Once a physical connection has been established either dynamically or permanently then, in the on-demand virtual circuit case, the values of the logical identifier and the other associated parameters, as defined in clause 6, shall be negotiated during the call set-up by means of C-plane procedures. Depending on the parameters requested, the network can either accept or reject the call.

As a network option, the user-network interface shall allow for the establishment of multiple on-demand or permanent virtual circuits to one or more destinations.

8.2.1.2 Indications during call set-up

If interworking takes place an indication of such interworking is required. The user can then decide whether to proceed with the interworking or to clear the call (see clause 10 and ITU-T Recommendations of the I.500 [3] and CCITT Recommendations of the X.300 [14] series).

Annex A provides for indications specific to the support of the OSI network service.

8.2.1.3 Terminal selection/identification

Terminal selection and identification are network dependent. Supplementary services as well as subaddressing are methods applicable to terminal selection and identification.

NOTE: Some networks may not provide for terminal selection and identification.

8.2.1.4 Call notification

Network dependent signalling procedures are used to notify the user of incoming calls.

NOTE: Some networks allow the called user to request that a call be offered on a specific physical connection from a choice of physical connections. For load sharing purposes, networks may also deploy supplementary services, e.g. hunt groups.

8.2.1.5 Synchronization between C-plane and U-plane

In some cases, there is a gap between the time a connection confirmation is received and when the actual virtual circuit is established. It may be necessary to verify the virtual circuit prior to the beginning of the data transfer. This should be accomplished end-to-end in the U-plane.

8.2.1.6 Terminating the virtual circuit (call clearing)

When the call is cleared all resources used by the call are cleared (e.g. label, call reference value, etc.). In the on-demand physical connection establishment arrangement, if no calls are present and if the user or network so desires, either the user or the network may clear the physical connection.

If the network desires, it may deactivate the C-plane layer 2 and layer 1 connections.

NOTE: Not all access arrangements have a defined deactivated state of the user-network interface.

In the permanent physical connection access arrangement, the network or user may only deactivate the C-plane layer 2 connection.

The virtual circuit may be cleared by either or both of the users by indicating this to the network. In either case, an appropriate indication is sent to the other user. The network may terminate the call for several reasons (e.g. severe congestion, error or failure conditions).

8.2.2 Permanent virtual circuit procedures

For permanent virtual circuits, there is no call set-up or clearing. A physical connection to the network node needs to be in place. The logical identifier and the other associated parameters for the virtual circuit are defined by means of administrative procedures.

8.2.2.1 Layer 1 activation/establishment

The layer 1 physical connection may be permanently active. Such a channel is established at subscription time.

Alternatively, the physical connection may be established on-demand. Either the user and/or the network may release the physical connection (the network bases this decision on an inactivity timer).

In general, the status of the virtual circuits is monitored either via ITU-T Recommendation Q.933 [5], annex A or B procedures.

NOTE: ITU-T Recommendation Q.933 [5], annex A procedures are only applicable if no other signalling procedures are in effect for the physical connection.

8.2.2.2 Terminal selection/identification

No terminal selection or identification procedures are applicable as the terminal has been fixed at subscription time.

8.2.2.3 Virtual circuit establishment

Not applicable.

8.2.2.4 Terminating the virtual circuit

Not applicable.

8.2.3 Data transfer

8.2.3.1 Regular procedures

Frame relay data units are frames as defined in the core service (annex B). The basic frame relay service provided by the network is the unacknowledged transfer of frames between two user-network interfaces.

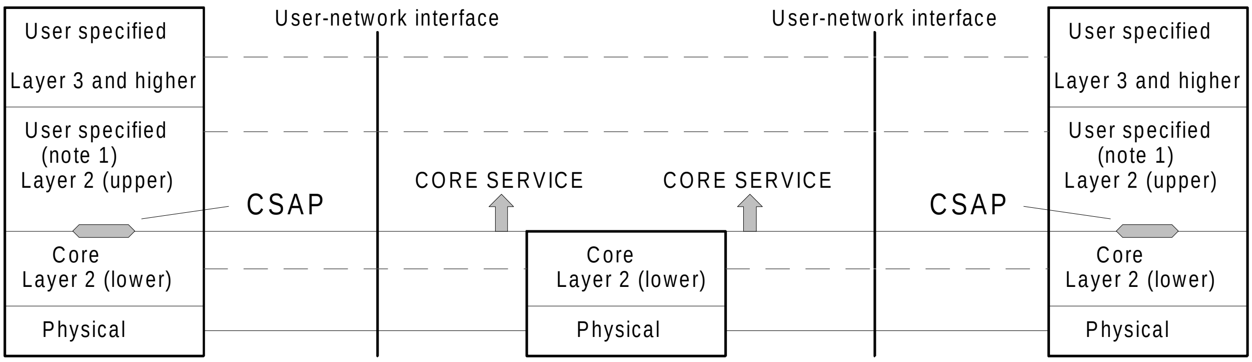
The frame size supported by this service is determined by:

a) the default maximum information field to be supported by all networks is 1 600 octets;

b) all other values are negotiated between users and networks and between networks;

c) certain physical connections (e.g. D-channel in ISDN) may restrict the maximum information field size to less than 1 600 octets.

Figure 2 illustrates the U-plane configuration for this service. Protocol functions up to and including layer 3 are shown. The network does not terminate the full layer 2 protocol; it offers the core service as defined in annex B. The virtual circuits are used to implement the core service; the protocols for the network dependent implementation are indicated in the network specific frame relay service definition (e.g. in ETS 300 399-2).



NOTE 1: CCITT Recommendation Q.922 [4] is one protocol which may be used. Other standard or proprietary protocols may be used.

NOTE 2: Protocols to support the core service are network dependent. The particular protocol to be used is defined, for example, in ETS 300 399-2.

Figure 2: U-plane configuration

The core service can be offered on a variety of access arrangements. Frame size restrictions apply, e.g. when in an end-to-end connection at least one of the access channels is the ISDN D-channel (16 kbit/s or 64 kbit/s).

