

INTERNATIONAL STANDARD

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Information technology — Open Systems Interconnection — Protocol for providing the connection-mode transport service

*Technologies de l'information — Interconnexion de systèmes ouverts
(OSI) — Protocole pour fourniture du service de transport en mode
connexion*



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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 8073 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.224.

This fourth edition cancels and replaces the third edition (ISO/IEC 8073:1992), which has been technically revised. It also incorporates Technical Corrigendum 1:1993 and Technical Corrigendum 2:1994.

Annexes A to E form an integral part of this International Standard.

Introduction

This Recommendation | International Standard is one of a set of Recommendations | International Standards produced to facilitate the interconnection of information processing systems. This set of Recommendations | International Standards covers the services and protocols required to achieve such interconnection.

The Transport Protocol is positioned with respect to other related Recommendations | International Standards by the layers defined in the Reference Model for Open Systems Interconnection (see CCITT Rec. X.200 | ISO 7498). It is most closely related to, and lies within the field of application of the Transport Service (see ITU-T Rec. X.214 | ISO/IEC 8072). It also uses and makes reference to the Network Service Standard (see CCITT Rec. X.213 | ISO/IEC 8348), whose provisions it assumes in order to accomplish the transport protocol's aims. The interrelationship of these Recommendations | International Standards is illustrated in Figure Intro. 1.

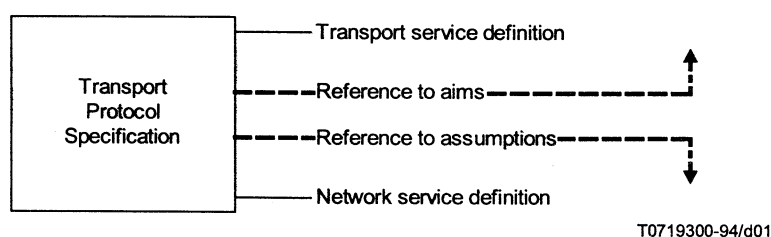


Figure Intro. 1 – Relationship between the Transport Protocol and adjacent services

This Recommendation | International Standard specifies a common encoding and a number of classes of transport protocol procedures to be used with different network qualities of service.

It is intended that the Transport Protocol should be simple but general enough to cater for the total range of Network Service qualities possible, without restricting future extensions.

The protocol is structured to give rise to classes of protocol which are designed to minimize possible incompatibilities and implementation costs.

The classes are selectable with respect to the Transport and Network Services in providing the required quality of service for the interconnection of two session entities (each class provides a different set of functions for enhancement of service qualities).

This Recommendation | International Standard defines mechanisms that can be used to optimize network tariffs and enhance the following qualities of service:

- a) different throughput;
- b) different error rates;
- c) integrity of data requirements;
- d) reliability requirements.

It does not require an implementation to use all of these mechanisms, nor does it define methods for measuring achieved quality of service or criteria for deciding when to release transport connections following quality of service degradation.

The primary aim of this Recommendation | International Standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer entities at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes, i.e.:

- a) as a guide for implementors and designers;
- b) for use in the testing and procurement of equipment;
- c) as part of an agreement for the admittance of systems into the open systems environment;
- d) as a refinement of the understanding of OSI.

As it is expected that the initial users of this Recommendation | International Standard will be designers and implementors of equipment, this Recommendation | International Standard contains, in notes or in annexes, guidance on the implementation of the procedures defined herein.

It should be noted that, as the number of valid protocol sequences is very large, it is not possible with current technology to verify that an implementation will operate the protocol defined in this Recommendation | International Standard correctly under all circumstances. It is possible by means of testing to establish confidence that an implementation correctly operates the protocol in a representative sample of circumstances. It is, however, intended that this Recommendation | International Standard can be used in circumstances where two implementations fail to communicate in order to determine whether one or both have failed to operate the protocol correctly.

This Recommendation | International Standard contains a clause on conformance of equipment claiming to implement the procedures in this Recommendation | International Standard. To evaluate conformance of a particular implementation, it is necessary to have a statement of which capabilities and options have been implemented for a given OSI protocol. Such a statement is called a Protocol Implementation Conformance Statement (PICS). A PICS proforma is provided in Annex C. Attention is drawn to the fact that this Recommendation | International Standard does not contain any tests to demonstrate this conformance.

The variations and options available within this Recommendation | International Standard are essential as they enable a transport service to be provided for a wide variety of applications over a variety of network qualities. Thus, a minimally conforming implementation will not be suitable for use in all possible circumstances. It is important, therefore, to qualify all references to this Recommendation | International Standard with statements of the options provided or required or with statements of the intended purpose of provision or use.

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – PROTOCOL FOR PROVIDING THE CONNECTION-MODE TRANSPORT SERVICE

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988, and at Geneva, 1993; revised in 1996)

1 Scope

This Recommendation | International Standard specifies:

- a) five classes of procedures when operating over the connection-mode network service:
 - 1) class 0: simple class;
 - 2) class 1: basic error recovery class;
 - 3) class 2: multiplexing class;
 - 4) class 3: error recovery and multiplexing class;
 - 5) class 4: error detection and recovery class;
 for the connection-mode transfer of data and control information from one transport entity to a peer transport entity;
- b) one class (class 4) of procedure when operating over the connectionless-mode network service;
- c) the means of negotiating the class of procedures to be used by the transport entities;
- d) the structure and encoding of the transport protocol data units used for the transfer of data and control information.

The procedures are defined in terms of:

- i) the interactions between peer transport entities through the exchange of transport protocol data units;
- ii) the interactions between a transport entity and the transport service user in the same system through the exchange of transport service primitives;
- iii) the interactions between a transport entity and the network service provider through the exchange of network service primitives.

These procedures are defined in the main text of this Recommendation | International Standard supplemented by state tables in Annex A.

These procedures are applicable to instances of communication between systems which support the Transport Layer of the OSI Reference Model and which wish to interconnect in an open systems environment.

This Recommendation | International Standard specifies, in clause 14, conformance requirements for systems implementing these procedures and provides the PICS proforma in compliance with the relevant requirements, and in accordance with the relevant guidance, given in CCITT Rec. X.291 and ISO/IEC 9646-2. It does not contain tests which can be used to demonstrate this conformance.

2 References

The following Recommendations and International Standards contain provisions which, through references in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

2.1 Identical Recommendations | International Standards

- CCITT Recommendation X.213 (1992) | ISO/IEC 8348:1993, *Information technology – Open Systems Interconnection – Network service definition.*
- ITU-T Recommendation X.214 (1993 | ISO/IEC 8072:1994, *Information technology – Open Systems Interconnection Transport service definition.*

2.2 Paired Recommendations | International Standards equivalent in technical content

- CCITT Recommendation X.200 (1988), *Reference model of Open Systems Interconnection for CCITT applications.*
ISO 7498:1984, *Information processing systems – Open Systems Interconnection – Basic Reference Model.*
- ITU-T Recommendation X.264 (1993), *Transport protocol identification mechanism.*
ISO/IEC 11570:1992, *Information technology – Telecommunications and information exchange between systems – Open Systems Interconnection – Transport protocol identification mechanism.*
- CCITT Recommendation X.290 (1992), *OSI Conformance testing methodology and framework for protocol Recommendations for CCITT applications – General concepts.*
ISO/IEC 9646-1:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 1: General concepts.*
- CCITT Recommendation X.291 (1992), *OSI conformance testing methodology and framework for protocol Recommendations for CCITT applications – Abstract test suite specification.*
ISO/IEC 9646-2:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 2: Abstract Test Suite specification.*
- CCITT Recommendation X.650 (1992), *Open Systems Interconnections (OSI) – Reference Model for naming and addressing.*
ISO 7498-3:1989, *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 3: Naming and addressing.*

3 Definitions

NOTE – The definitions contained in this clause make use of abbreviations defined in clause 4.

3.1 This Recommendation | International Standard is based on the concepts developed in CCITT Rec. X.200 and ISO 7498 and CCITT Rec. X.650 and ISO/IEC 7498-3 and makes use of the following terms defined in them:

- a) concatenation and separation;
- b) segmenting and reassembling;
- c) multiplexing and demultiplexing;
- d) splitting and recombining;
- e) flow control;
- f) connectionless-mode transmission;
- g) transport selector;
- h) nil selector value.

3.2 For the purposes of this Recommendation, the following definitions apply:

3.2.1 equipment: Hardware or software or a combination of both; it need not be physically distinct within a computer system.

3.2.2 transport service user: An abstract representation of the totality of those entities within a single system that make use of the transport service.

3.2.3 network service provider: An abstract machine that models the totality of the entities providing the network service, as viewed by a transport entity.

3.2.4 local matter: A decision made by a system concerning its behaviour in the Transport Layer that is not subject to the requirements of this protocol.

3.2.5 initiator: A transport entity that initiates a CR-TPDU.

3.2.6 responder: A transport entity with whom an initiator wishes to establish a transport connection.

NOTE – Initiator and responder are defined with respect to a single transport connection. A transport entity can be both an initiator and responder simultaneously.

3.2.7 sending transport entity: A transport entity that sends a given TPDU.

3.2.8 receiving transport entity: A transport entity that receives a given TPDU.

3.2.9 preferred class: The protocol class that the initiator indicates in a CR-TPDU as its first choice for use over the transport connection.

3.2.10 alternative class: A protocol class that the initiator indicates in a CR-TPDU as an alternative choice for use over the transport connection.

3.2.11 proposed class: A preferred class or an alternative class.

3.2.12 selected class: The protocol class that the responder indicates in a CC-TPDU that it has chosen for use over the transport connection.

3.2.13 proposed parameter: The value for a parameter that the initiator indicates in a CR-TPDU that it wishes to use over the transport connection.

3.2.14 selected parameter: The value for a parameter that the responder indicates in a CC-TPDU that it has chosen for use over the transport connection.

3.2.15 error indication: An N-RESET indication, or an N-DISCONNECT indication with a reason code indicating an error, that a transport entity receives from the NS-provider.

3.2.16 invalid TPDU: A TPDU that does not comply with the requirements of this Recommendation | International Standard for structure and encoding.

3.2.17 protocol error: A TPDU whose use does not comply with the procedures for the class.

3.2.18 sequence number:

- a) the number in the TPDU-NR field of a DT-TPDU that indicates the order in which the DT-TPDU was transmitted by a transport entity;
- b) the number in the YR-TU-NR field of an AK or RJ-TPDU that indicates the sequence number of the next DT TPDU expected to be received by a transport entity.

3.2.19 transmit window: The set of consecutive sequence numbers which a transport entity has been authorized by its peer entity to send at a given time on a given transport connection.

3.2.20 lower window edge: The lowest sequence number in a transmit window.

3.2.21 upper window edge: The sequence number which is one greater than the highest sequence number in the transmit window.

3.2.22 upper window edge allocated to the peer entity: The value that a transport entity communicates to its peer entity to be interpreted as its new upper window edge.

3.2.23 closed window: A transmit window that contains no sequence number.

3.2.24 window information: Information contained in a TPDU relating to the upper and the lower window edges.

3.2.25 frozen reference: A reference that is not available for assignment to a connection because of the requirements of 6.18.

3.2.26 unassigned reference: A reference that is neither currently in use for identifying a transport connection nor which is in a frozen state.

3.2.27 transparent (data): TS-user data that is transferred intact between transport entities and which is unavailable for use by the transport entities.

3.2.28 owner (of a network connection): The transport entity that issued the N-CONNECT request leading to the creation of that network connection. Only applicable when operating over the connection-mode network service.

3.2.29 retained TPDU: A TPDU that is subject to the retransmission procedure or retention and acknowledgement procedure and is available for possible retransmission.

3.3 This Recommendation | International Standard uses the following terms defined in CCITT Rec. X.213 | ISO/IEC 8348:

- a) connection-mode network service;
- b) connectionless-mode network service.

3.4 This Recommendation | International Standard uses the following terms defined in CCITT Rec. X.290 and ISO/IEC 9646-1:

- a) PICS proforma;
- b) Protocol Implementation Conformance Statement (PICS).

