Section two: Transport protocol specification

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.

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 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 initiator 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 transport entity that did not initiate the assignment 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.

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-UNITDATA.

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-UNITDATA.

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-UNITDATA 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 TPDUs.

6.3.2 TPDUs 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 TPDUs in one NSDU.

6.4.2 Procedure

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

A valid set of concatenated TPDUs may contain

a) any number of TPDUs from the following list: AK, EA, RJ, ER, DC TPDUs, provided that these TPDUs come from different transport connections;

b) no more than one TPDU from the following list: CR, DR, CC, DT, ED TPDUs; if this TPDU is present, it shall be placed last in the set of concatenated TPDUs.

A transport entity shall accept a valid set of concatenated TPDUs.

NOTES

1 The TPDUs 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 TPDUs 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 TPDUs that may be concatenated is bounded by the number of transport connections established between two NSAPs 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 operating over CLNS, the procedure uses the following network service primitive:

N-UNITDATA.

6.5.3 TPDUs and parameters used

The procedure uses the following TPDUs 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 TSAP-ID;
   - called TSAP-ID;
   - 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);
   - 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 TSAP-ID;
   - called TSAP-ID;
   - 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 TPDUs are sent.

NOTE – Even if the initiator assigns the transport connection to more than one network connection, all the CR TPDUs (if repeated) or DR TPDUs 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 – Except in class 4, it is recommended that the initiator starts 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 TPDUs 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 and called TSAP-IDs (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 the note). Up to 32 octets in other classes.

NOTE – 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:

j) 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 — 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.

NOTES

1 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

a) If class 3 or 4 is proposed then class 2 is valid response;

b) if class 1 is proposed then class 0 is a valid response.

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

3 Redundant combinations are not a protocol error.

k) TPDU size: The initiator may propose a maximum size for TPDUs, 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 — The length of the CR TPDU does not exceed 128 octets (see 13.3).

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

m) 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 proposed a preferred maximum size for TPDUs and the responder may accept this value or respond with a smaller value.

NOTE – 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 k);

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 k).

n) 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.

p) checksum selection: This defines whether or not TPDUs of the connection are to include a checksum.

q) quality of service parameters: This defines the throughput, transit delay, priority and residual error rate.

NOTE — 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 p), uses a value at 128 octets. Conversion to and from specifications based upon some other value is a local matter.

r) the non-use of explicit flow control in class 2.

s) the use of network receipt confirmation and network expedited when class 1 is to be used.

t) 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 ISO 8072).

u) the use of selective acknowledgement: This allows the transport entities to decide whether to use procedures that allow acknowledgement of DT TPDUs that are received out-of-sequence (only in class 4).

v) 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).

The following information is sent only in the CR TPDU:

w) version number: This defines the version of the transport protocol standard used for this connection.

x) reassignment time parameter: This indicates the time for which the initiator will persist in following the reassignment after failure procedure.

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 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

NOTE – Table 4 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).

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) called and calling TSAP-IDs (optional): Indicates the calling and called transport service access points. When either the 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.

j) 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 is not permitted.

The following negotiations take place:

k) TPDU size: The initiator may propose a maximum size for TPDUs 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 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)].

NOTES

1 The length of the CR TPDU does not exceed 128 octets (see 13.3).

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

m) 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 TPDUs and the responder may accept this value or respond with a smaller value.

NOTE – 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 k);

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 k).

n) 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.

p) checksum selection: This defines whether or not TPDUs of the connection are to include a checksum.

q) quality of service parameters: This defines the throughput, transit delay, priority and residual error rate.

NOTE – 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 p), uses a value at 128 octets. Conversion to and from specifications based upon some other value is a local matter.

r) 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 (ISO 8072).

s) the use of selective acknowledgement: This allows the transport entities to decide whether to use procedures that allow acknowledgement of DT TPDUs that are received out-of-sequence.

t) 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.

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.

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 TPDUs and parameters used

The procedure uses the follow TPDUs 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 TPDUs 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.

3 The release of a transport connection is initiated on occurance of a T-DISCONNECT request, or on occurance of an exception condition as described elsewhere in this International Standard.

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 1) shall

   1) send a DR TPDU;

   2) discard all subsequently received TPDUs other than a DR or DC TPDU;

   3) consider the transport connection released on receipt of a DR or DC 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, is 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 – 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 – 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).

NOTES

1 This requirement ensures that the transport entity is aware of the remote reference for the transport connection.

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

3 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).

4 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.

5 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-UNITDATA.

6.7.2.3 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.

6.7.2.4 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 TPDUs 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, regard less 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 TPDUs with transport connections

6.9.1 Association of TPDUs 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 TPDUs and parameters used

The procedure uses the following TPDUs 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, then 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.

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.

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 a SRC-REF set to zero, when no DC TPDU shall be sent, or in the case where the transport entity only supports class 0 when the network connection shall be disconnected;

3) If the TPDU is neither a CC or 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), 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 TPDUs 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-UNITDATA.

6.9.2.3 TPDUs and parameters used

This procedure makes use of the following TPDUs and parameters:

a) all TPDUs except CR TPDU;

– DST-REF;

b) CR, CC, DR and DC TPDUs;

– 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 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-UNITDATA.

6.11.2.3 TPDUs and parameters used

The procedures 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 min 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 min 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 min.

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-UNITDATA.

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 TPDUs

Copies of the following TPDUs 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 TPDUs shall be retained until

a) it is acknowledged, as specified in table 5; or

b) the transport connection is released.

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);

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).

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

– starts a timer after reception of DT TPDU;

– sends 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.

Table 5 – Acknowledgement of TPDUs

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

6.14 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 primatives

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 (6.14.4.3).

6.14.4.2 Passive resynchronization procedures

The transport entity shall not send any TPDUs 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 TPDUs and parameters used

The procedure uses the following TPDUs 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 TPDUs belonging to different transport connections.

NOTES

1 When performing demultiplexing the transport connection to which the TPDUs apply is determined by the procedures defined in 6.9.

2 Multiplexing allows the concatenation of TPDUs 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 TPDUs and parameters used

The procedure uses the following TPDUs 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:

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

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

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.

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 TPDUs 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 TPDUs 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 International Standard 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 TPDUs by the NS provider.

6.19.2 TPDUs used

The procedure uses the following TPDUs:

CR, CC, DR, DT, ED, AK TPDUs.

6.19.3 Procedure

The procedure is specified in the procedures for class 4 [see 12.2.1.2 j) 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 TPDUs by the network service provider.

6.20.2 TPDUs and parameters used

The procedure uses the following TPDUs 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 TPDUs.

6.22.1.2 TPDUs and parameters used

The procedure uses the following TPDUs 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 TPDUs are sent at intervals on each supporting network connection, for example, by sending successive TPDUs on successive network connections, where the set of network connections is used cyclically.

When splitting is used the inactivity control procedure defines in clause 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.

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	x					
		Explicit		x	x	x	x	x
Error release	6.8		x		x			
Association of TPDUs with transport connection	6.9		x	x	x	x	x	x
TPDU numbering	6.10	Normal		x	m(1)	m	m	m
		Extended			o(1)	o	o	o
Expedited data transfer	6.11	Network Normal		m	x(1)	x	x	x
		Network Expedited		ao				
Reassignment after failure	6.12			x		x	(3)	
Retention and acknowledgement of TPDUs	6.13	Confirmation of receipt		ao				
		AK		m		x	x	x
		Use of selective acknowledgement					o	o
		Use of request acknowledgement		o(4)		o	o	o
Resynchronization	6.14			x		x	(3)	
Multiplexing and demultiplexing	6.15				x(2)	x	x	
Explicit flow control (with)	6.16				m	x	x	x
Explicit flow control (without)			x	x	o			
Checksum (use of)	6.17						m	m
Checksum (non-use of)			x	x	x	x	o	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	

Key to Table 6:

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
(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

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 TPDUs 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 TPDUs shall contain no parameter fields in the variable part of the header other than those for TSAP-ID, maximum TPDU size, and preferred maximum TPDU size;

2) the CR and CC TPDUs 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.

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 the 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 entitles 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.

9.2.3.2 Expedited data

The transport entities shall use either the network normal data or the network expedited variants of the expedited data transfer procedure (see 6.11) if their use has been selected during connection establishment (see note 1).

The sending transport entity shall not allocate the same EDTPDU-NR to successive ED TPDUs (see notes 2 and 3).

When acknowledging an ED TPDU by sending an EA TPDU the transport entity shall put into the YR-EDTU-NR parameter of the EA TPDU the value received in the ED-TPDU-NR parameter of the ED TPDU.

NOTES

1 The negotiation of the variant of expedited data transfer procedure to be used over the transport connection has been designed such that if the initiator proposes the use of the network normal data variant (i.e. the mandatory implementation option), the responder has to accept use of this option and if the initiator proposes use of the network expedited variant, the responder is entitled to select use of the network normal data variant.

2 This numbering enables the receiving transport entity to discard repeated ED TPDUs when resynchronization (see 6.14) has taken place.

3 No other significance is attached to the ED-TPDU-NR parameter. It is recommended, but not essential, that the values used be consecutive modulo 128.

4 The use of RJ TPDUs during resynchronization (see 6.14) can lead to retransmission. Thus, the receipt of a duplicate ED TPDU is possible. Such an ED TPDU is discarded.

9.2.4 Release

The transport entities shall use the explicit variant of the release procedure (see 6.7.1.5).

10 Specification for class 2: Multiplexing class

10.1 Functions of class 2

Class 2 provides transport connections with or without individual flow control; no error detection or error recovery is provided.

If the network connection resets or disconnects, the transport connection is terminated without the transport release procedure and the TS-user is informed.

When explicit flow control is used, a credit mechanism is defined allowing the receiver to inform the sender of the exact amount of data he is willing to receive and that the expedited data transfer is available.

10.2 Procedures for class 2

10.2.1 Procedures applicable at all times

The transport entities shall use the following procedures

a) association of TPDUs with transport connection (see 6.9);

b) TPDU transfer (see 6.2);

c) treatment of protocol errors (see 6.22);

d) concatenation and separation (see 6.4);

e) error release (see 6.8).

Additionally the transport entities may use the following procedures:

f) multiplexing and demultiplexing (see 6.15).

10.2.2 Connection establishment

The transport entities may use the following procedures:

a) assignment to network connection (see 6.1.1); then

b) connection establishment (see 6.5) and, if applicable, connection refusal (see 6.6).

10.2.3 Data transfer when non-use of explicit flow control has been selected

If this option has been selected as a result of the connection establishment, the transport entities shall use the segmenting procedure (see 6.3).