The data transfer phase of the OSI Connection Oriented Network layer Service (CONS)/(see ITU-T Recommendation X.213 [13]) can be provided by using ITU-T Recommendation X.25 [6] Data Transfer Protocol (X.25 DTP), appropriate ISO layer 2/3 protocols or a convergence protocol above CCITT Recommendation Q.922 [4]. In the latter case, only the mandatory features of the network service as defined in ITU-T Recommendation X.213 [13] are provided. Even though all these arrangements are permitted, the combination of CCITT Recommendation Q.922 [4] and X.25 DTP protocols is preferred because it allows for easy interworking with networks using ITU-T Recommendation X.25 [6] (see annex A for details).

The core service provided in the U-plane can be used to provide the OSI connectionless network service (addendum 1 to ISO 8348 [15]) by using ISO 8473 [16] or other OSI connectionless network protocols directly above the core service or, for example, above the CCITT Recommendation Q.922 [4] unacknowledged information transfer service. In this case, it is assumed that a permanent virtual circuit is used. The use of on-demand virtual circuits is for further study.

8.2.3.2 Congestion management and control

Congestion in the U-plane of a frame relay service occurs when traffic, arriving at a resource (e.g. memory, bandwidth, processor), exceeds the network engineered level. It can also occur for other reasons (e.g. equipment failure). The impact of network congestion is performance degradation in terms of throughput and delay.

The primary objectives of congestion control mechanisms are to maintain, with very high probability, a specified QoS (e.g. throughput, delay, frame loss) for each on-demand or permanent virtual circuit. annex C deals with this in detail.

8.3 Exceptional procedures, invocation and operation

8.3.1 On-demand virtual circuit

In case of failure situations due to calling or called user error, user state, or network conditions, appropriate failure indications will be signalled from the network and the virtual circuit set-up or the established virtual circuit may be terminated.

Depending on the signalling capabilities of the network, restart procedures may be invoked. Restart procedures apply only to the on-demand physical connections. A restart procedure clears all remaining virtual circuits (with their associated call references and DLCI values) active in the specified physical connection that have not been explicitly cleared prior to invocation of the procedure.

8.3.2 Permanent virtual circuit

In case of failure situations due to user error, user state, or network conditions, and if monitoring procedures are deployed, appropriate failure indications shall be signalled from the network.

9 Network capabilities for charging

This ETS does not cover charging principles (see CCITT D-series of Recommendations). However, congestion management procedures and QoS requirements may have charging implications.

10 Interworking

It may be necessary to provide interworking between a network offering the frame relay service described in this service description and other services, e.g. ITU-T Recommendation X.25 [6] based services offered by either an ISDN or a Packet Switched Public Data Network (PSPDN).

For detailed interworking requirements see the ITU-T Recommendations of the I.500 [3] and CCITT Recommendations of the X.300 [14] series.

11 Attributes and values of attributes

The attributes and values are given in table 2.

Table 2: Frame relay service attributes

	Information transfer attributes	
1	Information transfer mode	Frame
2	Information transfer rate	Less than or equal to the maximum bit rate of the user information access channel and the throughput of the frame relay connection (DLCI)
3	Information transfer capability	Unrestricted
4	Structure	Service data unit integrity
5	Establishment of communication	On-demand Permanent
6	Symmetry	Bi-directional symmetric
7	Communication configuration	Point-to-point
	Access attributes	
8	Access channel	Network dependent
9	Access protocol	Network dependent
	General attributes	
10	Supplementary services provided	Network dependent
11	QoS	Network dependent (note)
12	Interworking possibilities	Network dependent
13	Operational and commercial	Network dependent
NOTE: Congestion management can affect QoS.		

12 Dynamic description

No dynamic description is provided for this ETS.

13 Numbering plan

The numbering plan applicable is network dependent. In some situations, more than one numbering plan may be applicable. In this case, the numbering plan used is service provider dependent.

Annex A (normative): Support of the OSI network layer service

A.1 General

This annex describes how the frame relay service supports the OSI Network layer Service (OSI-NS) described in ITU-T Recommendation X.213 [13].

NOTE 1: Among all the elements included in the OSI-NS some are "service provider options". Therefore, a distinction is drawn between elements indicated as optional below, and all of the others, indicated as mandatory.

The OSI-NS consists of three phases:

- connection establishment phase;
- data transfer phase;
- connection release phase.

In the following, it is shown how connection establishment and release phases are provided using C-plane procedures. The data transfer phase is provided by the core service, the CCITT Recommendation Q.922 [4] service above the core service, plus another protocol.

Also illustrated is the way in which support of the OSI-NS provides a general framework for interworking.

The following functions need to be supported by the protocol above the CCITT Recommendation Q.922 [4] service:

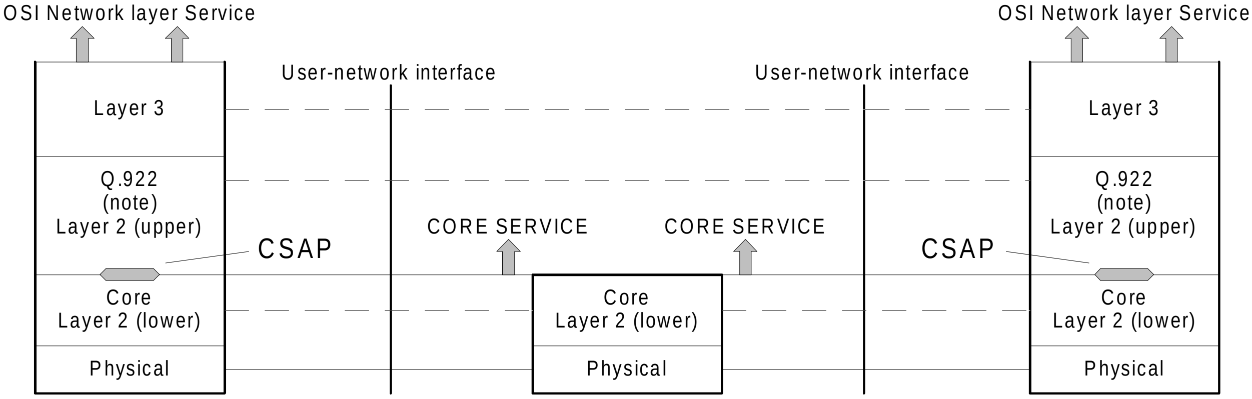
- segmentation and reassembly (see note 2);
- RESET (see note 2);
- protocol discriminator;
- expedited data;
- qualified data indication.