4 Abbreviations

4.1 Data units

TPDU Transport-protocol-data-unit
TSDU Transport-service-data-unit
NSDU Network-service-data-unit

4.2 Types of Transport Protocol data units

CR TPDU Connection Request TPDU
CC TPDU Connection Confirm TPDU
DR TPDU Disconnect Request TPDU
DC TPDU Disconnect Confirm TPDU
DT TPDU Data TPDU
ED TPDU Expedited Data TPDU
AK TPDU Data Acknowledge TPDU
EA TPDU Expedited Acknowledge TPDU
RJ TPDU Reject TPDU
ER TPDU Error TPDU

4.3 TPDU fields

LI Length Indicator (field)
CDT Credit (field)
T-selector Transport selector (field)
DST-REF Destination Reference (field)
SRC-REF Source Reference (field)
EOT End of TSDU Mark
DT-TPDU-NR DT-TPDU Number (field)
ED-TPDU-NR ED-TPDU Number (field)
YR-TU-NR Sequence Number Response (field)
YR-EDTU-NR ED-TPDU Number Response (field)
ROA Request of Acknowledgement Mark

4.4 Times and associated variables

TI Local Retransmission Time
N The Maximum Number of Transmissions
L Time Bound on Reference and Sequence Number
I Inactivity Time

<i>W</i>	Window Time
<i>TTR</i>	Time to Try Reassignment/Resynchronization
<i>TWR</i>	Time to Wait for Reassignment/Resynchronization
<i>TS1</i>	Supervisory Timer 1
<i>TS2</i>	Supervisory Timer 2
<i>M_{LR}</i>	NSDU Lifetime Local-to-remote
<i>M_{RL}</i>	NSDU Lifetime Remote-to-local
<i>E_{LR}</i>	Expected Maximum Transit Delay Local-to-remote
<i>E_{RL}</i>	Expected Maximum Transit Delay Remote-to-local
<i>R</i>	Persistence Time
<i>A_L</i>	Local Acknowledgement Time
<i>A_R</i>	Remote Acknowledgement Time
<i>I_L</i>	Local Inactivity Time
<i>I_R</i>	Remote Inactivity Time

4.5 Miscellaneous

TS-user	Transport-service user
TSAP	Transport-service-access-point
NS-provider	Network Service Provider
NSAP	Network-service-access-point
QOS	Quality of Service
CLNS	Connectionless-mode network service
CONS	Connection-mode network service

5 Overview of the Transport Protocol

NOTE – This overview is not exhaustive and has been provided for guidance.

5.1 Service provided by the Transport Layer

The protocol specified in this Recommendation | International Standard supports the Transport Service defined in ITU-T Rec. X.214 | ISO/IEC 8072.

Information is transferred to and from the TS-user in the transport service primitives listed in Table 1.

5.2 Service assumed from the Network Layer

The protocol specified in this Recommendation | International Standard assumes the use of the Network Service defined in CCITT Rec. X.213 | ISO/IEC 8348.

When operating over CONS, information is transferred to and from the NS-provider in the network service primitives listed in Table 2a). When operating over CLNS, information is transferred to and from the NS-provider in the network service primitives listed in Table 2b).

NOTES

1 The parameters listed in Table 2a) are those in the current connection-mode network service (see CCITT Rec. X.213 | ISO/IEC 8348).

2 The parameters listed in Table 2b) are those in the current connectionless-mode network service (see CCITT Rec. X.213 | ISO/IEC 8348).

3 The way the parameters are exchanged between the transport entity and the NS-provider is a local matter.

Table 1 – Transport service primitives

Primitives		Parameters
T-CONNECT	request indication	Called address Calling address Expedited data option Quality of service TS-user data
T-CONNECT	response confirm	Responding address Quality of service Expedited data option TS-user-data
T-DATA	request indication	TS-user-data
T-EXPEDITED DATA	request indication	TS-user-data
T-DISCONNECT	request	TS-user-data
T-DISCONNECT	indication	Disconnect reason TS-user-data

5.3 Functions of the Transport Layer

5.3.1 Overview of functions

The functions in the Transport Layer are those necessary to bridge the gap between the services available from the Network Layer and those to be offered to the TS-users.

The functions in the Transport Layer are concerned with the enhancement of quality of service, including aspects of cost optimization.

These functions are grouped below into those used at all times during a transport connection and those concerned with connection establishment, data transfer and release.

NOTE – This Recommendation | International Standard does not include the following functions which are under consideration for inclusion in future editions of this Recommendation:

- a) encryption;
- b) accounting mechanisms;
- c) status exchanges and monitoring of QOS;
- d) blocking;
- e) temporary release of network connections;
- f) alternative checksum algorithm.

5.3.1.1 Functions used at all times

The following functions, depending upon the selected class and options, are used at all times during a transport connection:

- a) *Transmission of TPDUs* (see 6.2 and 6.9).
- b) *Multiplexing and demultiplexing* (see 6.15) – A function used only when operating over CONS to share a single network connection between two or more transport connections.
- c) *Error detections* (see 6.10, 6.13 and 6.17) – A function used to detect the loss, corruption, duplication, misordering, or misdelivery of TPDUs.
- d) *Error recovery* (see 6.12, 6.14, 6.18, 6.19, 6.20, 6.21, and 6.22) – A function used to recover from detected and signalled errors.

Table 2a) – Connection-mode network service primitives

Primitives		X/Y	Parameters	W/X/Y/Z
N-CONNECT	request	X	Called address	X
			Calling address	X
	indication	X	Receipt confirmation selection	Y
			Expedited data selection	Y
			QOS parameter set	X
NS-user-data			Z	
N-CONNECT	response confirm	X	Responding address	X
		X	Receipt confirmation selection	Y
			Expedited data selection	Y
			QOS parameter set	X
			NS-user-data	Z
N-DATA			request indication	X
	X	Confirmation request		Y
N-DATA ACKNOWLEDGE				
	request indication	Y		
		Y		
N-EXPEDITED DATA	request indication	Y Y	N-user-data	Y
N-RESET	request indication	X	Reason	W
		X	Originator	W
			Reason	W
N-RESET	response confirm	X	–	
		X	–	
N-DISCONNECT	request	X	Reason	W
			NS-user-data	Z
			Responding address	Z
	indication	X	Originator	W
			Reason	W
			NS-user-data	Z
			Responding address	Z
W	The usage of this parameter is a local matter, e.g. for diagnostic or to decide whether to attempt resynchronization.			
X	The Transport Protocol assumes that this facility is provided in all networks.			
Y	The Transport Protocol assumes that this facility is provided in some networks and a mechanism is provided to optionally use the facility.			
Z	The Transport Protocol does not use this parameter.			

Table 2b) – Connectionless-mode network service primitives

Primitives		X/Y	Parameters	W/X/Y/Z
N-UNIT-DATA	request	X	Source address Destination address Quality of service NS-user-data	X X X X
	indication	X	Source address Destination address Quality of service NS-user-data	X X X X
W The usage of this parameter is a local matter, e.g. for diagnostic or to decide whether to attempt resynchronization. X The Transport Protocol assumes that this facility is provided in all networks. Y The Transport Protocol assumes that this facility is provided in some networks and a mechanism is provided to optionally use the facility. Z The Transport Protocol does not use this parameter.				

5.3.1.2 Connection establishment

The purpose of connection establishment is to establish a transport connection between two TS-users. The following functions of the Transport Layer during this phase match the TS-users' requested quality of service with the services offered by the Network Layer:

- a) select the network service which best matches the requirement of the TS-user taking into account charges for various services (see 6.5);
- b) decide whether to multiplex multiple transport connections onto a single network connection only when operating over CONS (see 6.5);
- c) establish the optimum TPDU size (see 6.5);
- d) select the functions that will be operational upon entering the data transfer phase (see 6.5);
- e) map transport addresses onto network addresses;
- f) provide a means to distinguish between two different transport connections (see 6.5);
- g) transport of TS-user data (see 6.5);
- h) exchange values of Inactivity timers (see 6.5).

5.3.1.3 Data transfer

The purpose of data transfer is to permit duplex transmission of TSDUs between the two TS-users connected by the transport connection. This purpose is achieved by means of two-way simultaneous communication and by the following functions, some of which are used or not used in accordance with the result of the selection performed in connection establishment.

- a) *Concatenation and separation* (see 6.4) – A function used to collect several TPDU's into a single NSDU at the sending transport entity and to separate the TPDU's at the receiving transport entity.
- b) *Segmenting and reassembling* (see 6.3) – A function used to segment a single data TSDU into multiple TPDU's at the sending transport entity and to reassemble them into their original format at the receiving transport entity.
- c) *Splitting and recombining* (see 6.23) – A function allowing, only when operating over CONS, the simultaneous use of two or more network connections to support the same transport connection.
- d) *Flow control* (see 6.16) – A function used to regulate the flow of TPDU's between two transport entities on one transport connection.
- e) *Transport connection identification* – A means to uniquely identify a transport connection between the pair of transport entities supporting the connection during the lifetime of the transport connection.
- f) *Expedited data* (see 6.11) – A function used to bypass the flow control of normal data TPDU. Expedited data TPDU flow is controlled by separate flow control.
- g) *TSDU delimiting* (see 6.3) – A function used to determine the beginning and ending of a TSDU.

5.3.1.4 Release

The purpose of release (see 6.7 and 6.8) is to provide disconnection of the transport connection, regardless of the current activity.

5.4 Classes and options when operating over CONS

5.4.1 General

The functions of the Transport Layer have been organized into classes and options.

A class defines a set of functions. Options define those functions within a class which may or may not be used.

This Recommendation | International Standard defines five classes of protocol:

- a) class 0: simple class;
- b) class 1: basic error recovery class;
- c) class 2: multiplexing class;
- d) class 3: error recovery and multiplexing class;
- e) class 4: error detection and recovery class.

NOTES

- 1 Transport connections of classes 2, 3 and 4 may be multiplexed together onto the same network connection.
- 2 Classes 0 to 3 do not specify mechanisms to detect unsignalled network transmission failures.

5.4.2 Negotiation

The use of classes and options is negotiated during connection establishment. The choice made by the transport entities will depend upon:

- a) the TS-users' requirements expressed via T-CONNECT service primitives;
- b) the quality of the available network services;
- c) the user required service versus cost ratio acceptable to the TS-user.

5.4.3 Choice of network connection

The following list classifies network services in terms of quality with respect to error behaviour in relation to user requirements; its main purpose is to provide a basis for the decision regarding which class of transport protocol should be used in conjunction with given network connection:

- a) *Type A* – Network connection with acceptable residual error rate (for example, not signalled by disconnect or reset) and acceptable rate of signalled errors.
- b) *Type B* – Network connections with acceptable residual error rate (for example, not signalled by disconnect or reset) but unacceptable rate of signalled errors.
- c) *Type C* – Network connections with unacceptable residual error rate.

It is assumed that each transport entity is aware of the quality of service provided by particular network connections.

5.4.4 Characteristics of class 0

Class 0 provides the simplest type of transport connection and is fully compatible with the Recommendation T.70 for teletex terminals.

Class 0 has been designed to be used with type A network connections.

5.4.5 Characteristics of class 1

Class 1 provides a basic transport connection with minimal overheads.

The main purpose of the class is to recover from network disconnect or reset.

Selection of this class is usually based on reliability criteria. Class 1 has been designed to be used with type B network connections.

5.4.6 Characteristics of class 2**5.4.6.1 General**

Class 2 provides a way to multiplex several transport connections onto a single network connection. This class has been designed to be used with type A network connections.

5.4.6.2 Use of explicit flow control

The objective is to provide flow control to help avoid congestion at transport-connection-end-points and on the network connection. Typical use is when traffic is heavy and continuous, or when there is intensive multiplexing. Use of flow control can optimize response times and resource utilization.

5.4.6.3 Non-use of explicit flow control

The objective is to provide a basic transport connection with minimal overheads suitable when explicit disconnection of the transport connection is desirable. The option would typically be used for unsophisticated terminals, and when no multiplexing onto network connections is required. Expedited data is never available.

5.4.7 Characteristics of class 3

Class 3 provides the characteristics of class 2 plus the ability to recover from network disconnect or reset. Selection of this class is usually based upon reliability criteria. Class 3 has been designed to be used with type B network connections.

5.4.8 Characteristics of class 4

Class 4 provides the characteristics of class 3, plus the capability to detect and recover from errors which occur as a result of the low grade of service available from the NS-provider. The kind of errors to be detected include:

- TPDU loss;
- TPDU delivery out of sequence;
- TPDU duplication; and
- TPDU corruption.

These errors may affect control TPDUs as well as data TPDUs.

This class also provides for increased throughput capability and additional resilience against network failure.

Class 4 has been designed to be used with type C network connections.

5.5 Characteristics of class 4 transport protocol when operating over CLNS

In operation over a connectionless-mode network service the class 4 transport protocol provides flow control between communicating peer transport entities, the capability to detect and recover from errors which occur as a result of a low grade of service available from the NS-provider, and resilience from failure of the peer entity. The kind of errors to be detected include:

- TPDU loss;
- TPDU delivery out of sequence;
- TPDU duplication; and
- TPDU corruption.

These errors may affect control TPDUs as well as data TPDUs.

NOTE – The transport entity is incapable of distinguishing between failure of the network service and failure of the peer entity, except optionally, by some local means, in the case of the failure of the local interface to the network service (e.g. in the failure of the local transceiver on a local area network).

There is no indication given to the transport entity about the ability of the network entity to fulfill the service requirements given in the N-UNIT-DATA primitive. However, it can be a local matter to make transport entities aware of the availability and characteristics (QOS) of connectionless-mode network services, as the corresponding NSAP associations, exist logically by the nature of the connectionless-mode network service and may be recognized by network entities.

5.6 Model of the Transport Layer

A transport entity communicates with its TS-users through one or more TSAPs by means of the service primitives as defined by the transport service definition (see ITU-T Rec. X.214 | ISO/IEC 8072). Service primitives will cause or be the result of transport protocol data unit exchanges between the peer transport entities supporting a transport connection. These protocol exchanges are effected using the services of the Network Layer as defined by the network service definition (see CCITT Rec. X.213 | ISO/IEC 8348) through one or more NSAPs. (See Figure 2.)