The TPDU-NR field of DT TPDUs is not significant and may take any value.

NOTE – Expedited data transfer is not applicable (see 6.5).

10.2.4 Data transfer when use of explicit flow control has been selected

10.2.4.1 General

The sending transport entity shall use the following procedures:

a) segmenting (see 6.3); then

b) DT TPDU numbering (see 6.10).

The receiving transport entity shall use the following procedures:

1) DT TPDU numbering (see 6.10); if a DT TPDU is received which is out of sequence it shall be treated as a protocol error; then

2) reassembling (see 6.3).

The variant of the DT TPDU numbering which is used by both transport entities shall be that which was agreed at connection establishment.

10.2.4.2 Flow control

The transport entities shall send an initial credit (which may be zero) in the CDT field of the CR or CC TPDU. This credit represents the initial value of the upper window edge allocated to the peer entity.

The transport entity that receives the CR or the CC TPDU shall consider its lower window edge as zero, and its upper window edge as the value of the CDT field in the received TPDU.

In order to authorize the transmission of DT TPDUs, by its peer, a transport entity may transmit an AK TPDU at any time, subject to the following constraints:

a) the YR-TU-NR parameter shall be at most one greater than the TPDU-NR field of the last received DT TPDU or shall be zero if no DT TPDU has been received;

b) if an AK TPDU has previously been sent the value of the YR-TU-NR parameter shall not be lower than that in the previously sent AK TPDU;

c) the sum of the YR-TU-NR and CDT fields shall not be less than the upper window edge allocated to the remote entity (see note 1).

A transport entity which receives an AK TPDU shall consider the YR-TU-NR field as its new lower window edge, and the sum of YR-TU-NR and CDT as its new upper window edge. If either of these have been reduced or if the lower window edge has become more than one greater than the TPDU-NR of the last transmitted DT TPDU, this shall be treated as a protocol error (see 6.22).

A transport entity shall not send a DT TPDU with a TPDU-NR outside of the transmit window (see notes 2 and 3).

NOTES

1 This means that credit reduction is not applicable.

2 This means that a transport entity is required to stop sending if the TPDU-NR field of the next DT TPDU which would be sent would be the upper window edge. Sending of DT TPDU may be resumed if an AK TPDU is received which increases the upper window edge.

3 The rate at which a transport entity progresses the upper window edge allocated to its peer entity constrains the throughput attainable on the transport connection.

10.2.4.3 Expedited data

The transport entities shall follow the network normal data variant of the expedited data transfer procedure in 6.11.1 if its use has been agreed during connection establishment. ED and EA TPDUs are not subject to the flow control procedures in 10.2.4.2. The ED-TPDU-NR and YR-ETDU-NR fields of ED and EA TPDUs respectively are not significant and may take any value.

10.2.5 Release

The transport entities shall use the explicit variant of the release procedure in 6.7.1.

11 Specification for class 3: Error recovery and multiplexing class

11.1 Functions of class 3

Class 3 provides the functionality of class 2 (with use of explicit flow control) plus the ability to recover after a failure signalled by the Network Layer without involving the TS-user.

The mechanisms used to achieve this functionality also allow the implementation of more flexible flow control.

11.2 Procedures for class 3

11.2.1 Procedures applicable at all times

The transport entities shall use the following procedures:

a) association of TPDUs with transport connections (see 6.9);

b) TPDU transfer (see 6.2) and retention and acknowledgement of TPDUs (AK variant only) (see 6.13);

c) treatment of protocol errors (see 6.22);

d) concatenation and separation (see 6.4);

e) reassignment after failure (see 6.12), together with resynchronization (see 6.14);

f) frozen references (see 6.18).

Additionally, the transport entities may use the following procedure:

g) multiplexing and demultiplexing (see 6.15).

11.2.2 Connection establishment

The transport entities shall use the following procedures:

a) assignment to network connections (see 6.1.1); then

b) connection establishment (see 6.5) and, if appropriate, connection refusal (see 6.6).

11.2.3 Data transfer

11.2.3.1 General

The sending transport entity shall use the following procedures:

a) segmenting (see 6.3); then

b) DT TPDU numbering (see 6.10); after receipt of an RJ TPDU (see 11.2.3.2) the next DT TPDU to be sent may have a value which is not the previous value of TPDU-NR plus one.

The receiving transport entity shall use the following procedures:

1) DT TPDU numbering (see 6.10); the TPDU-NR field of each received DT TPDU shall be treated as a protocol error if it exceeds the greatest value received in a previous DT TPDU by more than one (see the note); then

2) Reassembling (see 6.3); duplicated TPDUs shall be eliminated before reassembling is performed.

NOTE – The use of RJ TPDUs (see 11.2.3.2) can lead to retransmission and reduction of credit. Thus the receipt of a DT TPDU which is a duplicate, or which is greater than or equal to the upper window edge allocated to the peer entity, is possible and is therefore not treated as a protocol error.

11.2.3.2 Use of an RJ TPDU

A transport entity may send an RJ TPDU at any time in order to invite retransmission or to reduce the upper window edge allocated to the peer entity (see note 1).

When an RJ TPDU is sent, the following constraints shall be respected:

a) the YR-TU-NR parameter shall be at most one greater than the greatest value received in a previous DT TPDU, or shall be zero if no DT TPDU has yet been received (see note 2);

b) if an AK or RJ TPDU has been sent previously the YR-TU-NR parameter shall not be lower than that in the AK or RJ TPDU sent previously.

When a transport entity receives an RJ TPDU (see note 3):

c) the next DT TPDU to be transmitted, or retransmitted, shall be that for which the value of the TPDU-NR parameter is equal to the value of the YR-TU-NR parameter of the RJ TPDU;

d) the sum of the values of the YR-TU-NR and CDT parameters of the RJ TPDU becomes the new upper window edge (see note 4).

NOTES

1 An RJ TPDU can also be sent as part of the resynchronization (see 6.14) and reassignment after failure (see 6.12) procedures.

2 It is recommended that the YR-TU-NR parameter be equal to the TPDU-NR parameter of the next expected DT TPDU.

3 These rules are a subset of those specified for the case when an RJ TPDU is received during resynchronization (see 6.14) and reassignment after failure (see 6.12).

4 This means that an RJ TPDU can be used to reduce the upper window edge allocated to the peer entity (credit reduction).

11.2.3.3 Flow control

The procedures shall be as defined in 10.2.4.2, except that

a) a credit reduction may lead to the reception of a DT TPDU with a TPDU-NR parameter whose value is not, but would have been less than the upper window edge allocated to the remote entity prior to the credit reduction. This shall not be treated as a protocol error;

b) receipt of an AK TPDU which sets the lower window edge more than one greater than the TPDU-NR of the last transmitted DT TPDU shall not be treated as a protocol error, provided that all acknowledged DT TPDUs have been previously transmitted (see notes 1 and 2).

NOTES

1 This can only occur during retransmission following receipt of an RJ TPDU.

2 The transport entity may either continue retransmission as before or retransmit only those DT TPDUs, not acknowledged by the AK TPDU. In either case, copies of the acknowledged DT TPDUs need not be retained.

11.2.3.4 Expedited data

The transport entities shall follow the network normal data variant of the expedited data transfer procedure in 6.11.1 if its use has been agreed during connection establishment.

The sending transport entity shall not allocate the same ED-TPDU-NR to successive ED TPDUs.

The receiving transport entity shall transmit an EA TPDU with the same value in its YR-EDTU-NR parameter. If, and only if, this number is different from that of the ED TPDU perceived previously, shall it generate a T-EXPEDITED DATA indication to convey the data to the TS-user (see note 2).

NOTES

1 No other significance is attached to the ED-TPDU-NR parameter. It is recommended, but not essential that the values be consecutive modulo 2^n, where n is the number of bits of the parameter.

2 This procedure ensures that the TS-user does not receive data corresponding to the same ED TPDU more than once.

11.2.4 Release

The transport entities shall use the explicit variant of the release procedure in 6.7.1.

12 Specification for class 4: Error detection and recovery class

12.1 Functions of class 4

12.1.1 Functions of class 4 when operating over CONS

Class 4 provides the functionality of class 3, plus the ability to detect and recover from lost, duplicated, or out of sequence TPDUs without involving the TS-user.

This detection of errors is made by extended use of the DT TPDU numbering of class 2 and class 3, by time-out mechanisms, and by additional procedures.

Class 4 detects signalled and unsignalled network failures (i.e. resets or disconnects or inactivity) and recovers from these failures by using time-out mechanisms.

This class detects and recovers from damaged TPDUs by using a checksum mechanism. The checksum mechanism shall be available but its use or its non-use is subject to negotiation.

This class also provides additional resilience against network failure and increased throughput capability by allowing a transport connection to make use of multiple network connections.

12.1.2 Functions of class 4 when operating over CLNS

Class 4 provides flow control between peer transport entities, the capability to detect and recover from errors which occur as a result of a low grade service available from the network service 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.

The detection of errors is made by use of TPDU numbering on DT, AK, ED and EA TPDUs, by time-out mechanisms and additional procedures such as the use of a checksum mechanism. The use of the checksum mechanism shall be available but its use or its non-use is subject to negotiation.

12.2 Procedures for class 4

12.2.1 Procedures available at all times

12.2.1.1 Timers used at all times

This sub-clause defines timers that apply at all times in class 4. These timers are listed in table 7.

This International Standard does not define specific values for the timers, and the derivations described in this sub-clause are not mandatory. The values should be chosen so that the required quality of service can be provided, given the known characteristics of the network.

Timers that apply only to specific procedures are defined under the appropriate procedure.

12.2.1.1.1 NSDU lifetime (M_{LR}, M_{RL})

The Network Layer is assumed to provide, as an aspect of its grade of service, for a bound on the maximum lifetime of NSDUs in the network. This value may be different in each direction of transfer through a network between two transport entities. The values, for both directions of transfer, are assumed to be known by the transport entities. The maximum NSDU lifetime local-to-remote (M_{LR}) is the maximum time which may elapse between the transmission of an NSDU from the local transport entity to the network and receipt of any copy of the NSDU from the network at the remote transport entity. The maximum NSDU lifetime remote-to-local (M_{RL}) is the maximum time which may elapse between the transmission of an NSDU from the remote transport entity to the network and receipt of any copy of the NSDU from the network at the local transport entity.