NOTE 2: There is a strong requirement for these functions.

A.2 Connection establishment and release

The connection establishment and release phases of the OSI-NS are provided by C-plane procedures. Network service connection establishment and release primitives are mapped into C-plane messages and exchanged out-of-band on the physical connection reserved for signalling or in-band on a signalling DLCI.

For example, the Q.930-series of ITU-T Recommendations provide the protocol capabilities for the negotiation of all the mandatory and optional elements of the service and parameters as recommended in ITU-T Recommendation X.213 [13], however, it is a service provider option to provide the capabilities.



NOTE: CCITT Recommendation Q.922 [4] is one protocol which may be used. Other standard or proprietary protocols may be used.

Figure A.1: Data transfer phase

A.3 Data transfer

The OSI data transfer phase is provided by a protocol that resides in the end systems and operates above the CCITT Recommendation Q.922 [4] layer service (protocol entity "layer 3" in figure A.1) on the virtual circuit obtained during the connection establishment phase. The protocol "layer 3" shall provide the elements of the network service that were negotiated during the connection establishment phase.

Two approaches are identified to provide for the functions depicted by "layer 3":

1) use of X.25 DTP;

2) a new convergence protocol.

Since approach 2) only ensures the provision of the mandatory features of the OSI-NS it needs to be determined, for a given service context, whether the optional features are required.

A.4 Interworking

For cases when there is a need for interworking with ITU-T Recommendation X.25 [6]/X.31 [7] networks or when all of the mandatory and optional elements of the OSI network service are desired, approach 1) of clause A.3 is recommended.

When interworking between networks supporting the ITU-T Recommendation X.213 [13] service is required, it can be accomplished through the mapping of protocol elements. In this case, some optional elements of the network service may not be supported.

A.5 Co-ordination of C-plane and U-plane

A co-ordination mapping function is needed to provide both call control and data transfer functions of the OSI CONS.

Annex B (normative): Core service description

Introduction

This annex contains the abstract description of the core service, a layer service in the U-plane.

The core service is provided by the frame relay service. In this case, the core service is supported by a sublayer of the data link layer of the OSI reference model, called the core sublayer.

The OSI layer service definition conventions (ITU-T Recommendation X.210 [12]) are the basis of the abstract description of the core service. The abstract description focuses on a data transfer service. Call control aspects are:

- supported by functions in the control plane and co-ordinated by systems management;
- in the case of permanent core service provision, created by fixed allocation of resources.

B.1 Definitions

B.1.1 OSI reference model definitions

This annex is based on the concepts developed in the basic reference model and makes use of the following terms defined in CCITT Recommendation X.200 [11], as they apply to the core service:

a) (N)-entity;

b) (N)-sublayer;

c) (N)-service;

d) (N)-service-access-point;

e) (N)-connection;

f) (N)-connection-endpoint;

g) (N)-connection-endpoint-identifier;

h) (N)-service-data-unit.

B.1.2 Service conventions definitions

This annex makes use of the following terms defined in ITU-T Recommendation X.210 [12], as they apply to the core service:

a) service user;

b) service provider;

c) primitive;

d) request;

e) indication.

B.2 Definition of the core service

B.2.1 Scope

This subclause defines the core service in terms of:

a) the primitive actions and events of the service;
b) the parameters associated with each primitive action and event and the form that they take; and

c) the interrelationship between, and the valid sequences of, these actions and events.

The principal objective of this clause is to specify the characteristics of a conceptual core service and, therefore, to guide the development of core protocols. This annex does not specify individual implementation of products, nor does it constrain the implementation of core entities and interfaces within a system. Instead, conformance is achieved through implementation of conforming core protocols that fulfil the core service defined in this annex.

B.2.2 Overview of the core service

The core service provides for the connection-oriented transparent transfer of data between core service users. It makes invisible to these core service users the way in which supporting communications resources are utilized to achieve this transfer.

In particular, the core service provides the following:

a) independence of the underlying physical layer.

   The core service relieves core service users from all concerns, with the exception of QoS considerations, regarding the means for providing the physical layer service (e.g. basic rate or primary rate interface, point-to-point or point-to-multipoint access);

b) transparency of transferred information.

   The core service provides for the transparent transfer of core service user data. It does not restrict the content, format, or coding of the information; nor does it ever need to interpret its structure or meaning. It may, however, restrict the maximum length of a core service data unit.

   NOTE: Addressing (i.e. of Core Service Access Points (CSAPs)) is not provided by the core service or needed by the core service user. Selection of a CSAP to be associated with a core connection is a local matter.

B.2.3 Features of the core service

The core service provides the following features to the core service user:

a) core connections of which establishment is co-ordinated by systems management;

b) agreed QoS for a core connection, co-ordinated on behalf of the peer core service users and the core service provider by protocols in the C-plane and management plane;

c) a means by which CSDUs are transparently transferred in sequence on a core connection. The transfer of CSDUs, which consist of a limited, integer number of octets, is transparent in that the boundaries and contents of the CSDU are preserved unchanged by the core service and there are no constraints on CSDU content imposed by the core service;

d) associated with each instance of unconfirmed transmission, certain measures of QoS;

e) the means by which the core service provider may indicate present or incipient congestion to the core service user;

f) the unconditional, and therefore possibly destructive, release of a core connection by either of the core service users or the core service provider.

B.2.4 Model of the core service

The core service is modelled using the abstract model of a layer service defined in the OSI service convention (ITU-T Recommendation X.210 [12]). The model defines the interactions between the core service users and the core service provider which take place at the two CSAPs. Information is passed between the core service user and the core service provider by service primitives, which convey parameters. Figure B.1 shows this model.