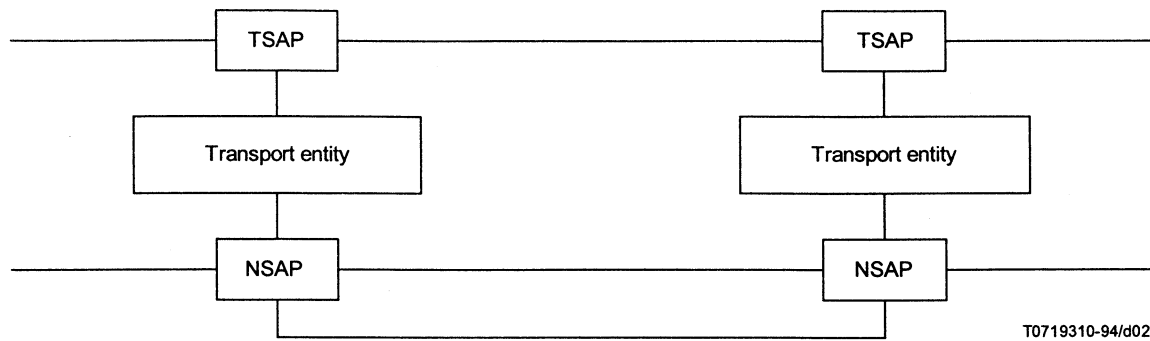
Transport connection endpoints are identified in end systems by an internal, implementation dependent, mechanism so that the TS-user and the transport entity can refer to each transport connection.

6 Elements of procedure

This clause contains elements of procedure which are used in the specification of protocol classes in clauses 7 to 12. These elements are not meaningful on their own.

The procedures define the transfer of TPDUs whose structure and coding is specified in clause 13. Transport entities shall accept and respond to any TPDU received in a valid NSDU and may issue TPDUs initiating specific elements of procedure specified in this clause.

NOTE – Where network service primitives, TPDUs and parameters used are not significant for a particular element of procedure, they have not been included in the specification.



NOTE – For the purposes of illustration, this figure shows only one TSAP and one NSAP for each transport entity. In certain instances, more than one TSAP and/or more than one NSAP may be associated with a particular transport entity.

Figure 2 – Model of the Transport Layer

6.1 Use of the network service

6.1.1 Assignment to network connection when operating over CONS

This procedure is used only when operating over the connection-mode network service.

6.1.1.1 Purpose

The procedure is used in all classes to assign transport connections to network connections.

6.1.1.2 Network service primitives

The procedure uses the following network service primitives:

- a) N-CONNECT;
- b) N-DISCONNECT.

6.1.1.3 Procedure

Each transport connection shall be assigned to a network connection. The initiator may assign the transport connection to an existing network connection of which it is the owner or to a new network connection (see Note 1) which it creates for this purpose.

The initiator shall not assign or reassign the transport connection to an existing network connection if the protocol class(es) proposed for the class in use for the transport connection, (is) (are) incompatible with the current usage of the network connection with respect to multiplexing (see Note 2).

During the resynchronization (see 6.14) and reassignment after failure (see 6.12) procedures, the transport entity may reassign a transport connection to another network connection joining the same NSAPs, provided that it is the owner of the network connection and that the transport connection is assigned to only one network connection at any given time.

During the splitting procedure (see 6.23), a transport entity may assign a transport connection to any additional network connection joining the same NSAPs, provided that it is the owner of the network connection and that either the network connection does not have another transport connection assigned to it or multiplexing is possible on the network connection.

The responder becomes aware of the assignment when it receives:

- a) a CR-TPDU during the connection establishment procedure (see 6.5); or
- b) an RJ-TPDU or a retransmitted CR or DR TPDU during the resynchronization (see 6.14) and reassignment after failure (see 6.12) procedures; or
- c) any TPDU when splitting (see 6.23) is used.

NOTES

1 When a new network connection is created, the quality of service requested is a local matter, although it will normally be related to the requirements of transport connection(s) expected to be assigned to it.

2 An existing network connection may also not be suitable if, for example, the quality of service requested for the transport connection cannot be attained by using or enhancing the network connection.

3 A network connection with no transport connection(s) assigned to it, may be available after initial establishment, or because all of the transport connections previously assigned to it have been released. It is recommended that only the owner of such a network connection should release it. Furthermore, it is recommended that it not be released immediately after the transmission of the final TPDU of a transport connection, either a DR-TPDU in response to CR-TPDU or a DC-TPDU in response to DR-TPDU. An appropriate delay will allow the TPDU concerned to reach the other transport entity allowing the freeing of any resources associated with the transport connection concerned.

4 After the failure of a network connection, transport connections which were previously multiplexed together may be assigned to different network connections, and vice versa.

5 The transport protocol identification procedures specified in Recommendation X.264 may need to be considered in conjunction with this procedure.

6.1.2 Transmission over CLNS

This procedure is used only when operating over the connectionless-mode network service.

6.1.2.1 Purpose

The procedure is used to transmit TPDUs over the connectionless-mode network service.

6.1.2.2 Network service primitives

The procedure makes use of the following network service primitive:

- N-UNIT-DATA.

6.1.2.3 Procedure

Each TPDU shall be transmitted in a single invocation of the connectionless-mode network service, over a pre-existing association between a pair of NSAPs. The association is considered by transport entities as permanently established and available.

6.2 Transport Protocol Data Unit (TPDU) transfer

6.2.1 Purpose

The TPDU transfer procedure is used in all classes to convey transport protocol data units in user data fields of network service primitives.

6.2.2 Network service primitives

The procedure uses the following network service primitives when operating over CONS:

- a) N-DATA;
- b) N-EXPEDITED DATA.

The procedure uses the following network service primitive when operating over CLNS:

- N-UNIT-DATA.

6.2.3 Procedure

The Transport Protocol Data Units (TPDUs) defined for the protocol, are listed in 4.2.

When operating over CLNS, the transport entities shall transmit and receive all TPDUs as NS-user data parameters of N-UNIT-DATA primitives.

When operating over CONS and when the network expedited variant has been selected for class 1, the transport entities shall transmit and receive ED and EA-TPDUs as NS-user data parameters of N-EXPEDITED DATA primitives.

In all other cases, transport entities shall transmit and receive TPDUs as NS-user data parameters of N-DATA primitives.

When a TPDU is put into an NS-user data parameter, the significance of the bits within an octet and the order of octets within a TPDU shall be defined in 13.2.

NOTE – TPDUs may be concatenated (see 6.4).

6.3 Segmenting and reassembling

6.3.1 Purpose

The segmenting and reassembling procedure is used in all classes to map TSDUs onto TPDU's.

6.3.2 TPDU and parameter used

The procedure makes use of the following TPDU and parameter:

- DT-TPDU:
 - end of TSDU.

6.3.3 Procedure

A transport entity shall map a TSDU onto an ordered sequence of one or more DT-TPDUs. This sequence shall not be interrupted by other DT-TPDUs on the same transport connection.

All DT-TPDUs except the last DT-TPDU in a sequence greater than one shall have a length of data greater than zero.

NOTES

- 1 The EOT parameter of a DT-TPDU indicates whether or not there are subsequent DT-TPDUs in the sequence.
- 2 There is no requirement that the DT-TPDUs shall be of the maximum length selected during connection establishment.

6.4 Concatenation and separation

6.4.1 Purpose

The procedure for concatenation and separation is used in classes 1, 2, 3 and 4 to convey multiple TPDU's in one NSDU.

6.4.2 Procedure

A transport entity may concatenate TPDU's from the same or different transport connections, while maintaining the order of TPDU's for a given transport connection compatible with the protocol operation.

A valid set of concatenated TPDU's may contain:

- a) any number of TPDU's from the following list: AK, EA, RJ, ER, DC-TPDU's, provided that these TPDU's come from different transport connections;
- b) no more than one TPDU from the following list: CR, DR, CC, DT, ED TPDU's; if this TPDU is present, it shall be placed last in the set of concatenated TPDU's.

A transport entity shall accept a valid set of concatenated TPDU's.

NOTES

- 1 The TPDU's within a concatenated set may be distinguished by means of the length indicator parameter.
 - 2 The end of a TPDU containing data is indicated by the termination of the NSDU.
 - 3 When operating over CONS, the number of concatenated TPDU's referred to in 6.4.2 a) is bounded by the maximum number of transport connections which are multiplexed together except during assignment or reassignment.
- When operating over CLNS, the number of TPDU's that may be concatenated is bounded by the number of transport connections established between two NSAP's and/or the maximum available NSDU size.

6.5 Connection establishment

6.5.1 Purpose

The procedure for connection establishment is used in all classes to create a new transport connection.

6.5.2 Network service primitives

When operating over CONS, the procedure uses the following network service primitive:

- N-DATA.

When optionally operating over CLNS, the procedure uses the following network service primitive:

- N-UNIT-DATA.

6.5.3 TPDU's and parameters used

The procedure uses the following TPDU's and parameters:

- a) CR-TPDU:
 - CDT;
 - DST-REF (set to zero);
 - SRC-REF;
 - CLASS and OPTIONS (i.e. preferred class, use of extended format, non-use of explicit flow control in class 2);
 - Calling Transport Selector;
 - Called Transport-Selector;
 - TPDU size (proposed);
 - preferred maximum TPDU size (proposed);
 - version number;
 - protection parameter;
 - checksum;
 - additional option selection (i.e. use of network expedited in class 1, use of receipt confirmation in class 1, non-use of checksum in class 4, use of transport expedited data transfer service, use of selective acknowledgement, use of request acknowledgement, use of non-blocking transport expedited data service);
 - alternative protocol class(es);
 - acknowledgement time;
 - inactivity time;
 - throughput (proposed);
 - residual error rate (proposed);
 - priority (proposed);
 - transit delay (proposed);
 - reassignment time;
 - user data.
- b) CC-TPDU:
 - CDT;
 - DST-REF;
 - SRC-REF;
 - CLASS and OPTIONS (selected);
 - Calling Transport Selector;
 - Responding Transport-Selector;
 - TPDU size (selected);
 - the preferred maximum TPDU size (selected);
 - protection parameter;
 - checksum;
 - additional option selection (selected);
 - acknowledgement time;
 - inactivity time;
 - throughput (selected);
 - residual error rate (selected);

- priority (selected);
- transit delay (selected);
- user data.

6.5.4 Procedure for operating over CONS

A transport connection is established by means of one transport entity (the initiator) transmitting a CR-TPDU to the other transport entity (the responder), which replies with a CC-TPDU.

Before sending the CR-TPDU, the initiator assigns the transport connection being created to one (or more if the splitting procedure is being used) network connection(s). It is this set of network connections over which the TPDU's are sent.

NOTE 1 – Even if the initiator assigns the transport connection to more than one network connection, all the CR-TPDU's (if repeated) or DR-TPDU's with DST-REF set to zero which are sent prior to the receipt of the CC-TPDU shall be sent on the same network connection, unless an N-DISCONNECT indication is received. (This is necessary because the remote entity may not support class 4 and therefore may not recognize splitting.) If the initiator has made other assignments, it will use them only after receipt of a class 4 CC-TPDU (see also the splitting procedure 6.23).

During this exchange, all information and parameters needed for the transport entities to operate shall be exchanged or negotiated.

NOTE 2 – Except in class 4, it is recommended that the initiator start an optional timer TS1 at the time the CR-TPDU is sent. This timer should be stopped when the connection is considered as accepted or refused or unsuccessful. If the timer expires, the initiator should reset or disconnect the network connection, and in classes 1 and 3, freeze the reference (see 6.18). For all other transport connection(s) multiplexed on the same network connection, the procedures for reset or disconnect as appropriate should be followed.

When an unexpected duplicated CR-TPDU is received (with class 4 as preferred class) it shall be ignored in classes 0, 1, 2, and 3 and a CC-TPDU shall be returned in class 4.

After receiving the CC-TPDU for a class which includes the procedure for retention until acknowledgement of TPDU's, the initiator shall acknowledge the CC-TPDU as defined in Table 5 (see 6.13).

When the network expedited variant of the expedited data transfer (see 6.11) has been agreed (possible in class 1 only), the responder shall not send an ED-TPDU before the CC-TPDU is acknowledged.

The following information is exchanged:

- a) *References* – Each transport entity chooses a reference to be used by the peer entity which is 16-bits long and which is arbitrary under the following restrictions:
 - 1) it shall not already be in use nor frozen (see 6.18);
 - 2) it shall not be zero.

This mechanism is symmetrical and provides identification of the transport connection independent of the network connection. The range of references used for transport connections, in a given transport entity, is a local matter.
- b) *Calling, Called and Responding Transport-Selectors (optional)* – When either network address unambiguously defines the transport address, this information may be omitted.
- c) *Initial credit* – Only relevant for classes which include the explicit flow control function.
- d) *User data* – Not available if class 0 is the preferred class (see Note 3). Up to 32 octets in other classes.