12.2.1.1.2 Expected maximum transit delay (E_{LR}, E_{RL})

The Network Layer is assumed to provide, as an aspect of its grade of service, an expected maximum transit delay for NSDUs in the network. This value may be different in each direction of transfer through a network between two transport entities. The values, for both directions of transfer, are assumed to be known by the transport entities. The expected maximum transit delay local-to-remote (E_{LR}) is the maximum delay suffered by all but a small proportion of NSDUs transferred through the network from the local transport entity to the remote transport entity. The expected maximum transit delay remote-to-local (E_{RL}) is the maximum delay suffered by all but a small proportion of NSDUs transferred through the network from the remote transport entity to the local transport entity.

12.2.1.1.3 Acknowledgement time (A_R, A_L)

Any transport entity is assumed to provide a bound for the maximum time which can elapse between its receipt of a TPDU from the Network Layer and its transmission of the corresponding response. This value is referred to as A_L. The corresponding time given by the remote transport entity is referred to as A_R.

12.2.1.1.4 Local retransmission time (T1)

The local transport entity is assumed to maintain a bound on the time it will wait for an acknowledgement before retransmitting the TPDU. Its value is given by

$$T1 = E_{LR} + E_{RL} + A_R + x$$

where

E_{LR} is the expected maximum transit delay local-to-remote;

E_{RL} is the expected maximum transit delay remote-to-local;

A_R is the remote acknowledgement time;

x is the local processing time for a TPDU.

NOTE – During connection establishment the value of A_R is not known. In this case a suitable bound for T1 may be established either by estimating (or having a priori knowledge of) A_R or by applying a suitable algorithm to the transport connection establishment delay QOS parameter.

12.2.1.1.5 Persistence time (R)

The local transport entity is assumed to provide a bound for the maximum time for which it may continue to retransmit a TPDU requiring positive acknowledgement and which is not outside the current transmit window, even after credit reduction. This value is referred to as R.

The value is clearly related to the time elapsed between retransmission, T1, and the maximum number of transmissions, N. It is not less than T1 * (N - 1) + x, where x is a small quantity to allow for additional internal delays, the granularity of the mechanism used to implement T1, etc. Because R is a bound, the exact value of x is unimportant as long as it is bounded and the value of a bound is known.

12.2.1.1.6 Time bound of references and sequence numbers (L)

A bound for the maximum time between the decision to transmit a TPDU and the receipt of any acknowledgement relating to it (L) is given by:

$$L = M_{LR} + M_{RL} + R + A_R$$

where

M_{LR} is the NSDU lifetime local-to-remote;

M_{RL} is the NSDU lifetime remote-to-local;

R is the persistence time;

A_R is the remote acknowledgement time.

It is necessary to wait for a period of time before reusing any reference or sequence number in order to avoid confusion when a TPDU referring to it is duplicated or delayed.

The period of time during which the sequence numbers for DT TPDUs should be frozen is the period L, starting from the time when the sequence number has fallen below the lower window edge.

NOTES

1 In practice, the value of L may be too large. It may also be only a statistical figure at a certain confidence level. A smaller value may therefore be used where this still allows the required quality of service to be provided.

2 The relationships between times discussed above are illustrated in figures 3 and 4.

12.2.1.1.7 Inactivity timer (I_L, I_R)

Any transport entity is assumed to provide a lower bound for the time which can elapse without receipt of a TPDU before it will initiate the release procedure to terminate the transport connection. This value is referred to as I_L. The corresponding time given by the remote transport entity is referred to as I_R.

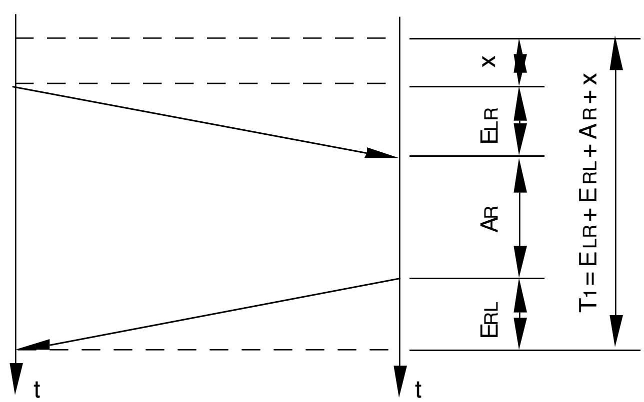

Figure 3 – Interrelationship of times for the average case in class 4

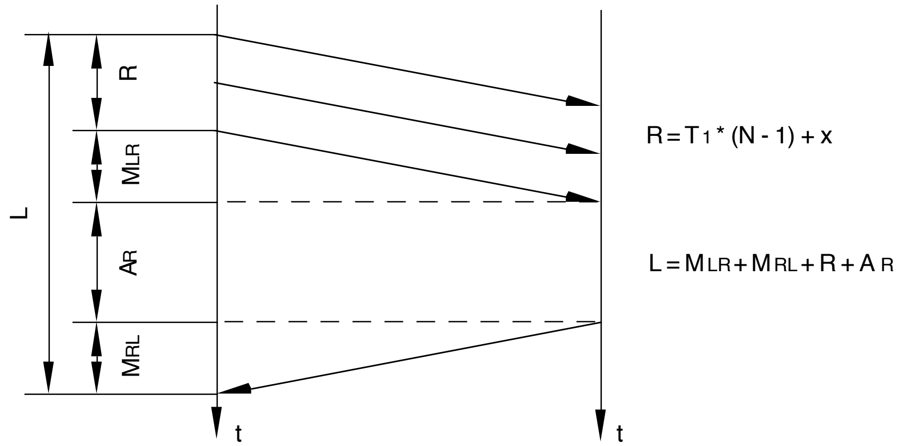

Figure 4 – Interrelationship of times for maximum delay in class 4

Table 7 – Time parameters related to the operation of class 4

Symbol	Name	Definition
M_{LR}	NSDU lifetime local-to-remote	A time bound for the maximum time which may elapse between the transmission of an NDSU by a local transport entity and the receipt of any copy of it by a remote peer entity.
M_{RL}	NSDU lifetime remote-to-local	A time bound for the maximum time which may elapse between the transmission of an NSDU from a remote transport entity and the receipt of any copy of it by the local peer entity.
E_{LR}	Expected maximum transit delay local-to-remote	A time bound for the maximum delay suffered by all but a small proportion of NSDUs transferred from the local transport entity to a remote peer entity.
E_{RL}	Expected maximum transit delay remote-to-local	A time bound for the maximum delay suffered by all but a small proportion of NSDUs transferred from a remote peer entity to the local transport entity.
A_L	Local acknowledgement time	A time bound for the maximum time which can elapse between the receipt of a TPDU by the local transport entity from the network layer and the transmission of the corresponding acknowledgement.
A_R	Remote acknowledgement time	As A_L, but for the remote entity.
T1	Local retransmission time	A time bound for the maximum time the local transport entity will wait for acknowledgement before retransmitting a TPDU.
R	Persistence time	A time bound for the maximum time the local transport entity will continue to transmit a TPDU that requires acknowledgement.
N	Maximum number of transmissions	A time bound for the maximum number of times which the local transport entity will continue to transmit a TPDU that requires acknowledgement.
L	Time bound on references and sequence numbers	A time bound for the maximum time between the transmission of a TPDU and the receipt of any acknowledgement relating to it.
I_L	Local inactivity time	A lower bound for the time after which the local transport entity will, if it does not receive a TPDU, initiate the release procedure to terminate the transport connection. NOTE – This parameter is required for protection against unsignalled failures.
I_R	Remote inactivity time	A lower bound for the time after which the remote transport entity will, if it does not receive a TPDU, initiate the release procedure to terminate the transport connection. NOTE – This parameter is required for protection against unsignalled failures.
W	Window time	A time bound for the maximum time a transport entity will wait before retransmitting up-to-date window information.

12.2.1.2 General procedures when operating over CONS

The transport entity shall use the following procedures:

a) TPDU transfer (see 6.2);

b) association of TPDUs with transport connections (see 6.9.1);

c) treatment of protocol errors (see 6.22);

d) checksum (see 6.17);

e) splitting and recombining (see 6.23);

f) multiplexing and demultiplexing (see 6.15);

g) retention and acknowledgement of TPDUs (see 6.13);

h) frozen references (see 6.18);

j) retransmission procedures; when a transport entity has some outstanding TPDUs that require acknowledgement, it will check that no T1 interval elapses without the arrival of a TPDU that acknowledges at least one of the outstanding TPDUs. If the timer expires, the first TPDU is retransmitted and the timer is restarted except if the TPDU to be retransmitted is a DT TPDU and is outside the transmit window due to credit reduction. Retransmission of a TPDU is subject to the availability of a network connection. If no network connection is available, and the retransmission timer runs out, then the retransmission counter may be incremented without sending the TPDU subject to the retransmission procedure. After N transmissions (i.e. N-1 retransmissions) it is assumed that useful two-way communication is no longer possible and the release procedure is used, and the TS-user is informed;

NOTES

1 This procedure may be implemented by different means. For example:

a) one interval is associated with each TPDU. If the timer expires the associated TPDU will be retransmitted and the timer T1 will be restarted for all subsequent TPDUs; or

b) one interval is associated with each transport connection:

1) if the transport entity transmits a TPDU requiring acknowledgement, it starts timer T1;

2) if the transport entity receives a TPDU that acknowledges one of the TPDUs to be acknowledged, it restarts timer T1 unless the received TPDU is an AK which explicitly closes the transmit window;

3) if the transport entity receives a TPDU that acknowledges the last TPDU to be acknowledged, it stops timer T1.

For a decision whether the retransmission timer T1 is maintained on a per TPDU or on a per transport connection basis, throughput considerations have to be taken into account.

2 For DT TPDUs it is a local choice to retransmit either only the first DT TPDU or all TPDUs waiting for an acknowledgement up to the upper window edge.

3 It is recommended that after N transmissions, the transport entity waits $T1 + W + M_{RL}$ in order to provide a higher possibility of receiving an acknowledgement before entering the release phase. For other TPDU types which may be retransmitted, it is recommended that after N transmissions the transport entity waits $T1 + M_{RL}$ in order to provide a greater possibility of receiving the expected reply.

4 If use of selective acknowledgement has been negotiated, a selective acknowledgement implicitly identifies DT TPDUs not received. Since such a DT TPDU could be a lost DT TPDU, or simply a delayed DT TPDU, it is a local matter whether DT TPDUs not acknowledged in a selective acknowledgement should be retransmitted immediately.

k) concatenation and separation (see 6.4).