B.2.4.1 Core connection endpoint identification

To distinguish among several core connections at a CSAP, a local connection endpoint identification mechanism shall be provided. All primitives issued at the CSAP are required to use this mechanism to identify the core connection with which they are associated. Such identification is a local matter, and, therefore, is not described further in this annex.

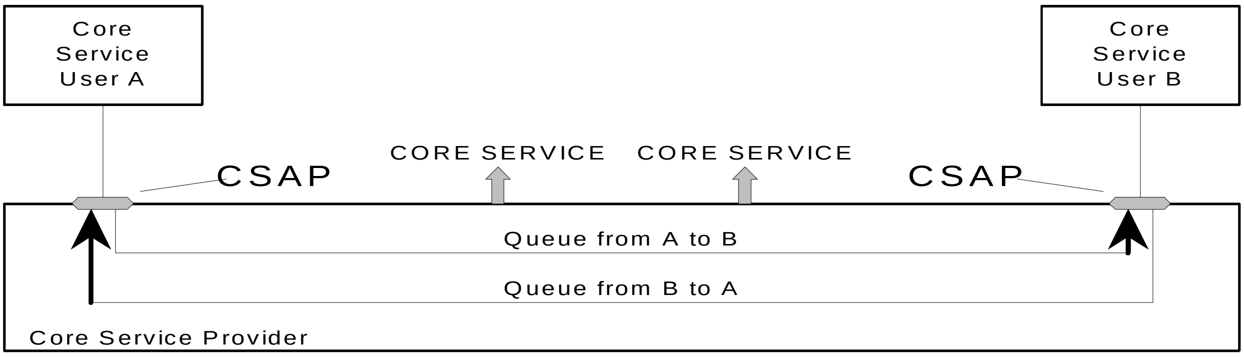


Figure B.1

B.2.4.2 Model of the core connection

The queue model of a core connection is discussed only as an aid to understanding of the end-to-end service features perceived by the core service users. It does not attempt to describe all the functions or operations of core entities that are used to provide the core service. No attempt to specify or constrain implementations is implied.

The internal mechanisms which support the operation of the core service are not visible to the core service user.

B.2.4.3 Queue model concepts

The queue model represent the operation of a core connection in the abstract by a pair of queues linking the two CSAPs. There is one queue for each direction of information flow. These queues operate independently. Objects are added to or removed from the queue as a result of interaction at the two CSAPs.

NOTE: The queue model does not model the operation of underlying management protocols.

Only the core service user may place objects in the queue. The only object defined in this service is a data object, which represents a Core-DATA-request or Core-DATA-indication primitive and its parameters. The queue has the following properties:

1) the queue is empty when it is created by core connection establishment, and becomes empty with the loss of its contents during connection release;

2) objects are entered into the queue by the sending core service user. Objects are never entered into the queue by the core service provider;

3) objects are removed from the queue by the core service user. They may be deleted from the queue by the core service provider;

4) objects are removed from the queue in the same order that they were entered;

5) a queue has limited capacity, but this capacity is not necessarily fixed or determinable by the core service user.

B.2.4.4 Core connection establishment

A pair of queues is associated with a core connection between two CSAPs when the core service provider establishes a core connection. The queues remain associated with a core connection until the core connection is released.

Core connection establishment is co-ordinated between core service users and the core service provider through systems management.

B.2.4.5 Data transfer

To transfer data, the sending core service user enters data object in the queue. The receiving core service user removes data objects from the queue in the order in which they were entered. Data objects do not interfere with one another, i.e. they are not defined to be destructive (although their cumulative effect may result in some data objects being deleted by the core service provider).

The core service provider may delete data objects from the queue at any time. The core service users negotiate rate and burst size QoS parameters with the core service provider. In general, data objects entered into the queue in excess of the agreed rate and burst size parameters (where this determination is made based on both the rate at which objects are entered and their size) have a higher probability of being deleted than objects entered into the queue within these parameters. The sending core service user may also indicate data objects which may be deleted with this higher probability. The core service provider may provide an indication to the sending core service user and/or the receiving core service user when the capacity of the queue is exceeded and/or has been reached.

B.2.4.6 Core connection release

The core service provider may release the core connection at any time. This results in disassociation of the queues from the core connection, and destruction of any data objects in the queues.

Core connection release is co-ordinated between core service users and core service providers through systems management.

B.2.5 Sequence of primitives at one core connection endpoint

The possible overall allowed sequence of primitives at a core connection endpoint are defined in the state transition diagram of figure B.2.

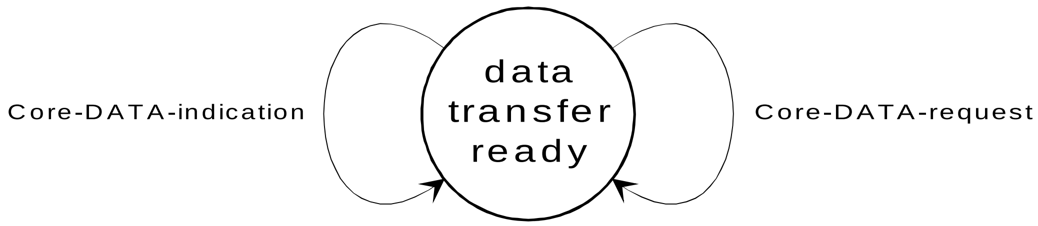


Figure B.2: State transition diagram for a sequence of core service primitives at a core connection endpoint

B.2.6 Data transfer primitives

The data transfer service primitives provide for an exchange of user data (CSDUs) in either direction or both directions on a core connection. The core service preserves the sequence and boundaries of the CSDUs.

B.2.6.1 Service primitives and parameters

Table B.1 summarizes the primitives and parameters for data transfer in the core service.