NOTE 3 – If class 0 is a valid response according to Table 3, inclusion of user data in the CR-TPDU may cause the responding entity to refuse the connection (for example, if it only supports class 0).
- e) *Acknowledgement time* – Only in class 4.
- f) *Checksum parameter* – Only in class 4.
- g) *Protection parameter* – This parameter and its semantics are user defined.
- h) *Inactivity time* – Only in class 4. The inactivity time parameter shall not be included in a CC-TPDU if it was not present in the corresponding CR-TPDU.

The following negotiations take place:

- i) *Protocol class* – The initiator shall propose a preferred class and may propose any number of alternative classes which permit a valid response as defined in Table 3. The initiator should assume when it sends the CR-TPDU that its preferred class will be agreed to, and commence the procedures associated with that class, except that if class 0 or class 1 is an alternative class, multiplexing shall not commence until a CC-TPDU selecting the use of classes 2, 3 or 4 has been received.

NOTE 4 – This means, for example, that when the preferred class includes resynchronization (see 6.14) the resynchronization will occur if a reset is signalled during connection establishment.

The responder shall select one class defined in Table 3 as a valid response corresponding to the preferred class and to the class(es), if any, contained in the alternative class parameter of the CR-TPDU. It shall indicate the selected class in the CC-TPDU and shall follow the procedures for the selected class.

If the preferred class is not selected, then on receipt of the CC-TPDU, the initiator shall adjust its operation according to the procedures of the selected class.

NOTE 5 – The valid responses indicated in Table 3 result from both explicit negotiation, whereby each of the classes proposed is a valid response, and implicit negotiation whereby:

- if class 3 or 4 is proposed, then class 2 is a valid response;
- if class 1 is proposed, then class 0 is a valid response.

NOTE 6 – Negotiation from class 2 to class 1 and from any class to an higher-numbered class is not valid.

NOTE 7 – Redundant combinations are not a protocol error.

- j) *TPDU size* – The initiator may propose a maximum size for TPDU, and the responder may accept this value or respond with any value between 128 and the proposed value in the set of values available [see 13.3.4 b)].

NOTE 8 – The length of the CR-TPDU does not exceed 128 octets (see 13.3).

NOTE 9 – The transport entities may have knowledge, by some local means, of the maximum available NSDU size.

- k) *Preferred maximum TPDU size* – The value of this parameter, multiplied by 128, yields the proposed or accepted maximum TPDU size in octets. The initiator may propose a preferred maximum size for TPDU and the responder may accept this value or respond with a smaller value.

NOTE 10 – If this parameter is used in a CR-TPDU without also including the TPDU size parameter, this will result in a maximum TPDU size of 128 octets being selected if the remote entity does not recognize the preferred TPDU size parameter. Therefore, it is recommended that both parameters be included in the CR-TPDU.

If the preferred maximum TPDU size parameter is present in a CR-TPDU the responder shall either:

- ignore the preferred maximum TPDU size parameter and follow TPDU size negotiation as defined in 6.5.4 j); or
- use the preferred maximum TPDU size parameter to determine the maximum TPDU size requested by the initiator and ignore the TPDU size parameter. In this case the responder shall use the preferred maximum TPDU size parameter in the CC-TPDU and shall not include the TPDU size parameter in the CC-TPDU.

If the preferred maximum TPDU size parameter is not present in the CR-TPDU it shall not be included in the corresponding CC-TPDU. In this case TPDU size negotiation is as defined in 6.5.4 j).

- l) *Normal or extended format* – Either normal or extended is available. When extended is used, this applies to CDT, TPDU-NR, ED-TPDU-NR, YR-TU-NR and YR-EDTU-NR parameters.
- m) *Checksum selection* – This defines whether or not TPDU of the connection are to include a checksum.
- n) *Quality of service parameters* – This defines the throughput, transit delay, priority and residual error rate.
NOTE 11 – The transport service defines transit delay as requiring a previously stated average TSDU size as a basis for any specification. This protocol as specified in 13.3.4 m), uses a value at 128 octets. Conversion to and from specifications based upon some other value is a local matter.
- o) The non-use of explicit flow control in class 2.
- p) The use of network receipt confirmation and network expedited when class 1 is to be used.
- q) *Use of expedited data transfer service* – This allows both TS-users to negotiate the use or non-use of the expedited data transport service as defined in the transport service (see ITU-T Rec. X.214 | ISO/IEC 8072).
- r) *The use of selective acknowledgement* – This allows the transport entities to decide whether to use procedures that allow acknowledgement of DT-TPDU that are received out-of-sequence (only in class 4).
- s) *The use of request acknowledgement* – This allows both transport entities to negotiate the use or non-use of the request acknowledgement facility specified in 6.13.4.2 (only in classes 1, 3, 4).
- t) *the use of non-blocking expedited data transfer service* – This allows both transport entities to negotiate the use or non-use of the non-blocking expedited data transfer service (only in class 4). This option will only be valid when the option of “use of expedited data transfer service” is negotiated.

The following information is sent only in the CR-TPDU:

- u) *Version number* – This defines the version of the transport protocol standard used for this connection.
- v) *Reassignment time parameter* – This indicates the time for which the initiator will persist in following the reassignment after failure procedure.

Table 3 – Valid responses corresponding to the preferred class and any alternative class proposed in the CR-TPDU

Preferred class	Alternative class					
	0	1	2	3	4	None
0	Not valid	Not valid	Not valid	Not valid	Not valid	Class 0
1	Class 1 or 0	Class 1 or 0	Not valid	Not valid	Not valid	Class 1 or 0
2	Class 2 or 0	Not valid	Class 2	Not valid	Not valid	Class 2
3	Class 3, 2 or 0	Class 3, 2, 1 or 0	Class 3 or 2	Class 3 or 2	Not valid	Class 3 or 2
4	Class 4, 2 or 0	Class 4, 2, 1 or 0	Class 4 or 2	Class 4, 3 or 2	Class 4 or 2	Class 4 or 2

The negotiation rules for the options are such that the initiator may propose either to use or not to use the option. The responder may either accept the proposed choice or select an alternative choice as defined in Table 4.

When a parameter [which is valid for the proposed class(es)] is absent and a default value is defined in this Recommendation | International Standard, this is equivalent to the presence of the parameter with the default value.

In class 2, whenever a transport entity requests or agrees to the transport expedited data transfer service or to the use of extended formats, it shall also request or agree (respectively) to the use of explicit flow control.

Table 4 – Negotiation of options during connection establishment

Option	Proposal made by the initiator	Valid selection by the responder
Transport expedited data transfer service (classes 1, 2, 3, 4 only)	Yes No	Yes or No No
Use of receipt confirmation (class 1 only)	Yes No	Yes or No No
Use of the network expedited variant (class 1 only)	Yes No	Yes or No No
Non-use of checksum (class 4 only)	Yes No	Yes or No No
Non-use of explicit flow control (class 2 only)	Yes No	Yes or No No
Use of extended format (classes 2, 3, 4 only)	Yes No	Yes or No No
Use of selective acknowledgement (class 4 only)	Yes No	Yes or No No
Use of request acknowledgement (classes 1, 3, 4 only)	Yes No	Yes or No No
Use of non-blocking expedited data transfer service (class 4 only)	Yes No	Yes or No No
NOTE – This table defines the procedures for negotiation of options. This negotiation has been designed such that if the initiator proposes the mandatory implementation option specified in clause 14, the responder has to accept use of this option over the transport connection except for the use of the transport expedited data transfer service which may be rejected by the TS-user. If the initiator proposes a non-mandatory implementation option, the responder is entitled to select use of the mandatory implementation option for use over the transport connection.		

6.5.5 Procedure for operating over CLNS

A transport connection is established by means of one transport entity (the initiator) transmitting a CR-TPDU to the other transport entity (the responder), which replies with a CC-TPDU. During this exchange, all information and parameters needed for the transport entities to operate shall be exchanged or negotiated. When an unexpected duplicated CR-TPDU is received (with class 4 as preferred class) a CC-TPDU shall be returned.

After receiving the CC-TPDU, the initiator shall acknowledge the CC-TPDU as defined in Table 5 (see 6.13).

NOTE 1 – If the initiator does not receive any response from the remote entity, it may choose to use the procedure for operating over CONS (see 6.5.4). This is a local matter.

The following information is exchanged:

- a) *References* – Each transport entity chooses a reference to be used by the peer entity which is 16-bits long and which is arbitrary under the following restrictions:
 - 1) it shall not already be in use nor frozen (see 6.18);
 - 2) it shall not be zero.

This mechanism is symmetrical and provides identification of the transport connection itself. The range of references used for transport connections, in a given transport entity, is a local matter.
- b) *Calling, Called and Responding Transport-Selectors* (optional) – Indicates the calling and called transport service access points. When either network address unambiguously defines the transport address, this information may be omitted.
- c) *Initial credit*.
- d) *User data* – Up to 32 octets.
- e) *Acknowledgment time*.
- f) *Checksum parameter*.
- g) *Protection parameter* – This parameter and its semantics are user defined.
- h) *Inactivity time* – The inactivity time parameter shall not be included in a CC-TPDU if it was not present in the corresponding CR-TPDU.
- i) *Protocol class* – Class 4 is the only valid value for the preferred protocol class proposed by the initiator, and for the class selected by the responder. An alternative class shall not be present.

The following negotiations take place:

- j) *TPDU size* – The initiator may propose a maximum size for TPDU in the set of values available [see 13.3.4 b)]. This value may be limited by the maximum available NSDU size if known, and cannot exceed the maximum NSDU size for connectionless-mode network service as defined in CCITT Rec. X.213 | ISO/IEC 8348. The responder may accept this value or respond with any value between 128 and the proposed value in the set of values available [see 13.3.4 b)].

NOTE 2 – The length of the CR-TPDU does not exceed 128 octets (see 13.3).

NOTE 3 – The transport entities may have knowledge, by some local means, of the maximum available NSDU size.

- k) *Preferred maximum TPDU size* – The value of this parameter, multiplied by 128, yields the proposed or accepted maximum TPDU size in octets. The initiator may propose a preferred maximum size for TPDU and the responder may accept this value or respond with a smaller value.

NOTE 4 – If this parameter is used in a CR-TPDU without also including the TPDU size parameter, this will result in a maximum TPDU size of 128 octets being selected if the remote entity does not recognize the preferred TPDU size parameter. Therefore, it is recommended that both parameters be included in the CR-TPDU.

If the preferred maximum TPDU size parameter is present in a CR-TPDU the responder shall either:

- ignore the preferred maximum TPDU size parameter and follow TPDU size negotiation as defined in 6.5.5 j); or
- use the preferred maximum TPDU size parameter to determine the maximum TPDU size requested by the initiator and ignore the TPDU size parameter. In this case the responder shall use the preferred maximum TPDU size parameter in the CC-TPDU and shall not include the TPDU size parameter in the CC-TPDU.

If the preferred maximum TPDU size parameter is not present in the CR-TPDU it shall not be included in the corresponding CC-TPDU. In this case TPDU size negotiation is as defined in 6.5.5 j).

- l) *Normal or extended format* – Either normal or extended is available. When extended is used, this applies to CDT, TPDU-NR, ED-TPDU-NR, YR-TU-NR and YR-EDTU-NR parameters.
- m) *Checksum selection* – This defines whether or not TPDU's of the connection are to include a checksum.
- n) *Quality of service parameters* – This defines the throughput, transit delay, priority and residual error rate.
NOTE 5 – The transport service defines transit delay as requiring a previously stated average TSDU size as a basis for any specification. This protocol as specified in 13.3.4 m), uses a value at 128 octets. Conversion to and from specifications based upon some other value is a local matter.
- o) *Use of expedited data transfer service* – This allows both TS-users to negotiate the use or non-use of the expedited data transport service as defined in the transport service (see ITU-T Rec. X.214 | ISO/IEC 8072).
- p) *The use of non-blocking expedited data transfer service* – This allows both transport entities to negotiate the use or non-use of the non-blocking expedited data transfer service (only in class 4). This option will only be valid when the option of “use of expedited data transfer service” is negotiated.
- q) *The use of selective acknowledgement* – This allows the transport entities to decide whether to use procedures that allow acknowledgement of DT-TPDU's that are received out-of-sequence.
- r) *The use of request acknowledgement* – This allows both transport entities to negotiate the use or non-use of the request acknowledgement facility specified in 6.13.4.3.

The following information is sent only in the CR-TPDU:

- s) *Version number* – This defines the version of the transport protocol standard used for this connection.

6.6 Connection refusal

6.6.1 Purpose

The connection refusal procedure is used in all classes when a transport entity refuses a transport connection in response to a CR-TPDU.

6.6.2 TPDU's and parameters used

The procedure uses the following TPDU's and parameters:

- a) DR-TPDU:
 - SRC-REF;
 - reason;
 - user data;
- b) ER-TPDU:
 - reject cause;
 - invalid TPDU.