12.2.1.3 General procedures when operating over CLNS

The transport entity shall use the following procedures:

a) TPDU transfer (see 6.2);

b) association of TPDUs with transport connections (see 6.9.1);

c) treatment of protocol errors (see 6.22);

d) checksum (see 6.17);

e) retention and acknowledgment of TPDUs (see 6.13);

f) frozen references (see 6.18);

g) retransmission procedures; when a transport entity has some outstanding TPDUs that require acknowledgment, it will check that no T1 interval elapses without the arrival of a TPDU that acknowledges at least one of the outstanding TPDUs.

If the timer expires, except if the TPDU to be retransmitted is a DT TPDU and it is outside the transmit window due to credit reduction, the first TPDU is retransmitted and the timer is restarted. After N transmissions (i.e. N-1 retransmissions) it is assumed that useful two-way communication is no longer possible and the release procedure is used, and the TS-user is informed;

NOTES

1 This procedure may be implemented by different means. For example:

a) one interval is associated with each TPDU. If the timer expires the associated TPDU will be transmitted and the timer T1 will be restarted for all subsequent TPDUs; or

b) one interval is associated with each transport connection:

1) if the transport entity transmits a TPDU requiring acknowledgment, it starts timer T1;

2) if the transport entity receives a TPDU that acknowledges one of the TPDUs to be acknowledged, it restarts timer T1 unless the received TPDU is an AK which explicitly closes the transmit window;

3) if the transport entity receives a TPDU that acknowledges the last TPDU to be acknowledged, it stops timer T1.

For a decision whether the retransmission timer T1 is maintained on a per TPDU or on a per transport connection basis, throughput considerations have to be taken into account.

2 For DT TPDUs it is a local choice to retransmit either only the first DT TPDU or all TPDUs waiting for an acknowledgment up to the upper window edge.

3 It is recommended that after N transmissions, the transport entity waits $T1 + W + M_{RL}$ to provide a higher possibility for receiving an acknowledgment before entering the release phase. For other TPDU types which may be retransmitted, it is recommended that after N transmissions the transport entity waits $T1 + M_{RL}$ to provide an higher possibility of receiving the expected reply.

4 If use of selective acknowledgement has been negotiated, a selective acknowledgement implicitly identifies DT TPDUs not received. Since such a DT TPDU could be a lost DT TPDU, or simply a delayed DT TPDU, it is a local matter whether DT TPDUs not acknowledged in a selective acknowledgement should be retransmitted immediately.

h) concatenation and separation (see 6.4).

12.2.2 Procedures for connection establishment

12.2.2.1 Timers used in connection establishment

There are no timers specific to connection establishment.

12.2.2.2 General procedures when operating over CONS

The transport entities shall use the following procedures:

a) assignment to network connection (see 6.1.1);

When a network connection to which the transport connection is assigned is released (NDISind received):

1) if a CC TPDU is awaited the initiator shall perform a new assignment according to QOS and the retransmission procedure (i.e. not sending the CR TPDU for more than N * T1);

2) if there is at least one other network connection to which the transport connection is assigned both initiator and acceptor may either perform a new assignment or continue operation using one of the remaining network connections;

3) if the transport connection becomes unassigned the acceptor may either perform a new assignment or wait (there is no risk of deadlock as either T1 or I_L will be running); the initiator shall perform a new assignment (except in the closing state);

b) connection establishment (see 6.5) and if appropriate connection refusal (see 6.6) together with the additional procedures:

1) a connection is not considered established until the successful completion of a 3-way TPDU exchange. The sender of a CR TPDU shall respond to the corresponding CC TPDU by immediately sending a DT, ED, DR, or AK TPDU;

2) as a result of duplication or transmission, a CR TPDU may be received specifying a source reference which is already in use with the sending transport entity. If the receiving transport entity is in the data transfer phase, having completed the 3-way TPDU exchange procedure, or is waiting for the T-CONNECT response from the TS-user, the receiving transport entity shall discard such a TPDU. Otherwise a CC TPDU shall be transmitted.

3) as a result of duplication or retransmission, a CC TPDU may be received specifying a paired reference which is already in use. The receiving transport entity shall only acknowledge the duplicate CC TPDU according to the procedure in 12.2.2.2.b)1);

4) a CC TPDU may be received specifying a reference which is in the frozen state. The response to such a TPDU shall be a DR TPDU;

5) the retransmission procedures (see 12.2.1.2) are used for both the CR TPDU and CC TPDU.

NOTE - After receiving a CR TPDU, it is recommended that the transport entity enforce a time limit upon the transport service user so that late acceptance of the transport connection will not cause a delayed CC TPDU to be sent.

12.2.2.3 General procedures when operating over CLNS

The transport entity shall use the procedure of connection establishment (see 6.5) and if appropriate connection refusal (see 6.6) together with the additional procedures:

1) a connection is not considered established until the successful completion of a three-way TPDU exchange. The sender of a CR TPDU shall respond to the corresponding CC TPDU by immediately sending a DT, ED, DR or AK TPDU;

2) as a result of duplication or retransmission, a CR TPDU may be received specifying a source reference which is already in use with the sending transport entity. If the receiving transport entity is in the data transfer phase, having completed the three-way TPDU exchange procedure, or is waiting for the T-CONNECT response from the TS-user, the receiving transport entity shall discard such a TPDU. Otherwise a CC TPDU shall be transmitted;

3) as a result of duplication or retransmission, a CC TPDU may be received specifying a paired reference which is already in use. The receiving transport entity shall only acknowledge the duplicate CC TPDU according to the procedure in 12.2.2.3.1);

4) a CC TPDU may be received specifying a reference which is in the frozen state. The response to such a TPDU shall be a DR TPDU;

5) the retransmission procedures (see 12.2.1.3) are used for both the CR TPDU and CC TPDU.

NOTE – After receiving a CR TPDU, it is recommended that the transport entity enforce a time limit upon the transport service user so that late acceptance of the transport connection will not cause a delayed CC TPDU to be sent.

12.2.3 Procedures for data transfer

12.2.3.1 Timers used in data transfer

12.2.3.1.1 Timers used in data transfer when operating over CONS

The data transfer procedures use one additional timer:

a) Window timer (W)

A transport entity maintains a timer interval to ensure that there is a bound on the maximum interval between window updates.

NOTE – A suitable upper bound value for W is such that $W < I_R - E_{LR}$. It is recommended that the value for W be sufficiently less than (I_R - E_{LR}) such that the inactivity control procedure in 12.2.3.3 can be operated having regard to the possibility of TPDU loss.

12.2.3.1.2 Timers used in data transfer when operating over CLNS

The data transfer procedures use one additional timer:

a) Window timer (W)

A transport entity maintains a timer interval to ensure that there is a bound on the maximum interval between window updates.

NOTE – A suitable upper band value for W is such that $W < I_R - E_{LR}$. It is recommended that the value for W be sufficiently less than (I_R – E_{LR}) such that the inactivity control procedure in 12.2.3.3 can be operated having regard to the possibility of TPDU loss.

12.2.3.2 General procedures for data transfer

The transport entities shall use the following procedures:

a) inactivity control (see 6.21);

b) expedited data (see 6.11);

c) Explicit flow control (see 6.16).

The sending transport entity shall use the following procedures in the following order:

1) segmenting (see 6.3);

2) DT TPDU numbering (see 6.10).

The receiving transport entity shall use the following procedures in the following order:

– DT TPDU numbering (see 6.10);

– resequencing (see 6.20);

– reassembling (see 6.3).

12.2.3.3 Inactivity control

If the interval of the inactivity timer I expires without receipt of some TPDU, the transport entity shall initiate the release procedures. To prevent expiration of the remote transport entity's inactivity timer when no data is being sent, the local transport entity must send AK TPDUs at suitable intervals in the absence of data, having regard to the probability of TPDU loss. The window synchronization procedures (see 12.2.3.8) ensure that this requirement is met.

NOTE – It is likely that the release procedure initiated due to the expiration of the inactivity timer will fail, as such expiration indicates probable failure of the supporting network connection or of the remote transport entity.

12.2.3.4 Expedited data

12.2.3.4.1 Expedited data when operating over CONS

The transport entities shall follow the network normal data variant of the expedited data transfer procedures (see 6.11.1), if the use of the transport expedited service option has been agreed during connection establishment.

The ED TPDU shall have a TPDU-NR which is allocated from a separate sequence space from that of the DT TPDUs.

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

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.

The receiving transport entity shall transmit an EA TPDU with the same sequence number in its YR-EDTU-NR field. If this number is one greater than in the previously received in-sequence ED TPDU, the receiving transport entity shall transfer the data in the ED TPDU to the TS-user.

If a transport entity does not receive an EA TPDU in acknowledgement to an ED TPDU it shall follow the retransmission procedures (see note and 12.2.1.2).

The sender of an ED TPDU shall not send any new DT TPDU created from a T-DATA request subsequent to the T-EXPEDITED DATA request, until it receives the EA TPDU.

NOTE - This procedure ensures that ED TPDUs are delivered to the TS-user in sequence and that the TS-user does not receive data corresponding to the same ED TPDU more than once. Also it guarantees the arrival of the ED TPDU before any data subsequently sent by the TS user.

12.2.3.4.2 Expedited data when operating over CLNS

The transport entities shall follow the expedited data transfer procedures in 6.11.2, if the use of the transport expedited data service option has been agreed during connection establishment.

The ED TPDU shall have a TPDU-NR which is allocated from a separate sequence space from that of the DT TPDUs.

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

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.

The receiving transport entity shall transmit an EA TPDU with the same sequence number in its YR-EDTU-NR field. If this number is one greater than in the previously received in-sequence ED TPDU, the receiving transport entity shall transfer the data in the ED TPDU to the TS-user.

If a transport entity does not receive an EA TPDU in acknowledgment to an ED TPDU it shall follow the retransmission procedures (see note and 12.2.1.3).

The sender of an ED TPDU shall not send any new DT TPDU created from a T-DATA request subsequent to the T-EXPEDITED DATA request, until it receives the EA TPDU.

NOTE – This procedure ensures that ED TPDUs are delivered to the TS-user in sequence and that the TS-user does not receive data corresponding to the same ED TPDU more than once. Also it guarantees the arrival of the ED TPDU before any data subsequently sent by the TS user.

12.2.3.5 Resequencing

The receiving transport entity shall deliver all DT TPDUs to the TS-user in the order specified by the sequence number field.

DT TPDUs received out-of-sequence but within the transmit window shall not be delivered to the TS-user until all in-sequence TPDUs have been received. DT TPDUs received out-of-sequence and outside the transmit window shall be discarded but may result in transmission of an AK TPDU with up-to-date window information (see 12.2.3.8). If the selective acknowledgement option has been agreed to at connection establishment, DT TPDUs that have been selectively acknowledged shall be retained by the receiving transport entity until delivered to the TS-user. They shall be retained even if the selectively acknowledged DT TPDUs later fall outside the transmit window due to a subsequent credit reduction.