Table B.1: Core service primitives and parameters

	Core-DATA-request	Core-DATA-indication
Core-user-data	X	X
Discard eligibility (optional)	X	
Congestion encountered backward (optional)		X
Congestion encountered forward (optional)		X
Core service user protocol control information	X	X

B.2.6.1.1 Primitives: Core-DATA-request and Core-DATA-indication

The Core-DATA-request and Core-DATA-indication primitives permit peer core service users to transfer Core-user-data on an active core connection. This is an unconfirmed service; i.e. there is no confirmation to the core service user that CSDUs have been accepted by the service provider or the peer core service user, and no response to the core service provider that CSDUs have been accepted by the core service user. Therefore, only the Core-DATA-request and Core-DATA-indication are provided. In addition, as Core Protocol Data Units (CPDU) are subject to discarding (e.g. due to congestion or corruption) a Core-DATA-request primitive conveyed to the core service provider in one peer system will not necessarily cause a corresponding Core-DATA-indication primitive to be conveyed to the core service user in the other peer system. Further, there is a residual probability of CSDU misdelivery and/or misordering.

The Core-DATA-indication primitive may have associated with it an optional congestion encountered parameter. The Core-DATA-request primitive may have associated with it an optional transfer priority parameter.

B.2.6.1.2 Parameters

B.2.6.1.2.1 Core-user-data

The Core-user-data parameter conveys data between users of the core service. The minimum size of the Core-user-data parameter is one octet. the maximum size of the Core-user-data parameter is bounded, and is established either by configuration management or by negotiation by the network layer on behalf of the peer core entities in the C-plane. Core-user-data is transferred by the core service provider without modification or regard to content; however, there is a residual probability that it will be subject to corruption (i.e. insertion, deletion or alteration of bits).

B.2.6.1.2.2 Congestion

The congestion parameters convey information about the capability of the core service provider to transfer additional CSDUs from the core service provider to the core service user. There are two congestion encountered parameters. The congestion encountered forward parameter indicates that the core service provider has determined incipient congestion in transferring a CSDU to the core service user. The congestion backward parameter indicates that the core service provider is experiencing congestion in transferring CSDUs units from the core service user.

B.2.6.1.2.3 Discard eligibility

The transfer priority parameter conveys from the core service user to the core service provider the priority of the CSDU relative to other CSDUs. It may be used by the core service provider to select CSDUs to discard, in the event that discard of CSDUs is necessary.

B.2.6.1.2.4 Core service user protocol control information

One bit of core service user protocol control information is transparently conveyed by the core service provider on behalf of the core service user.

NOTE: This capability is provided in support of existing data link protocols. It is present for pragmatic reasons, and is sanctioned by the OSI reference model (CCITT Recommendation X.200 [11]).

B.2.6.1.3 Sequence of primitives

The sequence of primitives in a successful data transfer is defined in the time sequence diagram in figure B.3.

Figure B.3: Sequence of primitives in the data transfer phase

B.2.7 Quality of service

The term "quality of service" refers to certain characteristics of a core connection as observed between the core connection endpoints. QoS describes aspects of the core connection that are attributable solely to the core service provider.

The core service QoS parameters can be divided into the following types, based on the way in which their values are determined:

a) those QoS parameters which may be selected on a per-connection basis during the establishment of core connection;

b) those QoS parameters which are not selected during core connection establishment but whose values are known by other methods.

The following QoS parameters are of the type which may be selected during core connection establishment:

- throughput (i.e. CIR, committed burst size B_C, excess burst size B_E);

- transit delay.

Selection procedures are co-ordinated through system management. Once the core connection is established, throughout the lifetime of the core connection the agreed QoS parameter can be reselected at any point by the core service provider, and there is no guarantee that the original values will be maintained. The core service users may or may not receive notification of changes in QoS.

The following QoS characteristics are identified as parameters, but not selected during core connection establishment:

- residual error rate (corruption, extra, loss);

- resilience.

Protection and priority, which are part of the QoS of other OSI service definitions, are not presently described and are for further study.

NOTE: Misdelivered frames are accounted for as "extra" and "loss".

B.2.7.1 Throughput

The throughput parameters are defined in clause 3.

B.2.7.2 Transit delay

Transit delay is the elapsed time between Core-DATA-request primitives and the corresponding Core-DATA-indication primitives. Elapsed time values are calculated only on CSDUs that are successfully transferred.

NOTE: Transit delay in this service definition takes into account those delays associated with the local systems containing the core service users as well as those defined in clause 3.

Annex C (normative): Congestion management for the frame relay service

C.1 Congestion management principles

C.1.1 Scope

This annex describes U-plane based congestion management strategy and mechanisms for the frame relay service. It covers both network and end-user mechanisms and responsibilities to avoid or recover from periods of congestion. C-plane procedures at the user network interface other than clearing or not accepting calls are not recommended. Procedures, objectives and requirements for C-plane congestion management between networks are for further study. This strategy is intended to operate for physical connection rates of 2 048 kbit/s or less.

C.1.2 Objectives of congestion management

The primary objectives of congestion control mechanisms are to maintain, with a very high probability, specified QoS (e.g. throughput, delay, frame loss) for each on-demand or permanent virtual circuit.

Congestion in the U-plane of a frame relay service occurs when traffic, arriving at a resource (e.g. memory, bandwidth, processor), exceeds the network engineered level. It can also occur for other reasons (e.g. equipment failure). The impact of network congestion is performance degradation in terms of throughput and delay.

Two levels of congestion in terms of impact on class of service, are defined. Point A is the point beyond which the transit delay in the frame relay network increases at a rate faster than the rate at which offered load is increased. This is due to the network entry into a mild congestion state. This point is the final point on the curve that the network can guarantee the negotiated class of service. A further increase in offered load may cause a degradation in class of service. Point B is the point where the network begins discarding frames to control the existing level of congestion and prevent additional damage to the network provided services (see figure C.1 for points A and B).

Points A and B are dynamic values determined by the instantaneous condition of the network resources. The end-user may perceive the movement from point A to point B without increasing the offered load (e.g. due to resource failure or reconfiguration within the network). Threshold values are determined relative to the U-plane QoS objectives to the end-user. Specific networks may define different values, reflecting different performance objectives (e.g. for the support of different grades of services), even within the same network.