6.6.3 Procedure

If a transport connection cannot be accepted, the responder shall respond to the CR-TPDU with a DR-TPDU. The reason shall indicate why the connection was not accepted. The source reference field in the DR-TPDU shall be set to zero to indicate an unassigned reference.

If a DR-TPDU is received, the initiator shall regard the connection as released.

The responder shall respond to an invalid CR-TPDU by sending an ER or DR-TPDU. If an ER-TPDU is received in response to a CR-TPDU, the initiator shall regard the connection as released.

NOTES

- 1 When the invalid CR-TPDU can be identified as having class 0 as the preferred class, it is recommended to respond with an ER-TPDU. For all other invalid CR-TPDU's either an ER-TPDU or DR-TPDU may be sent.
- 2 If the optional supervisory timer TS1 has been set for this connection, then the initiator should stop the timer on receipt of the DR or ER-TPDU.
- 3 It is a local matter whether the initiator releases the network connection if no transport connections are now assigned to it.

6.7 Normal release

6.7.1 Normal release when operating over CONS

6.7.1.1 Purpose

The release procedure is used by a transport entity in order to terminate a transport connection. The implicit variant is used only in class 0. The explicit variant is used in classes 1, 2, 3 and 4.

NOTES

1 When the implicit variant is used (i.e. in class 0), the lifetime of the transport connection is directly correlated with the lifetime of the network connection.

2 The use of the explicit variant of the release procedure enables the transport connection to be released independently of the underlying network connection.

6.7.1.2 Network service primitives

The procedure uses the following network service primitives:

- a) N-DISCONNECT;
- b) N-DATA.

6.7.1.3 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- a) DR-TPDU:
 - reason;
 - user data;
 - SRC-REF;
 - DST-REF;
- b) DC-TPDU.

6.7.1.4 Procedure for implicit variant

In the implicit variant either transport entity disconnects a transport connection by disconnecting the network connection to which it is assigned. When a transport entity receives an N-DISCONNECT this should be considered as the release of the transport connection.

6.7.1.5 Procedure for explicit variant

When the release of a transport connection is to be initiated, a transport entity:

- a) If it has previously sent or received a CC-TPDU (see Note 3) shall:
 - 1) send a DR-TPDU;
 - 2) discard all subsequently received TPDUs other than a DR, DC or ER-TPDU;
 - 3) consider the transport connection released on receipt of a DR, DC or ER-TPDU.
- b) If a) is not applicable and if there is an outstanding CR-TPDU, it shall:
 - 1) For classes other than class 4 wait for the acknowledgement of the outstanding CR-TPDU; if it receives a CC-TPDU, it shall follow the procedures in 6.7.1.5 a).
 - 2) For class 4 either send a DR-TPDU with a zero value in the DST-REF field or follow the procedure in 6.7.1.5 b) 1). In the former case further receipt of a CC-TPDU specifying class 4 will be ignored. Receipt of CC-TPDU with another class will be processed as follows: if the class is 0, the network connection shall be disconnected, otherwise a DR-TPDU with the DST-REF field set to the value of the SRC-REF field of the received CC-TPDU shall be sent and the release procedure of the class is continued.

A transport entity that receives a DR-TPDU shall:

- c) If it has previously sent a DR-TPDU for the same transport connection, consider the transport connection released.
- d) If it has previously sent a CR-TPDU that has not been acknowledged by a CC-TPDU, consider the connection refused (see 6.6). If the SRC-REF is not zero a DC-TPDU shall be sent using the SRC-REF as the DST-REF.

NOTE 1 – In this case, the DR has been associated regardless of its SRC-REF field (see 6.9.1.4 and 6.9.2.4).

- e) If c) and d) are not applicable, send a DC-TPDU and consider the transport connection released. If the received DR has the DST-REF field set to zero, then a DC with SRC-REF set to zero shall be sent, regardless of the local reference.

NOTE 2 – If the entity receiving such a DR-TPDU has previously decided to negotiate down the class, this entity is always entitled to consider such a DR-TPDU as spurious. Since no association has been made the transport connection is not released at the responder side but the CC-TPDU, when sent, will be answered by a DR-TPDU (spurious CC-TPDU).

NOTE 3 – This requirement ensures that the transport entity is aware of the remote reference for the transport connection.

NOTE 4 – When the transport connection is considered as released, the local reference is either available for re-use or is frozen (see 6.18).

NOTE 5 – After the release of a transport connection, the network connection can be released or retained to enable its re-use for the assignment of other transport connections (see 6.1.1).

NOTE 6 – Except in class 4, it is recommended that, if a transport entity does not receive acknowledgement of a DR-TPDU within time TS2, it should either reset or disconnect the network connection, and freeze the reference when appropriate (see 6.18). For all other transport connection(s) multiplexed on this network connection, the procedures for reset or disconnect as appropriate should be followed.

NOTE 7 – When a transport entity is waiting for a CC-TPDU before sending a DR-TPDU and the network connection is reset or released, it should consider the transport connection released and, in classes other than classes 0 and 2, freeze the reference (see 6.18).

6.7.2 Normal release when operating over CLNS

6.7.2.1 Purpose

The release procedure is used by a transport entity in order to terminate a transport connection.

6.7.2.2 Network service primitives

The procedures makes use of the following network service primitive:

- N-UNIT-DATA.

6.7.2.3 TPDU and parameters used

The procedure uses the following TPDU and parameters:

- a) DR-TPDU:
 - reason;
 - user data;
 - SRC-REF;
 - DST-REF;
- b) DC-TPDU.

6.7.2.4 Procedure

When the release of a transport connection is to be initiated, a transport entity shall send a DR-TPDU and shall discard all subsequently received TPDU except for a DR or a DC-TPDU.

On the receipt of a DR or a DC-TPDU, it shall consider the transport connection to be released and the local reference shall be frozen (see 6.18). If a CC-TPDU has been previously sent or received by the transport connection, then the remote reference is known and shall be used for the DST-REF in the DR-TPDU to be sent. If the remote reference is not known, then the DST-REF in the DR-TPDU may be set to zero, or the entity may wait until a CC-TPDU is received before sending the DR-TPDU.

NOTE – In case that the entity decides to wait for the arrival of the CC-TPDU for the connection, deadlock could result from a CC-TPDU that never arrives. Such a deadlock is prevented by the expiration of the CR-TPDU retransmission counter, which forces the DR-TPDU to be sent.

A transport entity which receives a DR-TPDU shall:

- a) Consider the transport connection to be released if it has previously sent a DR-TPDU for that connection.
- b) Consider the transport connection to be refused (see 6.6) if it has previously sent a CR-TPDU for that connection and no CC-TPDU has been received in acknowledgment.
- c) Consider the transport connection to be released and send a DC-TPDU in all other cases. If the received DR-TPDU has the DST-REF field set to zero, then a DC-TPDU with SRC-REF set to zero shall be sent, regardless of the local reference.

6.8 Error release when operating over CONS

6.8.1 Purpose

This procedure is used only in classes 0 and 2 to release a transport connection on the receipt of an N-DISCONNECT or N-RESET indication.

6.8.2 Network service primitives

The procedure uses the following service primitives:

- a) N-DISCONNECT request;
- b) N-DISCONNECT indication;
- c) N-RESET indication;
- d) N-RESET response.

6.8.3 Procedure

When, on the network connection to which a transport connection is assigned, an N-DISCONNECT or N-RESET indication is received, both transport entities shall consider that the transport connection is released and so inform the TS-users.

On receipt of an N-RESET indication:

- In class 0, an N-DISCONNECT request shall be issued.
- In class 2, it is a local choice to issue an N-RESET response or an N-DISCONNECT request; one of these primitives shall be issued. However, if the Network Connection has other Transport Connections of a different class assigned to it, the error recovery procedure of that class shall be used to determine which primitive is issued.

6.9 Association of TPDU with transport connections

6.9.1 Association of TPDU with transport connections when operating over CONS

6.9.1.1 Purpose

This procedure is used in all classes to interpret a received NSDU as TPDU(s) and, if possible, to associate each such TPDU with a transport connection.

6.9.1.2 Network service primitives

The procedure uses the following network service primitives:

- a) N-DATA indication;
- b) N-EXPEDITED DATA indication;
- c) N-RESET request;
- d) N-DISCONNECT request.

6.9.1.3 TPDU and parameters used

The procedure uses the following TPDU and parameters:

- a) any TPDU except CR-TPDU, DT-TPDU in classes 0 or 1 and AK-TPDU in class 1:
 - DST-REF;

- b) CR, CC, DR and DC-TPDUs:
 - SRC-REF;
- c) DT-TPDU in classes 0 or 1 and AK-TPDU in class 1.

6.9.1.4 Procedures

6.9.1.4.1 Identification of TPDUs

If the received NSDU or expedited NSDU cannot be decoded (i.e. does not contain one or more correct TPDUs) or is corrupted (i.e. contains a TPDU with a wrong checksum), then the transport entity shall:

- a) if the network connection on which the error is detected has a class 0 or 1 transport connection assigned to it, treat as a protocol error (see 6.22) for that transport connection;
- b) otherwise:
 - 1) if the NSDU can be decoded but contains corrupted TPDUs, discard the TPDUs (class 4 only) and optionally apply 6.9.1.4.1 b) 2);
 - 2) if the NSDU cannot be decoded, issue an N-RESET or N-DISCONNECT request for the network connection and for all the transport connections assigned to this network connection (if any), apply the procedures defined for handling of network signalled reset or disconnect.

If the NSDU can be decoded and is not corrupted, the transport entity shall:

- a) if the network connection on which the NSDU was received has a class 0 transport connection assigned to it, consider the NSDU as forming one TPDU and associate the TPDU with the transport connection (see 6.9.1.4.2);
- b) otherwise, invoke the separation procedures and for each of the individual TPDUs in the order in which they appear in the NSDU apply the procedure defined in 6.9.1.4.2.

6.9.1.4.2 Association of individual TPDU

If the received TPDU is a CR-TPDU, and if the SRC-REF parameter and the remote NSAP indicate an existing transport connection at that receiving entity, then the CR-TPDU is associated with that transport connection, otherwise it is processed as requesting the creation of a new transport connection. However, if the Network connection already has assigned a class 0 or class 1 Transport connection, then, if the second CR that is the retransmitted TPDU of class 4 has arrived, discard it and keep the first Transport connection, otherwise (i.e. arrived CR-TPDU is not a retransmitted TPDU of class 4) disconnect the Network connection.

If the received TPDU is a DT-TPDU and the network connection has no TC assigned to it, and the DT-TPDU is a class 0 or class 1 TPDU (as recognized by the absence of a DST-REF field), then the TPDU should be ignored.

If the received TPDU is a DT-TPDU and the network connection has a class 0 or 1 transport connection assigned to it, or an AK-TPDU where a class 1 transport connection is assigned, then the TPDU is associated with the transport connection.

Otherwise, the DST-REF parameter of the TPDU is used to identify the transport connection. The following cases are distinguished:

- a) If the DST-REF is not allocated to a transport connection, then no association with a transport connection is made and there are three cases:
 - 1) If the TPDU is a CC-TPDU the transport entity shall respond on the same network connection with a DR-TPDU. The SRC-REF of the DR-TPDU may be either 0 or the DST-REF from the received CC-TPDU.
 - 2) If the TPDU is a DR-TPDU, the transport entity shall respond on the same network connection with a DC-TPDU, except in the case that the DR is carrying an SRC-REF set to zero, then no DC-TPDU shall be sent, or in the case where the transport entity only supports class 0, then the network connection shall be disconnected.
 - 3) If the TPDU is neither a CC nor a DR it shall be discarded.
- b) If the DST-REF is allocated to a transport connection, but the TPDU is received on a network connection to which this connection has not been assigned, then there are four cases:
 - 1) If the transport connection is of class 4 and if the TPDU is received on a network connection with the same pair of NSAPs as that of the CR-TPDU, then the TPDU is associated with this transport connection and considered as performing assignment.

- 2) If the transport connection is not assigned to any network connection (waiting for reassignment after failure) and if the TPDU is received on a network connection with the same pair of NSAPs as that of the CR-TPDU, then the association with that transport connection is made, except in the case of DC, DR and CC-TPDUs which are respectively described in 6.9.1.4.2 c), d) and e).
- 3) In classes 1 and 3, it is also possible to receive a TPDU performing reassignment prior to the notification of the disconnect of the current network connection (i.e. the transport connection is assigned to a network connection, but a TPDU containing the appropriate DST-REF is received on another network connection). In this case it is recommended that the transport entity:
 - issue an N-DISCONNECT request on the network connection to which the transport connection is currently assigned;
 - apply to all transport connections assigned to this network connection the procedure for processing a received N-DISCONNECT indication; and
 - then process the TPDU performing reassignment.
- 4) Otherwise, the TPDU is considered as having a DST-REF not allocated to a transport connection [case a)].
- c) If the TPDU is a DC-TPDU, then it is associated with the transport connection to which the DST-REF is allocated, unless the SRC-REF is not the expected one, in which case the DC-TPDU is discarded.
- d) If the TPDU is a DR-TPDU, then there are four cases:
 - 1) if the SRC-REF is not as expected, then a DC-TPDU with DST-REF equal to the SRC-REF of the received DR-TPDU is sent back and no association is made, except that in the case where the transport entity only supports class 0 and cannot transmit a DC-TPDU, it disconnects the network connection instead of transmitting a DC-TPDU;
 - 2) if a CR-TPDU is unacknowledged, then the DR-TPDU is associated with the transport connection, regardless of the value of its SRC-REF parameter;
 - 3) if the transport entity implements class 4 and if the DST-REF is zero and there is an unacknowledged CC-TPDU or T-CONNECT response is awaited, then the DR-TPDU shall be associated with the transport connection holding the SRC-REF as the remote reference;
 - 4) otherwise, the DR-TPDU is associated with the transport connection identified by the DST-REF parameter.
- e) If the TPDU is a CC-TPDU whose DST-REF parameter identifies an open connection (one for which a CC-TPDU has been previously received), and the SRC-REF in the CC-TPDU does not match the remote reference, then a DR-TPDU is sent back with DST-REF equal to the SRC-REF of the received CC-TPDU and no association is made.
- f) If none of the above cases apply, then the TPDU is associated with the transport connection identified by the DST-REF parameter.