NOTE – It is recommended that the transport entity sending the AK TPDU maintains a bound on the number of times a DT TPDU is selectively acknowledged in order to reduce the processing at the transport entity receiving the AK TPDU.

Duplicate TPDUs can be detected because the sequence number matches that of previously received TPDUs. Sequence numbers shall not be reused for the period L after their previous use. Otherwise, a new, valid TPDU could be confused with a duplicated TPDU which had previously been received and acknowledged.

Duplicated DT TPDUs shall be acknowledged, since the duplicated TPDU may be the result of a retransmission resulting from the loss of an AK TPDU.

The data contained in a duplicated DT TPDU shall be discarded.

12.2.3.6 Explicit flow control

The transport entities shall send an initial credit (which may take the value 0) in the CDT field of the CR TPDU or CC TPDU. This credit represents the initial value of the upper window edge of the peer entity.

The transport entity which receives the CR TPDU or CC TPDU shall consider its lower window edge as zero and its upper window edge as the value in the CDT field in the received TPDU.

In order to authorize the transmission of DT TPDUs by its peer, a transport entity may transmit an AK TPDU at any time.

The sequence number of an AK TPDU shall not exceed the sequence number of the next expected DT TPDU, i.e. it shall not be greater than the highest sequence number of a received DT TPDU, plus one.

A transport entity may send a duplicate AK TPDU containing the same sequence number, CDT, and subsequence number field at any time.

A transport entity may increase or decrease the upper window edge at any time.

A transport entity which receives an AK TPDU shall consider the value of the YR-TU-NR field as its new lower window edge if it is greater than any previously received in a YR-TU-NR field, and the sum of YR-TU-NR and CDT as its new upper window edge subject to the procedures for sequencing AK TPDUs (see 12.2.3.8). A transport entity shall not transmit or retransmit a DT TPDU with a sequence number outside the transmit window.

12.2.3.7 Sequencing of received AK TPDUs

To allow a receiving transport entity to properly sequence a series of AK TPDUs that all contain the same sequence number and thereby use the correct CDT value, AK TPDUs may contain a subsequence parameter. For the purpose of determining the correct sequence of AK TPDUs, the absence of the subsequence parameter shall be equivalent to the value of the parameter set to zero.

An AK TPDU is defined to be in sequence if

a) the sequence number is greater than any previously received AK TPDU, or

b) the sequence number is equal to the highest in any previously received AK TPDU, and the subsequence parameter is greater than in any previously received AK TPDU having the same value for YR-TU-NR field, or

c) the sequence number and subsequence parameter are both equal to the highest in any previously received AK TPDU and the credit field is greater than or equal to that in any previously received AK TPDU having the same YR-TU-NR field.

When the receiving transport entity recognizes an out-of-sequence AK TPDU it shall discard it.

12.2.3.8 Procedures for transmission of AK TPDUs

12.2.3.8.1 Transmission of AK TPDUs

An in-sequence DT TPDU shall be acknowledged within time A_L, by the transmission of an AK TPDU whose YR-TU-NR parameter is set to at least the sequence number of the received DT TPDU plus one. If the selective acknowledgement option has been agreed to at connection establishment, out of sequence DT TPDUs may also be acknowledged within time A_L. The YR-TU-NR parameter shall be set to one greater than the highest sequence number of an in-sequence DT TPDU and the selective acknowledgement parameter will be appropriately set.

An AK TPDU shall be transmitted containing up-to-date window information if

a) a DT TPDU is received whose sequence number is lower than the lower window edge, but greater than or equal to the lower window edge minus the maximum credit value ever given for this transport connection, or

b) a DT TPDU is received whose sequence number is above the current upper window edge, but following credit reduction is within the upper window edge which has been granted and then withdrawn.

NOTES

1 A simpler implementation may send an AK TPDU upon reception of any DT TPDU outside the transmit window.

2 The procedure a) is required so that loss of an AK TPDU is correctly recovered, i.e. when the sender of the DT TPDU retransmits it following non-receipt of an acknowledgement.

3 The procedure b) is required due to the possibility of loss of the AK TPDU indicating the upper window edge reduction, which could otherwise cause incorrect termination of the transport connection.

4 Wherever procedures a) and b) are invoked and selective acknowledgement option is being used, the selective acknowledgement parameters, if required, of the AK TPDU will be appropriately set.

A transport entity shall not allow an interval W to pass without the transmission of an AK TPDU. If the transport entity is not using the procedure following setting CDT to zero (see 12.2.3.8.3) or reduction of the upper window edge (see 12.2.3.8.4), and does not have to acknowledge receipt of any DT TPDU, then it shall achieve this by retransmission of the most recent AK TPDU, with up-to-date window information.

NOTE – The use of the procedures defined in 12.2.3.8.3 and 12.2.3.8.4 is optional for any transport entity. The protocol operates correctly either with or without these procedures which are defined to enhance the efficiency of its operation.

12.2.3.8.2 Sequence control for transmission of AK TPDUs

To allow the receiving transport entity to process AK TPDUs in the correct sequence, as described in 12.2.3.7, the subsequence parameter shall be included following reduction of CDT. If the value of the subsequence number to be transmitted is zero, then the parameter should be omitted.

The value of the subsequence parameter, if used, shall be zero (either explicitly or by absence of the parameter) if the sequence number is greater than the parameter in previous AK TPDUs, sent by the transport entity.

If the sequence number is the same as the previous AK TPDU sent and the CDT field is equal to or greater than the CDT field in the previous AK TPDU sent then the subsequence parameter, if used, shall be equal to that in the previously sent AK TPDU.

If the sequence number is the same as the previous AK TPDU sent and the CDT field is less than the value of the CDT field in the previous AK TPDU sent then the subsequence parameter, if used, shall be one greater than the value in the previous AK TPDU.

NOTE – If a transport entity never reduces credit, then it does not need to use the subsequence number.

12.2.3.8.3 Retransmission of AK TPDUs after CDT set to zero

Due to the possibility of loss of AK TPDUs, the upper window edge as perceived by the transport entity transmitting an AK TPDU may differ from that perceived by the intended recipient. To avoid the possibility of extra delay, the retransmission procedure (see 12.2.1.2 and 12.2.1.3) can be followed for an AK TPDU, if it opens the transmit window which has previously been closed by sending an AK TPDU with CDT field set to zero.

The retransmission procedure, if used, terminates and the procedure in 12.2.3.8.1 is used when

a) an AK TPDU is received containing the flow control confirmation parameter, whose lower window edge and your subsequence fields are equal to the sequence number and subsequence number in the retained AK TPDU and whose credit field is not zero;

b) an AK TPDU is transmitted with a sequence number higher than that in the retained AK TPDU, due to reception of a DT TPDU whose sequence number is equal to the lower window edge;

c) N transmissions of the retained AK TPDU have taken place. In this case the transport entity shall continue to transmit the AK TPDU at an interval of W.

An AK TPDU which is subject to the retransmission procedure shall not contain the flow control confirmation parameter. If it is required to transmit this parameter concurrently, an additional AK TPDU shall be transmitted having the same values in the sequence, subsequence (if applicable) and credit fields.

12.2.3.8.4 Retransmission procedures following reduction of the upper window edge

This sub-clause specifies the procedure for retransmission of AK TPDUs after a transport entity has reduced the upper window edge (see 12.2.3.6). This procedure is used until the lower window edge exceeds the highest value of the upper window edge ever transmitted (i.e. the value existing at the time of credit reduction, unless a higher value is retained from a previous credit reduction).

The retransmission procedure should be followed for any AK TPDU which increases the upper window edge, unless it is known that the remote transport entity has an open window. This is known if

– a flow control confirmation (FCC) parameter has been received corresponding to an AK TPDU transmitted following the most recent credit reduction, and;

– this FCC parameter conveys an upper window edge value (i.e. the sum of the lower window edge and credit fields) which is greater than the lower window edge of the transmitted AK TPDU.

This retransmission procedure for any particular AK TPDU shall terminate when

a) an AK TPDU is received containing the flow control confirmation parameter, whose lower window edge and your subsequence fields are equal to the lower window edge and subsequence number in the retained AK TPDU; or

b) N transmissions of the retained AK TPDU have taken place. In this case the transport entity shall continue to transmit the AK TPDU at an interval of W.

An AK TPDU which is subject to the retransmission procedure shall not contain the flow control confirmation parameter. If it is required to transmit this parameter concurrently, an additional AK TPDU shall be transmitted having the same values in the sequence, subsequence (if applicable) and credit fields.

NOTE - Retransmission of AK TPDUs is normally not necessary, except following explicit closing of the window (i.e. transmission of an AK TPDU with CDT field set to zero). If data are available for transmission, the retransmission procedure for DT TPDUs will ensure that an AK TPDU is received granting further credit where this is available; following credit reduction, this may no longer be so, because retransmission may be inhibited by the credit reduction. The rules described in this clause avoid extra delay.

The rules for determining whether to apply the retransmission procedure to an AK TPDU may be expressed alternatively as follows. Let

LWE = lower window edge

UWE = upper window edge

KUWE = lower bound on upper window edge held by remote transport entity.

The retransmission procedure is to be applied whenever:

(UWE > LWE) and (KUWE = LWE)

i.e. when the window is opened and it is not known definitely that the remote transport entity is aware of this.

KUWE is maintained as follows:

When credit is reduced, KUWE is set to LWE. Subsequently, it is increased only upon receipt of a valid flow control confirmation (i.e. one which matches the retained lower window edge and subsequence). In this case KUWE is set to the implied upper window edge of the flow control confirmation, i.e. the sum of its lower window edge and your credit fields. By using this method, it can be ensured that KUWE is always less than or equal to the actual upper window edge used by the transmitter of DT TPDUs.

12.2.3.9 Use of flow control confirmation parameter

An AK TPDU containing a flow control confirmation parameter may be transmitted at any time. The lower window edge, your subsequence and your credit fields shall be set to the same values as the corresponding fields in the most recently received in-sequence AK TPDU.

An AK TPDU containing a flow control confirmation parameter should be transmitted whenever

a) a duplicate AK TPDU is received, with the value of YR-TU-NR, CDT, and subsequence fields equal to the most recently received in sequence AK TPDU, but not itself containing the flow control confirmation parameter;

b) an AK TPDU is received which increases the upper window edge but not the lower window edge, and the upper window edge was formerly equal to the lower window edge; or

c) an AK TPDU is received which increases the upper window edge but not the lower window edge, and the lower window edge is lower than the highest value of the upper window edge received and subsequently reduced (i.e. following credit reduction).