Congestion avoidance mechanisms aim to:

- maintain, with high probability and minimal variance, an agreed QoS;
- minimize the possibility that one end-user can monopolize network resources at the expense of other end-users;
- be simple to implement, and place little overhead on either the end-user or the network;
- create minimal additional network traffic;
- distribute network resources fairly among end-users;
- limit spread of congestion to other networks and elements within the network;
- operate effectively regardless of the traffic flow in either direction between end-users;
- have minimum interaction or impact on other systems in the frame relay network; and
- minimize the variance in QoS delivered to individual virtual circuits during congestion (e.g. individual virtual circuits should not experience sudden degradation when congestion approaches or has occurred).

Congestion recovery mechanisms (in addition to the above) aim to ensure recovery of the network from a severely congested state.

C.1.3 Requirements of congestion control mechanisms

Congestion management mechanisms should have the following characteristics:

- be part of the U-plane. Explicit Congestion Notification (ECN) shall be provided for in the U-plane;

  NOTE: This applies to real time notification aspects of congestion control and assumes that management functions such as gathering of statistics on congestion (i.e. when, where, why) could be accomplished outside the U-plane.

- ensure transport of ECN across frame relay networks. The network(s) shall convey the Backward ECN (BECN) towards the source end-user and the Forward ECN (FECN) towards the destination end-user. This requires that these indications (if set) shall not be reset as they traverse the network(s) towards source and destination users;

- from a service perspective, call set-up negotiations (e.g. throughput) are rate based. This means that from the standpoint of the service provided by the network in a frame relay environment, the rate at which information is offered to the network (which may be expressed in a number of information units per unit of time) is fundamental to all types of traffic to be carried;

- reaction by the end-user to the receipt of ECN (FECN/BECN) is rate based and may be subject to standardization. It is noted that window mechanisms in terminals approximate rate based mechanisms and may be used to control the rate at which traffic is offered to a network;

- networks should utilize, and users should react to, ECN (i.e. not mandatory but highly desirable);

- data sources which are unable to respond to ECN (i.e. CLLM) can only be controlled by metering and discard;

- the network which perceives congestion should have the option to generate congestion notification using the appropriate congestion control protocols. When ECN is generated, it shall be sent in the appropriate direction(s). The policies for sending ECN will be different for the source control and destination control mechanisms;

- the end-users (e.g. private networks) may generate ECNs.

C.1.4 Congestion management strategy

Distributed real-time congestion controls are necessary to prevent, and recover from, congestion during infrequent periods of coincidental peak traffic demands.

Congestion avoidance action is the joint responsibility of both the network and the end-user and requires co-ordination between them. Avoidance procedures seek to return network operation to region 1 of figures C.1 and C.2.

Congestion avoidance with explicit signalling and congestion recovery with implicit signalling are considered to be effective and complementary forms of congestion control in the frame relay service.

Congestion avoidance and recovery schemes are distributed in that traffic monitoring (e.g. by buffer usage) is most efficient and accurate at congested resources, while traffic rate control is most effective when carried out by an end-user. For end-users to know when to decrease/increase their traffic rates, there needs to be a standardized notification mechanism between the network and end-user.

Joint responsibility and procedures between the end-user and the network should be verifiable by the network.

Congestion recovery initiation is the responsibility of the network. The end-user should assist the network by continuing the avoidance procedures. Congestion recovery is used to help control offered load on severely congested network and move from region 3 to region 1 of figures C.1 and C.2.

C.1.4.1 Congestion control mechanisms

C.1.4.1.1 Explicit congestion notification

Commonly used end-to-end protocols operate with either source controlled or destination controlled transmit mechanisms for which two optional ECN mechanisms for the frame relay service are provided. These mechanisms, when implemented, are independent, not mutually exclusive, and may be used concurrently.

Mechanism 1: For destination controlled transmitters, the FECN is set in the core aspects protocol.

Mechanism 2: For source controlled transmitters, the BECN is set in the core aspects protocol in frames transported in the reverse direction (i.e. toward the transmitter). Alternatively, a CLLM may be generated. This provides reverse notification for one or more DLCIs within a single frame. The CLLM is sent on the layer management DLCI in the U-plane in the backward direction (i.e. toward the source end-user). The CLLM and the BECN may be used together or separately to notify the end-user.

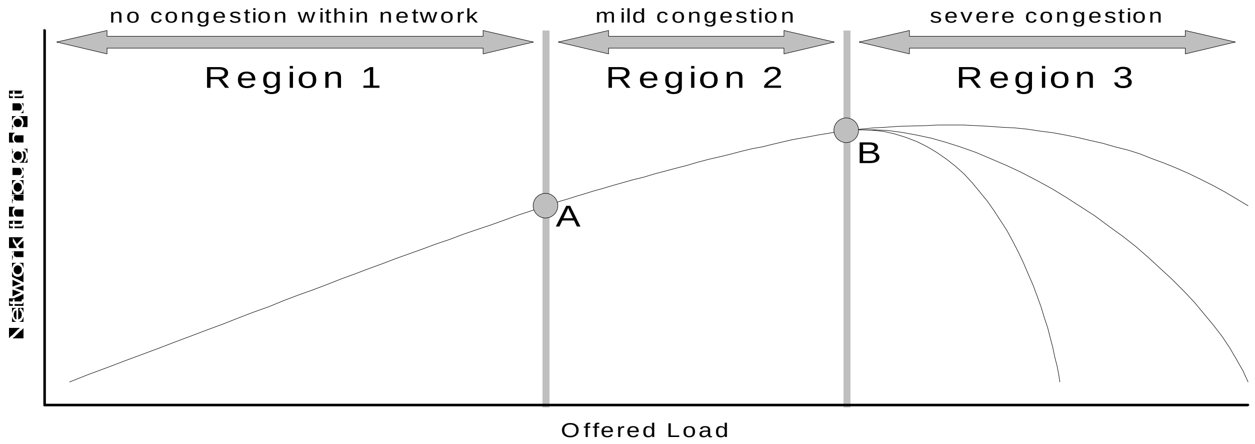
C.1.4.1.2 Discard eligibility

The use of the discard eligibility indicator by the users and the network is optional. This discard eligibility indicator may be set by the user and/or the network. The discard eligibility indicator determines whether or not this frame should be discarded by the network in preference to other frames. This decision would be necessary when the network is congested, and frames need to be discarded to ensure safe network operation and to maintain the committed level of service within the network. Frames offered in excess of the committed size (B_C) may be marked discard eligible by the network.