6.9.2 Association of TPDU with transport connections when operating over CLNS

6.9.2.1 Purpose

This procedure is used to interpret a received NSDU as TPDU(s) and, if possible, to associate each such TPDU with a transport connection.

6.9.2.2 Network service primitives

This procedure makes use of the following network service primitive:

- N-UNIT-DATA.

6.9.2.3 TPDU and parameters used

This procedure makes use of the following TPDU and parameters:

- a) all TPDU except CR-TPDU:
 - DST-REF.
- b) CR, CC, DR and DC-TPDU:
 - SRC-REF.

6.9.2.4 Procedures

6.9.2.4.1 Identification of TPDUs

If the received NSDU cannot be decoded (i.e. does not contain one or more correct TPDUs) or is corrupted (i.e. contains a TPDU with a wrong checksum), then the transport entity shall ignore (discard) the TPDUs. If the NSDU can be decoded and is not corrupted, the transport entity shall invoke the separation procedures and for each of the individual TPDUs in the order in which they appear in the NSDU, apply the procedure in 6.9.2.4.2.

6.9.2.4.2 Association of individual TPDUs

Association of a received TPDU with a transport connection is generally performed by attempting to match the DST-REF in the received TPDU and the NSAP pair over which it was received with those of an existing transport connection. There are three exceptions to this general procedure: when the received TPDU is a CR-TPDU, the SRC-REF is used instead of the DST-REF; when the received TPDU is either a DR or a DC-TPDU, the SRC-REF is used in addition to the DST-REF and when the received TPDU is a CC-TPDU, whose DST-REF parameter identifies an open connection (one for which a CC-TPDU has been previously received), then the SRC-REF is used in addition to the DST-REF.

The following actions shall be taken in consequence to the inability to match the TPDU to an existing transport connection:

- a) for a CR-TPDU, a new transport connection shall be created;
- b) for a CC-TPDU, a DR-TPDU shall be sent using the SRC-REF and DST-REF from the received CC-TPDU as the DST-REF and SRC-REF, respectively, of the DR-TPDU;
- c) for a DR-TPDU, there are four cases:
 - 1) if a CR-TPDU is unacknowledged for the connection identified by the DST-REF in the DR-TPDU, then the DR-TPDU is associated with that connection regardless of the SRC-REF in the DR-TPDU;
 - 2) if the CR-TPDU for the connection identified by the DST-REF of the DR-TPDU has been acknowledged and the SRC-REF is not as expected, then a DC-TPDU using the SRC-REF of the DR-TPDU as DST-REF is sent and no association is made;
 - 3) if the DST-REF in the DR-TPDU is zero and there is an unacknowledged CC-TPDU or a T-CONNECT response is awaited for a transport connection holding remote reference equal to the SRC-REF of the DR-TPDU, then the DR-TPDU is associated with that transport connection;
 - 4) in all other situations, the DR-TPDU is associated with the transport connection identified by the DST-REF of the DR-TPDU;
- d) for all other TPDU types, the TPDU is discarded.

6.10 Data TPDU numbering

6.10.1 Purpose

Data TPDU numbering is used in classes 1, 2 (except when the non-use of explicit flow control option is selected), 3 and 4. Its purpose is to enable the use of recovery, flow control and resequencing functions.

6.10.2 TPDUs and parameters used

The procedure uses the following TPDU and parameter:

- DT-TPDU:
 - TPDU-NR.

6.10.3 Procedure

A transport entity shall allocate the sequence number zero to the TPDU-NR of the first DT-TPDU which it transmits for a transport connection. For subsequent DT-TPDUs sent on the same transport connection, the transport entity shall allocate a sequence number one greater than the previous one.

When a DT-TPDU is retransmitted, the TPDU-NR parameter shall have the same value as in the first transmission of that DT-TPDU.

Modulo 2^7 arithmetic shall be used when normal formats have been selected and modulo 2^{31} arithmetic shall be used when extended formats have been selected. In this Recommendation | International Standard the relationships “greater than” and “less than” apply to a set of contiguous TPDU numbers whose range is less than the modulus and whose starting and finishing numbers are known. The term “less than” means “occurring sooner in the window sequence” and the term “greater than” means “occurring later in the window sequence”.

6.11 Expedited data transfer

6.11.1 Expedited data transfer when operating over CONS

6.11.1.1 Purpose

Expedited data transfer procedures are selected during connection establishment. The network normal data variant may be used in classes 1, 2, 3 and 4. The network expedited variant is only used in class 1.

6.11.1.2 Network service primitives

The procedure uses the following network service primitives:

- a) N-DATA;
- b) N-EXPEDITED DATA.

6.11.1.3 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- a) ED-TPDU:
 - ED-TPDU-NR;
- b) EA-TPDU:
 - YR-EDTU-NR.

6.11.1.4 Procedures

The TS-user data parameter of each T-EXPEDITED DATA request shall be conveyed as the data field of an Expedited Data (ED) TPDU.

Each ED-TPDU received shall be acknowledged by an Expedited Acknowledge (EA) TPDU.

No more than one ED-TPDU shall remain unacknowledged at any time for each direction of a transport connection.

An ED-TPDU with a zero length data field shall be treated as a protocol error.

NOTES

1 The network normal data variant is used, except when the network expedited variant (available in class 1 only), has been agreed, in which case ED and EA-TPDUs are conveyed in the data fields of N-EXPEDITED DATA primitives (see 6.2.3).

2 No TPDU can be transmitted using the network expedited variant until the CC-TPDU becomes acknowledged, to prevent the network expedited variant from overtaking the CC-TPDU.

6.11.2 Expedited data transfer when operating over CLNS

6.11.2.1 Purpose

Expedited data transfer procedures are selected during connection establishment.

6.11.2.2 Network service primitives

The procedure makes use of the following network service primitive:

- N-UNIT-DATA.

6.11.2.3 TPDUs and parameters used

The procedure makes use of the following TPDUs and parameters:

- a) ED-TPDU:
 - ED-TPDU-NR;

- b) EA-TPDU:
 - YR-EDTU-NR.

6.11.2.4 Procedures

The TS-user data parameter of each T-EXPEDITED DATA request shall be conveyed as the data field of an Expedited Data (ED) TPDU.

Each ED-TPDU received shall be acknowledged by an Expedited Acknowledge (EA) TPDU.

No more than one ED-TPDU shall remain unacknowledged at any time for each direction of a transport connection.

An ED-TPDU with a zero length data field shall be treated as a protocol error (see 6.22).

6.12 Reassignment after failure when operating over CONS

6.12.1 Purpose

The reassignment after failure procedure is used in classes 1 and 3 to commence recovery from an NS-provider signalled disconnect.

6.12.2 Network service primitives

The procedure uses the following network service primitive:

- N-DISCONNECT indication.

6.12.3 Procedure

When an N-DISCONNECT indication is received for the network connection to which a transport connection is assigned, the initiator shall apply one of the following alternatives:

- a) If the TTR timer has not already run out and no DR-TPDU is retained:
 - 1) assign the transport connection to a different network connection (see 6.1.1) and start its TTR timer if not already started;
 - 2) while waiting for the completion of assignment if:
 - an N-DISCONNECT indication is received, repeat the procedure from 6.12.3 a);
 - the TTR timer expires, begin procedure 6.12.3 b);
 - 3) when reassignment is complete perform active resynchronization by executing the procedure described in 6.14.4.1, and, if 6.14.4.1 b) has been performed, wait for the next event as follows:
 - if a valid TPDU is received as the result of the resynchronization, stop the TTR timer; or
 - if TTR runs out, wait for the next event; or
 - if an N-DISCONNECT indication is received, begin either procedure 6.12.3 a) or 6.12.3 b) depending on the TTR timer.

NOTE – After TTR expires and while waiting for the next event, it is recommended that the initiator set a timer with a value equal to TWR. If this timer expires before the next event, the initiator should begin the procedure in 6.12.3 b).
- b) If the TTR timer has run out, consider the transport connection as released and freeze the reference (see 6.18).
- c) If a DR-TPDU is retained and the TTR timer has not run out, then follow the actions in either 6.12.3 a) or 6.12.3 b).

The responder shall start its TWR timer if not already started. The arrival of the first TPDU related to the transport connection (because of resynchronization by the initiator) completes the reassignment after failure procedure. The TWR timer is stopped and the responder shall continue with resynchronization (see 6.14). If reassignment does not take place within this time, the transport connection is considered released and the reference is frozen (see 6.18).

6.12.4 Timers

The reassignment after failure procedure uses two timers:

- a) TTR, the time to try reassignment/resynchronization timer;
- b) TWR, the time to wait for reassignment/resynchronization timer.

The TTR timer is used by the initiator. Its value shall not exceed 2 minutes minus the sum of the maximum disconnect propagation delay and the maximum transit delay of the network connections (see Note 1). The value for the TTR timer may be indicated in the CR-TPDU.

The TWR timer is used by the responder. If the reassignment time parameter is present in the CR-TPDU, the TWR timer value shall be greater than the sum of the TTR timer plus the maximum disconnect propagation delay plus the maximum transit delay of the network connections.

If the reassignment time parameter is not present in the CR-TPDU, a default value of 2 minutes shall be used for the TWR timer.

NOTES

- 1 Provided that the required quality of service is met, TTR may be set to zero (i.e. no reassignment). This may be done, for example, if the rate of NS-provider generated disconnects is very low.
- 2 Inclusion of the reassignment time parameter in the CR-TPDU allows the responder to use a TWR value of less than 2 minutes.
- 3 If the optional TS1 and TS2 timers are used, it is recommended:
 - a) to stop TS1 or TS2 if running when TTR or TWR is started;
 - b) to restart TS1 or TS2 if necessary when the corresponding TPDU (CR-TPDU or DR-TPDU respectively) is repeated;
 - c) to select for TS1 and TS2 values greater than TTR.

6.13 Retention and acknowledgement of TPDUs

6.13.1 Purpose

The retention and acknowledgement of TPDUs procedure is used in classes 1, 3 and 4 to enable and minimize retransmission after possible loss of TPDUs.

The confirmation of receipt variant is used only in class 1 when it has been agreed during connection establishment (see the Note).

The AK variant is used in classes 3 and 4 and also in class 1 when the confirmation of receipt variant has not been agreed during connection establishment. In addition, in class 4, the option of using selective acknowledgement may be agreed to during connection establishment.

The request acknowledgement procedure is selected during connection establishment and may be used in classes 3 and 4, and in class 1 when the confirmation of receipt variant has not been agreed during connection establishment. It allows a transport entity to request acknowledgement of retained DT-TPDUs by setting the ROA parameter in a transmitted DT-TPDU.

NOTE – Use of the confirmation of receipt variant depends on the availability of the network layer receipt confirmation service and the expected cost reduction.

6.13.2 Network service primitives

When operating over CONS, the procedure uses the following network service primitives:

- a) N-DATA;
- b) N-DATA ACKNOWLEDGE.

When operating over CLNS, the procedure uses the following network service primitive:

- N-UNIT-DATA.

6.13.3 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- a) CR, CC, DR and DC-TPDUs;
- b) AK-TPDU:
 - YR-TU-NR;
 - selective acknowledgement parameters;
- c) RJ-TPDU:
 - YR-TU-NR;

- d) DT-TPDU:
 - TPDU-NR;
- e) ED-TPDU:
 - ED-TPDU-NR;
- f) EA-TPDU:
 - YR-EDTU-NR.

6.13.4 Procedures

6.13.4.1 Retention until acknowledgement of TPDU

Copies of the following TPDU shall be retained upon transmission to permit their later retransmission:

- CR, CC, DR, DT and ED-TPDUs,

except in the following case: if a DR-TPDU is sent in response to a CR-TPDU there is no need to retain a copy of the DR-TPDU.

A copy of each of these TPDU shall be retained until:

- a) it is acknowledged, as specified in Table 5; or
- b) the transport connection is released.