12.2.4 Procedures for release

12.2.4.1 Timers used for release

There are no timers used only for release.

12.2.4.2 General procedures for release

The transport entity shall use the explicit variant of normal release (see 6.7).

Although the retransmission procedure also apply to the DR TPDU in the release phase, the transport entity may however consider that the transport connection has been released if it would be necessary to open a new network connection in order to retransmit the DR TPDU.

13 Structure and encoding of TPDUs

13.1 Validity

Table 8 specifies those TPDUs which are valid for each class and the code for each TPDU.

Table 8 – TPDU codes

	Validity within classes					See sub-clause	Code
	0	1	2	3	4		
CR: connection request	x	x	x	x	x	13.3	1110 xxxx
CC: connection confirm	x	x	x	x	x	13.4	1101 xxxx
DR: disconnect request	x	x	x	x	x	13.5	1000 0000
DC: disconnect confirm		x	x	x	x	13.6	1100 0000
DT: data	x	x	x	x	x	13.7	1111 000y
ED: expedited data		x	NF	x	x	13.8	0001 0000
AK: data acknowledgement		NRC	NF	x	x	13.9	0110 zzzz
EA: expedited data acknowledgement		x	NF	x	x	13.10	0010 0000
RJ: reject		x		x		13.11	0101 zzzz
ER: TPDU error	x	x	x	x	x	13.12	0111 0000
Not available (see the note)						--	0000 0000
						--	0011 0000
						--	1001 xxxx
						--	1010 xxxx

Key:

xxxx (bits 4 to 1): used to signal the CDT (set to 0000 in classes 0 to 1).

zzzz (bits 4 to 1): used to signal CDT in classes 2,3,4 set to 1111 in class 1.

y (bit 1): used to signal ROA if the request acknowledgement procedure has been agreed at connection establishment (classes 1, 3, 4 only). This bit shall be set to 0 if the request acknowledgement procedure has not been agreed.

NF: Not available when the non-explicit flow control option is selected.

NRC: Not available when the receipt confirmation option is selected.

NOTE – These codes are already in use in related protocols defined by standard organizations other than CCITT/ISO.

13.2 Structure

All the transport protocol data units (TPDUs) shall contain an integral number of octets. The octets in a TPDU are numbered starting from 1 and increasing in the order they are put into an NDSU. The bits in an octet are numbered from 1 to 8, where bit 1 is the lowest order bit.

When consecutive octets are used to represent a binary number, the lower octet number has the most significant value.

NOTES

1 The numbering of bits within an octet is a convention local to this International Standard.

2 The use of the terms "high order" and "low order" is common to this International Standard and to adjacent layer standards.

3 The use of the above conventions does not affect the order of bit transmission on a serial communications link.

4 As described in 6.2.3, both transport entities respect these bit and octet ordering conventions, thus allowing communication to take place.

5 In this clause the encoding of TPDUs is represented in the following form:

a) octets are shown with the lowest numbered octet to the left; higher numbered octets being further to the right;

b) within an octet, bits are shown with bit 8 to the left and bit 1 to the right.

TPDUs shall contain, in the following order:

a) the header, comprising
   1) the length indicator (LI) field;
   2) the fixed part;
   3) the variable part, if present;

b) the data field, if present.

The structure is illustrated below:

Octets

1	2 3 4 ... n	n+1 ... p	p+1 ... end
LI	Fixed part	Variable part	Data Field

← header →

13.2.1 Length indicator field

The field is contained in the first octet of the TPDUs. The length is indicated by a binary number, with a maximum value of 254 (1111 1110). The length indicated shall be the header length in octets including parameters, but excluding the length indicator field and user data, if any. The value 255 (1111 1111) is reserved for possible extensions.

If the length indicated exceeds or is equal to the size of the NS-user data which is present, this is a protocol error.

13.2.2 Fixed part

13.2.2.1 General

The fixed part contains frequently occurring parameters including the code of the TPDU. The length and the structure of the fixed part are defined by the TPDU code and in certain cases by the protocol class and the formats in use (normal or extended). If any of the parameters of the fixed part have an invalid value, or if the fixed part cannot be contained within the header (as defined by LI), this is a protocol error.

NOTE – In general, the TPDU code defines the fixed part unambiguously. However, different variants may exist for the same TPDU code (see normal and extended formats).

13.2.2.2 TPDU code

This field contains the TPDU code and is contained in octet 2 of the header. It is used to define the structure of the remaining header. This field is a full octet except in the following cases:

1110 xxxx	Connection request
1101 xxxx	Connection confirm
1111 000y	Data
0101 xxxx	Reject
0110 xxxx	Data acknowledgement

where

xxxx (bits 4 to 1) is used to signal the CDT.

y (bit 1) is used to signal ROA if the request acknowledgement has been agreed at connection establishment (class 1, 3, 4 only).

Only those codes defined in 13.1 are valid.

13.2.3 Variable part

The variable part is used to define less frequently used parameters. If the variable part is present, it shall contain one or more parameters.

NOTE – The number of parameters that may be contained in the variable part is indicated by the length of the variable part which is LI minus the length of the fixed part.

Each parameter contained within the variable part is structured as follows:

Octets	Bits 8 7 6 5 4 3 2 1
n + 1	Parameter code
n + 2	Parameter length indication (for example m)
n + 3 n + 2 + m	Parameter value

The parameter code field is coded in binary.

NOTE – Without extensions, it provides a maximum number of 255 different parameters. However, as noted below, bits 8 and 7 cannot take every possible value, so the practical maximum number of different parameters is less. Parameter code 1111 1111 is reserved for possible extensions of the parameter code.

The parameter length indication indicates the length, in octets, of the parameter value field.

NOTE – The length is indicated by a binary number, m, with a theoretical maximum value of 255. The practical maximum value of m is lower. For example, in the case of a single parameter contained within the variable part, two octets are required for the parameter code and the parameter length indication itself. Thus, the value of m is limited to 248. For larger fixed parts of the header and for each succeeding parameter, the maximum value of m decreases.

The parameter value field contains the value of the parameter identified in the parameter code field.

No parameter code uses bits 8 and 7 with the value 00.

The parameters defined in the variable part may be in any order. If any parameter is duplicated then the last value shall be used. A parameter not defined in this International Standard shall be treated as a protocol error in any received TPDU except a CR TPDU; in a CR TPDU it shall be ignored. A called TSAP-ID parameter in a CC TPDU with a length indicator set to zero shall be treated as having the "nil selector value" (see ISO/IEC 7498-3, 9.5.2). If the responding transport entity selects a class for which a parameter of the CR TPDU is not defined, it may ignore this parameter, except if it is the class and option parameter, or the alternative protocol class parameter which shall always be interpreted. A parameter defined in this International Standard but having an invalid value shall be treated as a protocol error in any received TPDU except a CR TPDU. In a CR TPDU it shall be treated as a protocol error if it is either the class and option parameter or the alternative class parameter; bits 8 to 7, and bits 6 to 1, if not meaningful for the class proposed, of the additional options parameter shall be ignored; otherwise it shall be either ignored or treated as a protocol error.

13.2.3.1 Checksum parameter (class 4 only)

All TPDU types may contain a 16-bit checksum parameter in their variable part. This parameter shall be present in a CR TPDU and shall be present in all other TPDUs except when the non-use of checksum option is selected.

Parameter code: 1100 0011

Parameter length: 2

Parameter value: Result of checksum algorithm; this algorithm is specified in 6.17.

13.2.4 Data field

This field contains transparent user data. Restrictions on its size are noted for each TPDU.

13.3 Connection request (CR) TPDU

The length of the CR TPDU shall not exceed 128 octets.

13.3.1 structure

The structure of the CR TPDU shall be as follows:

1	2	3 4	5 6	7	8 p	p + 1 end
LI	CR CDT 1110 xxxx	DST-REF 0000 0000 0000 0000	SRC-REF	CLASS OPTION	Variable part	User Data

13.3.2 LI

See 13.2.1.

13.3.3 Fixed part (octets 2 to 7)

The structure of this part shall contain:

a) CR: Connection request code: 1110. Bits 8 to 5 of octet 2;

b) CDT: Initial credit allocation (set to 0000 in classes 0 and 1 when specified as preferred class). Bits 4 to 1 of octet 2;

c) DST-REF: Set to zero;

d) SRC-REF: Reference selected by the transport entity initiating the CR TPDU to identify the requested transport connection;

e) CLASS OPTION: Bits 8 to 5 of octet 7 define the preferred transport protocol class to be operated over the requested transport connection. When operating over CONS, this field shall take one of the following values:

0000 Class 0

0001 Class 1

0010 Class 2

0011 Class 3

0100 Class 4

When operating over CLNS, this field shall take the value 0100 to indicate class 4.

The CR TPDU contains the first choice of class in the fixed part. Second and subsequent choices are listed in the variable part if required.

Bits 4 to 1 of octet 7 define options to be used on the requested transport connection as follows:

BIT	OPTION
4	= 0 Always
3	= 0 Always

2	= 0 Use of normal formats in all classes
	= 1 Use of extended formats in classes 2, 3, and 4
1	= 0 Use of explicit flow control in class 2
	= 1 No use of explicit flow control in class 2

Bits related to options particular to a class are not meaningful if that class is not proposed and may therefore take any value.

NOTES

1 The connection establishment procedure (see 6.5) does not permit a given CR TPDU to request use of transport expedited data transfer service (additional option parameter) and not use of explicit flow control in class 2 (bit 1 = 1).

2 Bits 4 to 1 are always zero in class 0 and have no meaning.

13.3.4 Variable part (octets 8 to p)

The following parameters are permitted in the variable part:

a) Transport Service Access Point Identifier (TSAP-ID)

Parameter code: 1100 0001 for the identifier of the calling TSAP
1100 0010 for the identifier of the called TSAP

Parameter length: not defined in this International Standard

Parameter value: identifier of the calling or called TSAP respectively.

If a TSAP-ID is given in the request it may be returned in the confirmation.

b) TPDU size

This parameter defines the proposed maximum TPDU size (in octets including the header) to be used over the requested transport connection. The coding of this parameter is

Parameter code: 1100 0000

Parameter length: 1 octet

Parameter value:

0000 1101	8 192 octets	(not allowed in class 0)
0000 1100	4 096 octets	(not allowed in class 0)
0000 1011	2 048 octets	
0000 1010	1 024 octets	
0000 1001	512 octets	
0000 1000	256 octets	
0000 0111	128 octets	

Default value: 0000 0111 (128 octets).

c) Preferred maximum TPDU size

This parameter defines the proposed maximum TPDU size (in octets including the header) to be used over the requested transport connection.