The discard eligibility indicator is symmetrical, and is passed across both the user-network interface and the network-node interface.

C.1.4.2 Network response to congestion

The network should in principle generate ECN using the appropriate protocol to the source end-user and/or the destination end-user around point A (see figure C.1). All networks shall transport the FECN and BECN indications, either unmodified or, if in congested condition, with the appropriate indication set.



NOTE: The different lines in the severe congestion region reflect the fact that networks react and degrade differently in the face of severe congestion.

Figure C.1: Throughput and network congestion

Notification in the backward direction can be accomplished using either (or both) of two optional mechanisms:

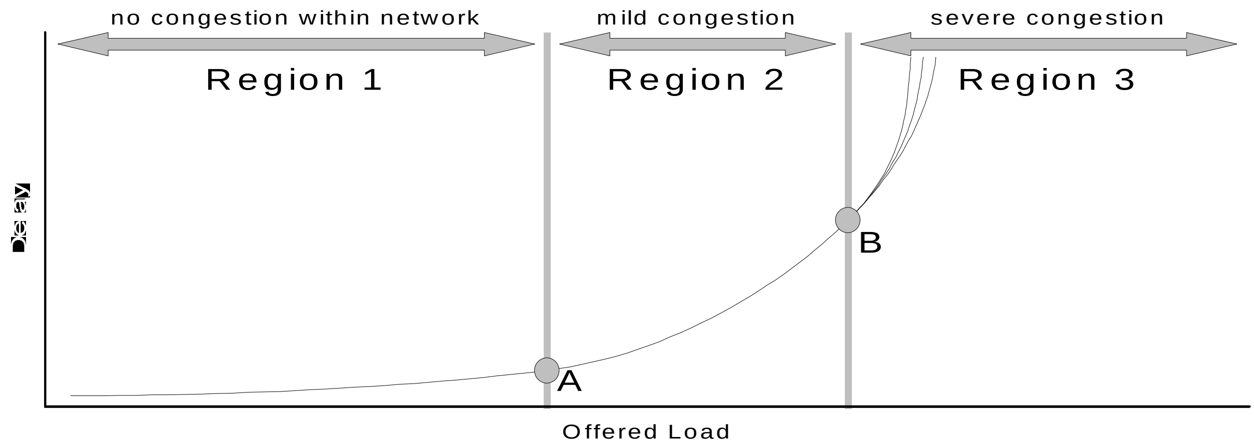
- **BECN:**

  a BECN indication is sent with reverse traffic. When there is reverse traffic at the time congestion is noted, then the BECN indication can be carried on an existing frame;

- **CLLM:**

  the generation and transport of consolidated link layer management messages by a network is optional. If a network receives this message and does not implement this option, then the consolidated link layer message should be discarded.

The network cannot rely solely on user behaviour to control network congestion. Therefore, the network is expected to protect itself from catastrophic congestion situations, and may do so by monitoring the throughput of each call and invoking the frame discard strategy under congestion conditions for those calls which exceed the lesser of CIR and the information rate currently available to be allocated by the network. Therefore, as congestion can occur even when the calls do not exceed their negotiated throughput (e.g. during network failures), the network should discard frames in a way that assures fairness among users. In certain congestion situations the network may refuse to accept new calls and/or clear existing calls.



NOTE: The different lines in the severe congestion region reflect the fact that networks react and degrade differently in the face of severe congestion.

Figure C.2: Delay and network congestion

C.1.4.3 User response to congestion

The end-users should in principle reduce their offered load upon receiving implicit or explicit indication of network congestion. Terminals shall have the capability to receive the ECN generated by the network even if they are not able to act on the information. Reduction of information transfer rate by an end-user may result in an increase in the effective throughput available to the end-user during congestion. A user of the frame relay service should implement some form of congestion-sensitive rate adjustment function that has the following characteristics:

- no blocking of data flow under normal conditions even when the offered load exceeds the CIR;
- reduction to a lower information transfer rate upon detection of network congestion;
- progressive return to the negotiated information transfer rate upon congestion abatement.

The end-user terminal should base the detection of network congestion on implicit congestion detection schemes as well as on ECN.

Implicit congestion detection schemes involve certain events available in the CCITT Recommendation Q.922 [4] elements of procedures (e.g. reception of a REJECT frame, detection of frame loss, timer expiration, etc.) or at a higher layer.

C.1.4.3.1 Terminals employing destination controlled transmitters

Reaction, to implicit congestion detection or ECN (FECN) bit, when supported, should be as follows:

- consistent with commonly used destination controlled protocol suites (e.g. the OSI Class 4 Transport protocol operated over the OSI connectionless network service);