Table 5 – Acknowledgement of TPDU

Retained TPDU	Variant	Retained until acknowledged by:
CR	Both	CC, DR or ER-TPDU.
DR	Both	DC or DR (in case of collision) TPDU.
CC	Confirmation of receipt variant	N-DATA ACKNOWLEDGE indication, RJ, DT, EA or ED-TPDU.
CC	AK variant	RJ, DT, AK, ED or EA-TPDU.
DT	Confirmation of receipt variant	N-DATA ACKNOWLEDGE indication corresponding to an N-DATA request which conveyed, or came after, the DT-TPDU.
DT	AK variant	AK or RJ-TPDU for which the YR-TU-NR is greater than TPDU-NR in the DT-TPDU. In case of selective acknowledgement, if the selective acknowledgement parameters in the AK TPDU include the TPDU-NR of the DT-TPDU.
ED	Both	EA-TPDU for which the YR-EDTU-NR is equal to the ED-TPDU-NR in the ED-TPDU.

6.13.4.2 Confirmation of receipt variant

In the confirmation of receipt variant, applicable only in class 1, transport entities shall:

- a) set the confirmation request parameter only if the data parameter contains a CC or DT-TPDU (see Notes 1 and 2 in 6.13.4.4);
- b) issue an N-DATA ACKNOWLEDGE request when it receives an N-DATA indication with the confirmation request parameter set.

6.13.4.3 Request of acknowledgement option

If the request acknowledgement procedure has been negotiated, transport entities:

- a) may request acknowledgement of retained DT-TPDUs by setting the ROA parameter in a transmitted DT-TPDU. The decision as to when the sending transport entity should request acknowledgement is a local matter (see Note 4 in 6.13.4.4);
- b) on receipt of a DT-TPDU with the ROA parameter set shall transmit an AK-TPDU containing up-to-date window information.

6.13.4.4 Selective acknowledgement option

If the selective acknowledgement option has been negotiated, transport entities:

- a) May include selective acknowledgement parameters in a transmitted AK-TPDU. These selective acknowledgement parameters, if included, shall contain acknowledgement of blocks of TPDUs not acknowledged by the YR-TU-NR field of the AK-TPDU. This procedure allows transport entities to acknowledge DT-TPDUs that are within the window but that are not in sequence.
- b) On receipt of an AK-TPDU containing selective acknowledgement parameter(s) shall discard the DT-TPDUs specified.

NOTES (Notes 1 to 3 only apply when operating over CONS)

1 It is a local matter for each transport entity to decide which N-DATA requests should have the confirmation request parameter set. This decision will normally be related to the amount of storage available for retained copies of the DT-TPDUs.

2 Use of the confirmation request parameter may affect the quality of network service.

3 In class 3, and in class 1, when use of explicit AK variant is selected, if a transport entity does not send an AK-TPDU after reception of each DT-TPDU, it is recommended that:

- it start a timer after reception of DT-TPDU;
- it send an AK-TPDU with up-to-date window information at expiration of the timer if an AK-TPDU with the same window information has not been previously sent.

Selection of the value of this timer is a local matter but may affect performance.

4 It is recommended that, if the sending transport entity has a restriction in the number of DT-TPDUs that it can retain, then it set the ROA parameter to avoid a delay in transmitting DT-TPDUs due to the remote transport entity operating an AK withholding policy.

6.14 Resynchronization

6.14.1 Purpose

The resynchronization procedures are used in classes 1 and 3 to restore the transport connection to normal after a reset or during reassignment after failure according to 6.12.

6.14.2 Network service primitives

The procedure uses the following network service primitive:

- N-RESET indication.

6.14.3 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- a) CR, DR, CC and DC-TPDUs;
- b) RJ-TPDU:
 - YR-TU-NR;
- c) DT-TPDU:
 - TPDU-NR;
- d) ED-TPDU:
 - ED-TPDU-NR;
- e) EA-TPDU:
 - YR-EDTU-NT.

6.14.4 Procedure

A transport entity which is notified of the occurrence of a N-RESET shall:

- a) if the transport entity is the responder, carry out the passive resynchronization procedure (see 6.14.4.2);
- b) if the transport entity has elected not to reassign, do nothing;

- c) otherwise, execute the active resynchronization procedure described in 6.14.4.1 and, if 6.14.4.1 b) has been performed, wait for the next event as follows:
 - if a valid TPDU is received as the result of the resynchronization, stop the TTR timer; or
 - if TTR runs out, wait for the next event; or
 - if an N-RESET indication is received, perform 6.14.4.

6.14.4.1 Active resynchronization procedures

The transport entity shall carry out one of the following actions:

- a) if the TTR timer has been previously started and has run out (i.e. no valid TPDU has been received), the procedures defined in 6.12.3 a) 3) shall apply;
- b) otherwise, the TTR timer shall be started (unless it is already running) and the first which become applicable of the following actions shall be taken:
 - 1) if a CR-TPDU is unacknowledged, then the transport entity shall retransmit it;
 - 2) if a DR-TPDU is unacknowledged, then the transport entity shall retransmit it;
 - 3) otherwise, the transport entity shall carry out the data resynchronization procedures (see 6.14.4.3).

6.14.4.2 Passive resynchronization procedures

The transport entity shall not send any TPDU until a TPDU has been received. The transport entity shall start its TWR timer if it has not already been started (due to a previous N-DISCONNECT or N-RESET indication). If the timer runs out prior to the receipt of a valid TPDU which commences resynchronization (i.e. CR or DR or ED or RJ-TPDU), the transport connection is considered as released and the reference is frozen (see 6.18).

When a valid TPDU is received the transport entity shall stop its TWR timer and carry out one of the following appropriate actions, depending on the TPDU:

- a) If it is a DR-TPDU, then the transport entity shall send a DC-TPDU.
- b) If it is a repeated CR-TPDU (see Note 1) the transport entity shall carry out the appropriate action from the following:
 - 1) if a CC-TPDU has already been sent, and acknowledged: treat as a protocol error;
 - 2) if the responder wants to release the transport connection or refuse the CR-TPDU: (re)transmit the DR-TPDU, setting the source reference to zero;
 - 3) if the T-CONNECT response has not yet been received from the user: take no action;
 - 4) otherwise (re)transmit the CC-TPDU, followed by retransmission of any unacknowledged ED-TPDU (see Note 2) and retransmission of the unacknowledged DT-TPDUs, subject to any applicable flow control procedures.

NOTES

1 A repeated CR-TPDU can be identified by being on a network connection with the appropriate network addresses and having a correct source reference.

2 The transport entity should not use network expedited until the CC-TPDU is acknowledged (see 6.5). This rule prevents the network expedited from overtaking the CC-TPDU.

- c) If it is an RJ or ED-TPDU, then one of the following actions shall be taken:
 - 1) if a DR-TPDU is unacknowledged, then the transport entity shall retransmit it;
 - 2) if a CC-TPDU is unacknowledged, the RJ or ED-TPDU shall be considered as acknowledging the CC-TPDU, and the transport entity shall carry out the data resynchronization procedures (6.14.4.3);
 - 3) otherwise, the transport entity shall carry out the data resynchronization procedures (6.14.4.3).

6.14.4.3 Data resynchronization procedures

The transport entity shall carry out the following actions in the following order:

- a) (Re)transmit any ED-TPDU which is unacknowledged.
- b) Transmit an RJ-TPDU with YR-TU-NR field set to the TPDU-NR of the next expected DT-TPDU.

- c) Wait for the next TPDU from the other transport entity, unless an RJ or DR-TPDU has already been received; if a DR-TPDU is received the transport entity shall send a DC-TPDU, freeze the reference, inform the TS-user of the disconnection and take no further action [i.e. it shall not follow the procedures in 6.14.4.3 d)]. If an RJ-TPDU is received, the procedure of 6.14.4.3 d) shall be followed. If an ED-TPDU is received the procedures as described in 6.11 shall be followed. If it is a duplicated ED-TPDU the transport entity shall acknowledge it with an EA-TPDU, discard the duplicated ED-TPDU and wait again for the next TPDU.
- d) (Re)transmit any DT-TPDUs which are unacknowledged, subject to any applicable flow control procedures (see the Note).

NOTE – The RJ-TPDU may have reduced the credit.

6.15 Multiplexing and demultiplexing when operating over CONS

6.15.1 Purpose

The multiplexing and demultiplexing procedures are used in classes 2, 3 and 4 to allow several transport connections to share a network connection at the same time.

6.15.2 TPDU and parameters used

The procedure uses the following TPDU and parameters:

- CC, DR, DC, DT, AK, ED, EA, RJ, and ER-TPDUs:
 - DST-REF.

6.15.3 Procedure

The transport entities shall be able to send and receive on the same network connection TPDU and parameters belonging to different transport connections.

NOTES

1 When performing demultiplexing, the transport connection to which the TPDU and parameters apply is determined by the procedures defined in 6.9.

2 Multiplexing allows the concatenation of TPDU and parameters belonging to different transport connections to be transferred in the same N-DATA primitive (see 6.4).

6.16 Explicit flow control

6.16.1 Purpose

The explicit flow control procedure is used in classes 2, 3 and 4 to regulate the flow of DT-TPDUs independently of the flow control in the other layers.

6.16.2 TPDU and parameters used

The procedure uses the following TPDU and parameters:

- a) CR, CC, AK and RJ-TPDUs:
 - CDT;
- b) DT-TPDU:
 - TPDU-NR;
 - ROA;
- c) AK-TPDU:
 - YR-TU-NR;
 - subsequence number;
 - flow control confirmation;
 - selective acknowledgement parameters;
- d) RJ-TPDU:
 - YR-TU-NR.

6.16.3 Procedure

The procedures differ in different classes. They are defined in the clauses specifying the separate classes.

6.17 Checksum

6.17.1 Purpose

The checksum procedure is used to detect corruption of TPDUs by the NS-provider.

NOTE – Although a checksum algorithm has to be adapted to the type of errors expected on the network connection, at present, only one algorithm is defined.

6.17.2 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- All TPDUs:
 - checksum.

6.17.3 Procedure

The checksum shall be used only in class 4. It shall always be used for the CR-TPDU, and shall be used for all other TPDUs unless the non-use of the checksum was selected during connection establishment.

The sending transport entity shall transmit TPDUs with the checksum parameter set such that the following formulae are satisfied:

$$\sum_{i=1}^L a_i = 0 \text{ (modulo 255)} \quad (6-1)$$

$$\sum_{i=1}^L ia_i = 0 \text{ (modulo 255)} \quad (6-2)$$

where

- i is the number (i.e. position) of an octet within the TPDU (see 13.2);
- a_i is the value of octet in position i ;
- L is the length of TPDU in octets.

A transport entity which receives a TPDU for a transport connection for which the use of the checksum has been agreed and which does not satisfy the above formulae shall discard the TPDU (see also Note 2).

When a spurious TPDU is received and an answer has to be sent, the transport entity shall:

- a) if it supports the checksum algorithm and the received TPDU contains a checksum parameter, include a checksum parameter in the answering TPDU; or
- b) in all other cases, not include a checksum parameter in the answering TPDU.

An entity not supporting the checksum may always suppose that a CR-TPDU with class 4 proposed is correct and therefore negotiate down to a class lower than 4. If such an entity refuses the connection, then it sends a DR-TPDU without checksum.

NOTES

- 1 An efficient algorithm for determining the checksum parameters is given in Annex B.
- 2 If the checksum is incorrect, it is impossible to know with certainty to which transport connection the TPDU is related; further action may be required dependent on the type of network service in use (see 6.9.1 for CONS and 6.9.2 for CLNS).
- 3 The checksum proposed is easy to calculate and so will not impose a heavy burden on implementations. However, it will not detect insertion or loss of leading or trailing zeros and will not detect some octets misordering.
- 4 When CONS is used and a TPDU is received on a network connection, it is impossible to know with certainty that only class 4 transport connections use this network connection as it may be a TPDU performing reassignment.

Consequently, the only way to check the validity is as follows:

- a) if the network connection is used by a class 0 or class 1 transport connection, there is no checksum;
- b) examine the TPDU code;

- c) deduce the fixed part length;
- d) from LI, deduce the variable part;
- e) go through parameters and if the checksum parameter is found, then verify it;
- f) if it is incorrect, then assume that transport connection is class 4 and drop it;
- g) if it is correct, then associate the TPDU with a transport connection; if the transport connection uses the checksum, it is correct; otherwise, it shall be considered as a protocol error.

6.18 Frozen references

6.18.1 Purpose

This procedure shall be used in order to prevent re-use of a reference while TPDU's associated with the old use of the reference may still exist.

6.18.2 Procedure

When a transport entity determines that a particular connection is released it shall place the reference which it has allocated to the connection in a frozen state according to the procedures of the class. While frozen, the reference shall not be re-used.

NOTE – The frozen reference procedure is necessary because retransmission or misordering can cause TPDU's bearing a reference to arrive at an entity after it has released the connection for which it allocated the reference. Retransmission, for example, can arise when the class includes either resynchronization (see 6.14) or retransmission on time-out (see 6.19).