The coding of this parameter is:

Parameter Code: 1111 0000

Parameter length: up to 4

Parameter value: a binary value. The binary value indicates the maximum TPDU size, expressed as a multiple of 128 octets [see 6.5.4 m) and 6.5.5 m)]. This binary value shall be greater than or equal to 1.

d) Version number (not used if class 0 is the preferred class)

Parameter code: 1100 0100

Parameter length: 1 octet

Parameter value field: 0000 0001

Default value: 0000 0001 (not used in class 0).

e) Protection parameters (not used is class 0 is the preferred class)

This parameter is user defined.

Parameter code: 1100 0101

Parameter length: user defined

Parameter value: user defined.

f) Checksum (used only if class 4 is the preferred class) (see 13.2.3.1)

This parameter shall always be present in a CR TPDU requesting class 4, even if the checksum selection parameter is used to request non-use of the checksum facility.

g) Additional option selection (not used if class 0 is the preferred class)

This parameter defines the selection to be made as to whether or not additional options are to be used.

Parameter code: 1100 0110

Parameter length: 1

Parameter value:

BIT	OPTION
6	= 1 Use of request acknowledgement in class 1, 3, 4
	= 0 Non-use of request acknowledgement in classes 1, 3, 4
5	= 1 Use of selective acknowledgement in class 4
	= 0 Non-use of selective acknowledgement in class 4
4	= 1 Use of network expedited in class 1
	= 0 Non-use of network expedited in class 1
3	= 1 Use of receipt confirmation in class 1
	= 0 Use of explicit AK variant in class 1
2	= 0 16-bit checksum defined in 6.17 shall be used in class 4
	= 1 16-bit checksum defined in 6.17 shall not be used in class 4
1	= 1 Use of transport expedited data transfer service
	= 0 Non-use of transport expedited data transfer service

Default value: 0000 0001.

Bits 8 and 7 shall be set to zero when sending the TPDU and ignored upon receipt.

Bits related to options particular to a class are not meaningful if that class is not proposed and may therefore take any value.

h) Alternative protocol class(es) (not used if class 0 is the preferred class or when operating over CLNS)

Parameter code: 1100 0111

Parameter length: n

Parameter value: Encoded as a sequence of single octets; each encoded as for octet 7 but with bits 4 to 1 set to zero (i.e. no alternative option selections permitted).

j) Acknowledgement time (used only if class 4 is the preferred class)

This parameter conveys the maximum acknowledgement time A_L to the remote transport entity. It is an indication only, and is not subject to negotiation (see 12.2.1.1.3).

Parameter code: 1000 0101

Parameter length: 2

Parameter value: n, a binary number where n is the maximum acknowledgement time, expressed in milliseconds.

k) Throughput (not used if class 0 is the preferred class)

Parameter code: 1000 1001

Parameter length: 12 or 24

Parameter value:

1st 12 octets: maximum throughput, as follows:
First 3 octets: target value, calling-called user direction
Second 3 octets: minimum acceptable, calling-called user direction
Third 3 octets: target value, called-calling user direction
Fourth 3 octets: minimum acceptable, called-calling user direction

2nd 12 octets (optional): average throughput, as follows:
Fifth 3 octets: target value, calling-called user direction
Sixth 3 octets: minimum acceptable, calling-called user direction
Seventh 3 octets: target value, called-calling user direction
Eighth 3 octets: minimum acceptable, called-calling user direction

Where average throughput is omitted, it is considered to have the same value as the maximum throughput. Values are expressed in octets per second.

m) Residual error rate (not used if class 0 is the preferred class)

Parameter code: 1000 0110

Parameter length: 3

Parameter value:

1st octet: target value, power of 10
2nd octet: minimum acceptable, power of 10
3rd octet: TSDU size of interest, expressed as a power of 2

n) Priority (not used if class 0 is the preferred class)

Parameter code: 1000 0111

Parameter length: 2

Parameter value: integer (0 is the highest priority)

p) Transit delay (not used if class 0 is the preferred class)

Parameter code: 1000 1000

Parameter length: 8

Parameter value:

First 2 octets: target value, calling-called user direction
Second 2 octets: maximum acceptable, calling-called user direction
Third 2 octets: target value, called-calling user direction
Fourth 2 octets: maximum acceptable, called-calling user direction

Values are expressed in milliseconds, and are based upon a TSDU size of 128 octets.

q) Reassignment time (not used if class 0 or 2 is the preferred class; if class 4 is preferred and class 3 is an alternate, it may be used)

This parameter conveys the Time to Try Reassignment (TTR) which shall be used when following the procedure for reassignment after failure (see 6.12).

Parameter code: 1000 1011

Parameter length: 2

Parameter value: n, a binary number where n is the TTR value expressed in seconds.

r) Inactivity timer (used only if class 4 is the preferred or selected class)

This parameter conveys the inactivity timer I_L to the remote transport entity. It is an indication only, and is not subject to negotiation (see 12.2.1.1.7).

Parameter code: 1111 0010

Parameter length: 4

Parameter value: a binary value. This binary value indicates the inactivity time expressed in milliseconds.

13.3.5 User data (octets p + 1 to the end)

No user data are permitted in class 0, and are optional in other classes. Where permitted, they shall not exceed 32 octets.

13.4 Connection Confirm (CC) TPDU

13.4.1 Structure

The structure of the CC TPDU shall be as follows:

1	2	3 4	5 6	7	8 p	p + 1 end
LI	CC CDT 1101 xxxx	DST-REF	SRC-REF	CLASS OPTION	Variable part	User Data

13.4.2 LI

See 13.2.1.

13.4.3 Fixed part (octets 2 to 7)

The fixed part shall contain

a) CC: Connection confirm code: 1101. Bits 8 to 5 of octet 2;

b) CDT: Initial credit allocation (set to 0000 in classes 0 and 1). Bits 4 to 1 of octet 2;

c) DST-REF: Reference identifying the requested transport connection at the remote transport entity;

d) SRC-REF: Reference selected by the transport entity initiating the CC TPDU to identify the confirmed transport connection;

e) CLASS OPTION: Defines the selected transport protocol class and option to be operated over the accepted transport connection according to the negotiation rules specified in 6.5.

13.4.4 Variable part (octets 8 to p)

The parameters are defined in 13.3.4 and are subject to the constraints stated in 6.5 (connection establishment). Parameters ruled out by selection of an alternative class and option shall not be present.

13.4.5 User data (octets p + 1 to the end)

No user data are permitted in class 0, and are optional in the other classes. Where permitted, they shall not exceed 32 octets. The user data are subject to the constraints of the negotiation rules (see 6.5).

13.5 Disconnect Request (DR) TPDU

13.5.1 Structure

The structure of the DR TPDU shall be as follows:

1	2	3 4	5 6	7	8 p	p + 1 end
LI	DR 1000 0000	DST-REF	SRC-REF	REASON	Variable part	User Data

13.5.2 LI

See 13.2.1.

13.5.3 Fixed part (octets 2 to 7)

The fixed part shall contain

a) DR: Disconnect request code: 1000 0000;

b) DST-REF: Reference identifying the transport connection at the remote transport entity;

c) SRC-REF: Reference identifying the transport connection at the transport entity initiating the TPDU. Value zero when reference is unassigned;

d) REASON: Defines the reason for disconnecting the transport connection. This field shall take one of the following values:

The following values may be used for classes 1 to 4:

1) 128 + 0: Normal disconnect initiated by session entity
2) 128 + 1: Remote transport entity congestion at connect request time
3) *128 + 2: Connection negotiation failed [i.e. proposed class(es) not supported]
4) 128 + 3: Duplicate source reference detected for the same pair of NSAPs.
5) 128 + 4: Mismatched references
6) 128 + 5: Protocol error
7) 128 + 6: Not used
8) 128 + 7: Reference overflow
9) 128 + 8: Connection request refused on this network connection
10) 128 + 9: Not used
11) 128 + 10: Header or parameter length invalid.

The following values can be used for all classes:

12) 0: Reason not specified

13) 1: Congestion at TSAP

14) *2: Session entity not attached to TSAP

15) *3: Address unknown.

NOTE – Reasons marked with an asterisk (*) may be reported to the TS-user as persistent, other reasons as transient.

13.5.4 Variable part (octets 8 to p)

The variable may contain

a) a parameter allowing additional information related to the clearing of the connection;

Parameter code: 1110 0000

Parameter length: any value provided that the length of the DR TPDU does not exceed the maximum agreed TPDU size or 128 when the DR TPDU is used during the connection refusal procedure.

Parameter value: additional information; the content of this field is user defined.

b) checksum (see 13.2.3.1).

13.5.5 User data (octets p + 1 to the end)

This field shall not exceed 64 octets and is used to carry TS-user data. The successful transfer of this data is not guaranteed by the transport protocol. When a DR TPDU is used in class 0 it shall not contain this field.

13.6 Disconnect Confirm (DC) TPDU

This TPDU shall not be used in class 0.

13.6.1 Structure

The structure of the DC TPDU shall be as follows:

1	2	3	4	5	6	7	p
LI	DC 1100 0000	DST-REF		SRC-REF		Variable part	

13.6.2 LI

See 13.2.1.

13.6.3 Fixed part (octets 2 to 6)

The fixed part shall contain

a) DC: Disconnect confirm code: 1100 0000;

b) DST-REF: see 13.4.3;

c) SRC-REF: see 13.4.3.

13.6.4 Variable part

The variable part shall contain the checksum parameter if the condition defined in 13.2.3.1 applies.

13.7 Data (DT) TPDU

13.7.1 Structure

Depending on the class and the option the DT TPDU shall have one of the following structures:

a) Normal format for classes 0 and 1

1	2	3	4 5 ... end
LI	DT ROA 1111 000y	TPDU-NR and EOT	User data

b) Normal format for classes 2, 3 and 4

1	2	3 4	5	6 p	p + 1 end
LI	DT ROA 1111 000y	DST-REF	TPDU-NR and EOT	Variable part	User data

c) Extended format for use in classes 2, 3 and 4 when selected during connection establishment

1	2	3 4	5, 6, 7, 8	9 p	p + 1 end
LI	DT ROA 1111 000y	DST-REF	TPDU-NR and EOT	Variable part	User data

13.7.2 LI

See 13.2.1.