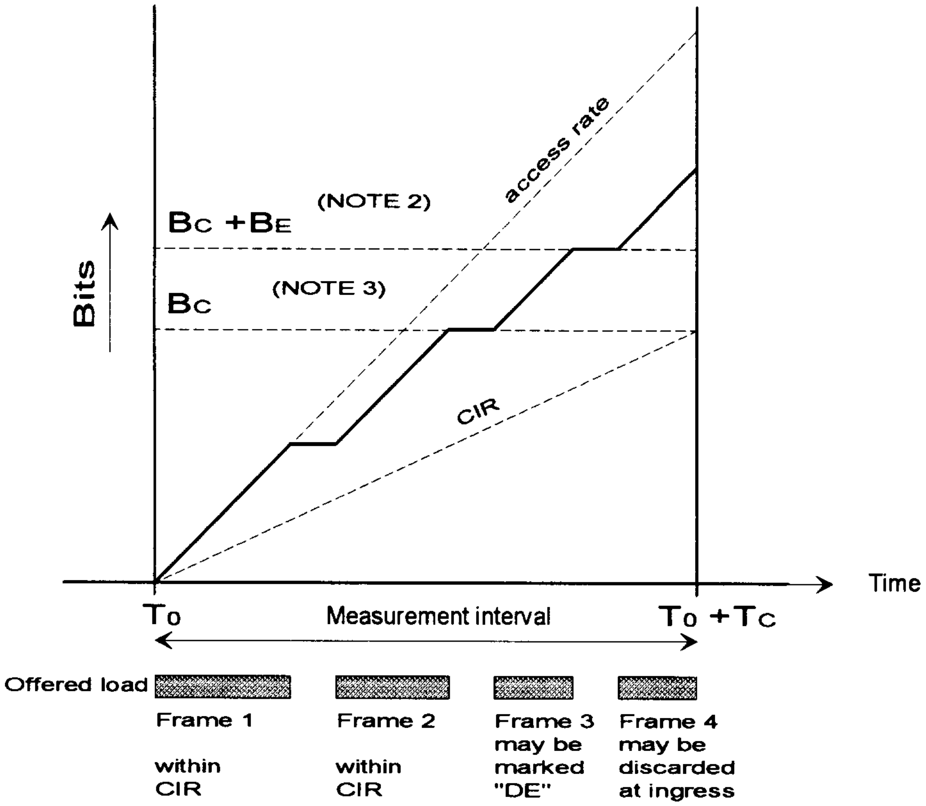
- rate adjustment is typically a function of higher layer protocols; and

- end-user reaction is based on the state of the FECN bits that are received over a period of time.

C.1.4.3.2 Terminals employing source controlled transmitters

Reaction, to implicit congestion detection or ECN (BECN) bit or CLLM, when supported, should be as follows: Rate adjustment is typically a function of the data link layer elements of procedure, and end-user reaction is expected to be immediate when a BECN bit or CLLM is received.

Figure C.3 illustrates the relationships between access rate, excess burst size (B_E), committed burst size (B_C), CIR, discard eligibility indicator, and the measurement interval parameters. The CIR, B_C and B_E parameters are negotiated at call establishment time (for demand establishment of communication or by subscription for permanent establishment of communication. Access rate is established by subscription for permanent access connections or during demand access connection establishment. Each end-user and the network participate in the negotiation of these parameters to agreed values. These negotiated values are then used to determine the measurement interval parameter T_C, also, when the discard eligibility indicator (if used) is set. These parameters are also used to determine the maximum allowable end-user input.



NOTE 1: Number of frames and size of frames are for illustrative purposes only.

NOTE 2: Frames may be discarded at ingress node. This is a region of rate enforcement.

NOTE 3: Frames may be marked as discard eligible.

Figure C.3: Illustration of the relationships between parameters

The measurement interval can be determined as shown in table C.1. The network and the end-users may control the operation of the discard eligibility indicator and the rate enforcer functions by adjusting the CIR, B_C and B_E parameters in relation to the access rate. If both the CIR and B_C parameters are not equal to zero, then $T_C=B_C/CIR$. In addition, there are two special conditions:

1) when CIR-access rate, $B_C = 0$ and $B_E = 0$, both access rates are equal (i.e. ingress = egress);

2) when CIR = 0 (B_C is equal to 0) and $B_E > 0$, then $T_C=B_E$/access rate.

Figure C.3 is a static illustration of the relationship among time cumulative user data (bits) and rate. In this example, the user sends four frames during the measurement interval T_0 to (T_0+T_C). The slope of the line marked CIR is B_C/T_C. Bits are received at the access rate (by the ingress node) of the access channel. Since the sum of the number of bits contained in frames 1 and 2 is not greater than B_C, the network does not mark these frames with the discard eligibility indicator. The sum of the number of bits in frames 1, 2, and 3 is greater than B_C but not greater than B_C+B_E; therefore, frame 3 may be marked discard eligible. Since the sum of the number of all bits received by the network in frames 1, 2, 3, and 4 exceeds B_C+B_E, frame 4 may be discarded at the ingress node. Figure C.3 does not illustrate the case where the end-user sets the discard eligibility indicator. In this case the frames are considered within B_E and not CIR.

Table C.1: Congestion parameter states

CIR	B_C	B_E	Measurement interval (T_C)
> 0	> 0	> 0	$T_C = B_C$ / CIR
> 0	> 0	= 0	$T_C = B_C$ / CIR
= 0	= 0	> 0	$T_C = B_E$ / access rate
NOTE: This table contains the known valid parameter configurations. Other parameter configurations are for further study.			

Annex D (informative): Bibliography

The following references are used for informative purposes in this ETS:

1) ETS 300 399-2: "Frame relay services; Part 2: Integrated Services Digital Network (ISDN); Frame relay bearer service; Service definition".

2) ETS 300 399-3: "Frame relay services; Part 3: Integrated Services Digital Network (ISDN); Frame relay data transmission service; Service definition".

3) ETS 300 399-4: "Frame relay services; Part 4: Broadband Integrated Services Digital Network (B-ISDN); Frame relay bearer service; Service definition" (DE/NA-053207, under development).

4) CCITT Recommendation I.320: "ISDN protocol reference model".

5) CCITT Recommendation I.370: "Congestion management for the ISDN frame relaying bearer service".

6) CCITT D-series of Recommendations: "Leasing, tariffing, charging and accounting".

7) ITU-T Q.930-series of Recommendations: "ISDN user-network interface layer 3".

8) CCITT Recommendation X.212: "Data link service definition for open systems interconnection for CCITT applications".

History

Document history	
March 1995	First Edition
October 1995	Converted into Adobe Acrobat Portable Document Format (PDF)

ISBN 2-7437-0096-3 - Edition complète
ISBN 2-7437-0097-1 - Partie 1
Dépôt légal : Mars 1995