6.18.2.1 Procedure for classes 0 and 2

This Recommendation does not specify frozen reference procedures for classes 0 and 2.

NOTE – For consistency with other classes, references may be frozen as a local matter.

6.18.2.2 Procedure for classes 1 and 3

The frozen reference procedure is used except in the following cases (see Note 1):

- a) when the transport entity receives a DC-TPDU in response to a DR-TPDU which it has sent (see Note 2);
- b) when the transport entity sends a DR or ER-TPDU in response to a CR-TPDU which it has received (see Note 3);
- c) when the transport entity has considered the connection to be released after the expiration of the TWR timer (see Note 4);
- d) when the transport entity receives a DR or ER-TPDU in response to a CR-TPDU which it has sent;
- e) when the reference is zero.

The period of time for which the reference remains frozen shall be greater than the TWR time.

NOTES

- 1 However, even in these cases, for consistency freezing the reference may be done as a local decision.
- 2 When the DC-TPDU is received it is certain that the other transport entity considers the connection released.
- 3 When the DR or ER-TPDU is sent, the peer transport entity has not been informed of any reference assignment and thus cannot possibly make use of a reference (this includes the case where a CC-TPDU was sent, but was lost).
- 4 In c) the transport entity has already effectively frozen the reference for an adequate period.

6.18.2.3 Procedure for class 4

The frozen reference procedure shall be used in class 4. The period for which the reference remains frozen shall be greater than L (see 12.2.1.1.6).

6.19 Retransmission on time-out

6.19.1 Purpose

The procedure is used in class 4 to cope with unsignalled loss of TPDU's by the NS provider.

6.19.2 TPDU's used

The procedure uses the following TPDU's:

- CR, CC, DR, DT, ED, AK-TPDU's.

6.19.3 Procedure

The procedure is specified in the procedures for class 4 [see 12.2.1.2 i) and 12.2.1.3 g)].

6.20 Resequencing

6.20.1 Purpose

The resequencing procedure is used in class 4 to cope with misordering of TPDU's by the network service provider.

6.20.2 TPDU's and parameters used

The procedure uses the following TPDU's and parameters:

- a) DT-TPDU:
 - TPDU-NR;
- b) ED-TPDU:
 - ED-TPDU-NR.

6.20.3 Procedure

The procedure is specified in the procedures for class 4 (see 12.2.3.5).

6.21 Inactivity control

6.21.1 Purpose

The inactivity control procedure is used in class 4 to cope with unsignalled termination of a network connection when using CONS and the failure of a remote transport entity when using CONS or CLNS.

6.21.2 Procedure

The procedure is specified in the procedures for class 4 (see 12.2.3.3).

6.22 Treatment of protocol errors

6.22.1 Treatment of protocol errors when operating over CONS

6.22.1.1 Purpose

The procedure for treatment of protocol errors is used in all classes to deal with invalid TPDU's.

6.22.1.2 TPDU's and parameters used

The procedure uses the following TPDU's and parameters:

- a) ER-TPDU:
 - reject cause;
 - invalid TPDU;
- b) DR-TPDU:
 - reason code.

6.22.1.3 Procedure

A transport entity that receives a TPDU that can be associated to a transport connection and is invalid or constitutes a protocol error (see 3.2.16 and 3.2.17) shall take one of the following actions so as not to jeopardize any other transport connections not assigned to that network connection:

- a) transmit an ER-TPDU;
- b) reset or close the network connection; or
- c) invoke the release procedures appropriate to the class.

Under certain circumstances, it is also possible to discard the TPDU.

If an ER-TPDU is sent in class 0 it shall contain the octets of the invalid TPDU up to and including the octet where the error was detected (see Notes 3, 4 and 5).

If the TPDU cannot be associated with a particular transport connection, the transport entity shall follow the procedures in 6.9.

NOTES

1 In general, no further action is specified for the receiver of the ER-TPDU but it is recommended that it initiates the release procedure appropriate to the class. If the ER-TPDU has been received as an answer to a CR-TPDU then the connection is regarded as released (see 6.6).

2 Care should be taken by a transport entity receiving several invalid TPDUs or ER-TPDUs to avoid looping if the error is generated repeatedly.

3 If the invalid received TPDU is greater than the selected maximum TPDU size-inclusion in the invalid TPDU parameter of the ER-TPDU may not be possible.

4 It is recommended that the sender of the ER-TPDU starts an optional timer TS2 to ensure the release of the connection. If the timer expires, the transport entity shall initiate the release procedures appropriate to the class. The timer should be stopped when a DR-TPDU or an N-DISCONNECT indication is received.

5 In classes other than 0, it is recommended that the invalid TPDU be also included in the ER-TPDU.

6.22.2 Treatment of protocol errors when operating over CLNS

6.22.2.1 Purpose

The procedure for treatment of protocol errors is used to deal with invalid TPDUs.

6.22.2.2 TPDUs and parameters used

The procedure uses the following TPDUs and parameters:

- a) ER-TPDU:
 - reject cause;
 - invalid TPDU;
- b) DR-TPDU:
 - reason.

6.22.2.3 Procedure

Invalid TPDUs and protocol errors shall be ignored (no action and TPDU discarded, or responded to with an ER-TPDU), except for the following case: a CC-TPDU is received in which the class field does not specify class 4 and a previously sent CR-TPDU has not yet been acknowledged. In this case, the transport connection shall be terminated (see 6.7).

NOTE – It is recommended that the sender of the ER-TPDU starts an optional timer TS2 to ensure the release of the connection. If the timer expires, the transport entity shall initiate the release procedure appropriate to class 4. The timer should be stopped when a DR-TPDU is received.

6.23 Splitting and recombining when operating over CONS

6.23.1 Purpose

This procedure is used only in class 4 to allow a transport connection to make use of multiple network connections to provide additional resilience against network failure, to increase throughput, or for other reasons.

6.23.2 Procedure

When this procedure is being used, a transport connection may be assigned (see 6.1) to multiple network connections (see Note 1). TPDUs for the connection may be sent over any such network connection.

If the use of class 4 is not accepted by the remote transport entity following the negotiation rules, then no network connection except that over which the CR-TPDU was sent may have the transport connection assigned to it.

NOTES

- 1 The resequencing function of class 4 (see 6.20) is used to ensure that TPDUs are processed in the correct sequence.

2 Either transport entity may assign the connection to further network connections of which it is the owner at any time during the life of the transport connection, provided the following constraints are respected:

- the initiator does not start splitting before having received the CC-TPDU;
- as soon as a new assignment is carried out it is recommended to send a TPDU on this network connection in order to make the remote entity aware of this assignment.

3 A transport entity performing splitting should ensure that TPDU's are sent at intervals on each supporting network connection, for example, by sending successive TPDU's on successive network connections, where the set of network connections is used cyclically.

When splitting is used the inactivity control procedure defined in 12.2.3.3 will not normally detect unsignalled network connection failure. Any method of monitoring network connections to detect such failure is a local matter.

7 Protocol classes

Table 6 gives an overview of which elements of procedure are included in each class. In certain cases, the elements of procedure within different classes are not identical and, for this reason, Table 6 cannot be considered as part of the definitive specification of the protocol.

8 Specification for class 0 – Simple class

8.1 Functions of class 0

Class 0 is designed to have minimum functionality. It provides only the functions needed for connection establishment with negotiation, data transfer with segmenting and protocol error reporting.

Class 0 provides transport connections with flow control based on the network service provided flow control, and disconnection based on the network service disconnection.

8.2 Procedures for class 0

8.2.1 Procedures applicable at all times

The transport entities shall use the following procedures:

- a) TPDU transfer (see 6.2);
- b) association of TPDU's with transport connections (see 6.9);
- c) treatment of protocol errors (see 6.22);
- d) error release (see 6.8).

8.2.2 Connection establishment

The transport entities shall use the following procedures:

- a) assignment to network connection (see 6.1.1); then
- b) connection establishment (see 6.5) and, if appropriate, connection refusal (see 6.6),

subject to the following constraints:

- 1) the CR and CC-TPDU's shall contain no parameter fields in the variable part of the header other than those for Transport-Selector, maximum TPDU size, and preferred maximum TPDU size;
- 2) the CR and CC-TPDU's shall not contain a data field.

8.2.3 Data transfer

The transport entities shall use the segmenting and reassembling procedure (see 6.3).

8.2.4 Release

The transport entities shall use the implicit variant of the normal release procedure (see 6.7.1.4).

NOTE – The lifetime of the transport connection is directly correlated with the lifetime of the network connection.

Table 6 – Allocation of elements of procedures within classes

Protocol mechanism	Cross-reference	Variant or Option	0	1	2	3	4 CONS	4 CLNS
Assignment to network connection	6.1.1		x	x	x	x	x	
TPDU transfer	6.2		x	x	x	x	x	x
Segmenting and reassembling	6.3		x	x	x	x	x	x
Concatenation and separation	6.4			x	x	x	x	x
Connection establishment	6.5		x	x	x	x	x	x
Connection refusal	6.6		x	x	x	x	x	x
Normal release	6.7	Implicit Explicit	x	x	x	x	x	x
Error release	6.8		x		x			
Association of TPDU's with transport connection	6.9		x	x	x	x	x	x
TPDU numbering	6.10	Normal Extended		x	m (Note 1) o (Note 1)	m o	m o	m o
Expedited data transfer	6.11	Network Normal Network Expedited		m ao	x (Note 1)	x	x	x
Reassignment after failure	6.12			x		x	(Note 3)	
Retention and acknowledgement of TPDU's	6.13	Confirmation of receipt AK Use of selective acknowledgement Use of request acknowledgement		ao m o (Note 4)		 x o	 x o o	 x o o
Resynchronization	6.14			x		x	(Note 3)	
Multiplexing and demultiplexing	6.15				x (Note 2)	x	x	
Explicit flow control (with) Explicit flow control (without)	6.16		x	x	m o	x	x	x
Checksum (use of) Checksum (non-use of)	6.17		x	x	x	x	m o	m o
Frozen references	6.18			x		x	x	x
Retransmission on time-out	6.19						x	x
Resequencing	6.20						x	x
Inactivity control	6.21						x	x
Treatment of protocol errors	6.22		x	x	x	x	x	x
Splitting and recombining	6.23						x	

x Procedure always included in class
Not applicable

m Negotiable procedure whose implementation in equipment is mandatory

o Negotiable procedure whose implementation in equipment is optional

ao Negotiable procedure whose implementation in equipment is optional and where use depends of availability within the network service

NOTES

1 Not applicable in class 2 when non-use of explicit flow control is selected.

2 Multiplexing may lead to degradation of the quality of service if the non-use of explicit flow control has been selected.

3 This function is provided in class 4 using procedures other than those used in the cross-reference.

4 This option is not applicable in class 1, when the confirmation of receipt variant has been selected.

9 Specification for class 1 – Basic error recovery class

9.1 Functions of class 1

Class 1 provides transport connections with flow control based on the network service provided flow control, error recovery, expedited data transfer, disconnection, and also the ability to support consecutive transport connections on a network connection.

This class provides the functionality of class 0 plus the ability to recover after a failure signalled by the Network Service, without involving the TS-user.

9.2 Procedures for class 1

9.2.1 Procedures applicable at all times

The transport entities shall use the following procedures:

- a) TPDU transfer (see 6.2);
- b) association of TPDU with transport connections (see 6.9);
- c) treatment of protocol errors (see 6.22);
- d) reassignment after failure (see 6.12);
- e) resynchronization (see 6.14), or reassignment after failure (see 6.12) together with resynchronization (see 6.14);
- f) concatenation and separation (see 6.4);
- g) retention and acknowledgement of TPDUs (see 6.13); the variant used, AK or confirmation of receipt, shall be as selected during connection establishment (see Notes);
- h) frozen references (see 6.18).

NOTES

1 The negotiation of the variant of retention and acknowledgement of TPDUs procedure to be used over the transport connection has been designed such that if the initiator proposes the use of the AK variant (i.e. the mandatory implementation option), the responder has to accept use of this option and if the initiator proposes use of the confirmation of receipt variant the responder is entitled to select use of the AK variant.

2 The AK variant makes use of AK-TPDUs to release copies of retained DT-TPDUs. The CDT parameter of AK-TPDUs in class 1 is not significant, and is set to 1111.

3 The confirmation of receipt variant is restricted to this class and its use depends on the availability of the network layer receipt confirmation service, and the expected cost reduction.

9.2.2 Connection establishment

The transport entities shall use the following procedures:

- a) assignment to network connection (see 6.1.1); then
- b) connection establishment (see 6.5) and, if appropriate, connection refusal (see 6.6).

9.2.3 Data transfer

9.2.3.1 General

The sending transport entity shall use the following procedures:

- a) segmenting (see 6.3); then
- b) the normal format variant of DT-TPDU numbering (see 6.10).

The receiving transport entity shall use the following procedures:

- 1) the normal format variant of DT-TPDU numbering (see 6.10); then
- 2) reassembling (see 6.3).

NOTE – The decision to issue an N-RESET request in order to force the remote entity to carry out the resynchronization (see 6.14) may be made on a local basis.