13.7.3 Fixed part

The fixed part shall contain

a) DT: Data transfer code: bits 8 to 5 shall be set to 1111. Bits 4 to 2 shall be set to zero.

b) ROA: Request of acknowledgement mark: If the request acknowledgement procedures has not been agreed during connection establishment, bit 1 shall be set to 0 in all DT TPDUs.

When the request acknowledgement procedure has been agreed during connection establishment, bit 1 (ROA) is used to request acknowledgement in classes 1, 3, and 4. When set to one, ROA indicates that the sending transport entity requests an acknowledgement from the receiving transport entity. Otherwise ROA is set to zero.

c) DST-REF: See 13.4.3;

d) EOT: When set to ONE, it indicates that the current DT TPDU is the last data unit of a complete DT TPDU sequence (end of TSDU). EOT is bit 8 of octet 3 in class 0 and 1 and bit 8 of octet 5 for classes 2, 3 and 4;

e) TPDU-NR: TPDU send sequence number (zero in class 0). May take any value in class 2 without explicit flow control. TPDU-NR is bits 7 to 1 of octet 3 for classes 0 and 1, bits 7 to 1 of octet 5 for normal formats in classes 2 3, and 4 and bits 7 to 1 of octet 5 together with octets 6, 7 and 8 for extended format.

NOTE – Depending on the class, the fixed part of the DT TPDU uses the following octets:

classes 0 and 1: octets 2 to 3;

classes 2, 3, 4 (normal format): octets 2 to 5;

classes 2, 3, 4 (extended format): octets 2 to 8.

13.7.4 Variable part

The variable part shall contain the checksum parameter if the condition defined in 13.2.3.1 applies.

13.7.5 User data field

This field contains data of the TSDU being transmitted.

NOTE – The length of this field is limited to the negotiated TPDU size for this transport connection minus 3 octets in classes 0 and 1, and minus 5 octets (normal header format) or 8 octets (extended header format) in the other classes. The variable part, if present, may further reduce the size of the user data field.

13.8 Expedited data (ED) TPDU

This ED TPDU shall not be used in class 0 or in class 2 when the no explicit flow control option is selected or when the expedited data transfer service has not been selected for the connection.

13.8.1 Structure

Depending on the format negotiated at connection establishment the ED TPDU shall have one of the following structures:

a) Normal format (classes 1, 2, 3, 4)

1	2	3	4	5	6 p	p + 1 end
LI	ED 0001 0000	DST-REF		ED TPDU-NR and EOT	Variable part	User data

b) Extended format (for use in classes 2, 3 and 4 when selected during connection establishment)

1	2	3	4	5, 6, 7, 8	9 p	p + 1 end
LI	ED 0001 0000	DST-REF		ED TPDU-NR and EOT	Variable part	User data

13.8.2 LI

See 13.2.1.

13.8.3 Fixed part

The fixed part shall contain

a) ED: Expedited data code: 0001 0000;

b) DST-REF: see 13.4.3;

c) ED TPDU-NR: Expedited TPDU identification number. ED TPDU-NR is used in classes 1, 3 and 4 and may take any value in class 2. For normal formats bits 7 to 1 of octet 5 and for extended formats bits 7 to 1 of octet 5 together with octets 6, 7 and 8;

d) EOT: End of TSDU always set to 1 (bit 8 of octet 5).

NOTE – Depending on the format the fixed part shall be either octets 2 to 5 or 2 to 8.

13.8.4 Variable part

The variable part shall contain the checksum parameter if the condition defined in 13.2.3.1 applies.

13.8.5 User data field

This field contains an expedited TSDU (1 to 16 octets).

13.9 Data acknowledgement (AK) TPDU

This TPDU shall not be used in class 0 or in class 2 when the no explicit flow control option is selected, nor for class 1 when the network receipt confirmation option is selected.

13.9.1 Structure

Depending on the class and option agreed the AK TPDU shall have one of the following structures:

a) Normal format (classes 1, 2, 3, 4)

1	2	3	4	5	6 … p
LI	AK CDT 0110 zzzz	DST-REF		YR-TU-NR	Variable part

b) Extended format (for use in classes 2, 3 and 4 when selected during connection establishment)

1	2	3	4	5, 6, 7, 8	9 10	11 ... p
LI	AK 0110 0000	DST-REF		YR-TU-NR	CDT	Variable part

13.9.2 LI

See 13.2.1.

13.9.3 Fixed part

The fixed part shall contain (in octets 2 to 5 when normal format is used or in octets 2 to 10) the following parameters:

a) AK: Acknowledgement code: 0110;

b) CDT: Credit value (set to 1111 in class 1). CDT is bits 4 to 1 of octet 2 for normal formats and octets 9 and 10 for extended formats;

c) DST-REF: See 13.4.3;

d) YR-TU-NR: Sequence number indicating the next expected DT TPDU number. For normal formats, bits 7 to 1 of octet 5; bit 8 of octet 5 is not significant and shall take the value 0. For extended formats, bits 7 to 1 of octet 5 together with octets 6, 7 and 8; bit 8 of octet 5 is not significant and shall take the value 0.

13.9.4 Variable part

The variable part contains the following parameters:

a) Checksum if the condition in 13.2.3.1 applies;

b) Subsequence number when optionally used under the conditions defined in class 4. This parameter is used to ensure that AK TPDUs are processed in the correct sequence. If it is absent, this is equivalent to transmitting the parameter with a value of zero.

Parameter code: 1000 1010

Parameter length: 2

Parameter value: 16-bit subsequence number;

c) Flow control confirmation when optionally used under the conditions defined in class 4. This parameter contains a copy of the information received in an AK TPDU, to allow the transmitter of the AK TPDU to be certain of the state of the receiving transport entity (see 12.2.3.9).

Parameter code: 1000 1100

Parameter length: 8

Parameter value: defined as follows:

1) Lower window edge (32 bits). Bit 8 of octet 1 of the parameter value field is set to zero, the remainder contains the YR-TU-NR value of the received AK TPDU. When normal format has been selected, only the least significant seven bits (bits 1 to 7 of octet 4 of the parameter value field) of this field are significant.

2) Your subsequence (16 bits). Contains the value of the subsequence parameter of the received AK TPDU, or zero if this parameter was not present.

3) Your credit (16 bits). Contains the value of the CDT field of the received AK TPDU. When normal format has been selected, only the least significant four bits (bits 1 to 4 of octet 2 of the Your Credit field) of this field are significant.

d) Selective acknowledgement parameters when optionally used, under conditions defined in class 4, to acknowledge out of sequence DT TPDUs received by the entity transmitting the AK TPDU. All consecutive DT TPDUs received shall be acknowledged by a single block. Different groups of DT TPDUs that are consecutive within group but not across groups shall be acknowledged using separate blocks (e.g., if DT TPDU numbers 3, 4, 5, 7, 8, 12, 13, 14, 15 and 17 are received with 3 the first out-of-sequence DT TPDU, then 3, 4, 5 form one group, 7, 8 another and 12, 13, 14, 15 a third, and 17 a fourth. The corresponding blocks would be (3, 5), (7, 8), (12, 15) and (17, 17)).

Parameter code: 1000 1111

Parameter length: 2n (normal format) or 8n (extended format) octets where n is the number if distinct blocks being selectively acknowledged. This length is constrained by the maximum header size of 254 octets.

Parameter value: In the normal format, the first octet of a pair of two octets shall represent the lower edge and the second octet the upper edge of each block. Bit 8 of each octet is set to zero, the remainder represents the sequence number of the edge.

In the extended format, the first four octets of a set of eight octets represent the lower edge and the subsequent four octets represent the upper edge. For each edge of four octets, Bit 8 of the first octet is not significant and is set to 0; bits 7 to 1 of the first octet together with the second, third and fourth octets represent the sequence number.

Whether normal or extended formats are used, each set of two or eight octets may be repeated as many times as there are blocks to be acknowledged.

13.10 Expedited data acknowledgement (EA) TPDU

The EA TPDU shall not be used for class 0, or for class 2 when the "no explicit flow control" option is selected, or when the expedited data transfer service has not been selected for the connection.

13.10.1 Structure

Depending on the option (normal or extended format) the TPDU structure shall be:

a) Normal format (classes 1, 2, 3, 4)

1	2	3, 4	5	6 … p
LI	EA 0010 0000	DST-REF	YR-EDTU-NR	Variable part

b) Extended format (for use in classes 2, 3 and 4 if selected during connection establishment)

1	2	3, 4	5, 6, 7, 8	9 … p
LI	EA 0010 0000	DST-REF	YR-EDTU-NR	Variable part

13.10.2 LI

See 13.2.1.

13.10.3 Fixed part

The fixed part shall contain (in octets 2 to 5 when normal format is used or in octets 2 to 8) the following parameters:

a) EA: Expedited acknowledgement code: 0010 0000;

b) DST-REF: See 13.4.3;

c) YR-EDTU-NR: Identification of the ED TPDU being acknowledged. May take any value in class 2. For normal formats bits 7 to 1 of octet 5; bit 8 of octet 5 is not significant and shall take the value 0. For extended formats, bits 7 to 1 of octet 5 together with octets 6, 7 and 8; bit 8 of octet 5 is not significant and shall take the value 0.

13.10.4 Variable part

The variable part may contain the checksum parameter (see 13.2.3.1).

13.11 Reject (RJ) TPDU

The RJ TPDU shall not be used in classes 0, 2, and 4.

13.11.1 Structure

The RJ TPDU shall have one of the following formats:

a) Normal format (classes 1 and 3)

1	2	3	4	5
LI	RJ CDT 0101 zzzz	DST-REF		YR-TU-NR

b) Extended format (for use in class 3 if selected during connection establishment)

1	2	3	4	5, 6, 7, 8	9	10
LI	RJ 0101 0000	DST-REF		YR-TU-NR	CDT	

13.11.2 LI

See 13.2.1.

13.11.3 Fixed part

The fixed part shall contain (in octets 2 to 5 when normal format is used or in octets 2 to 10) the following parameters:

a) RJ: Reject code: 0101. Bits 8 to 5 of octet 2;

b) CDT: Credit value (set to 1111 in class 1). For normal formats bits 4 to 1 of octet 2 and for extended formats octets 9 and 10;

c) DST-REF: See 13.4.3;

d) YR-TU-NR: Sequence number indicating the next expected TPDU from which retransmission should occur. For normal formats, bits 7 to 1 of octet 5, bit 8 of octet 5 is not significant and shall take the value 0. For extended formats, bits 7 to 1 of octet 5 together with octets 6, 7 and 8; bit 8 of octet 5 is not significant and shall take the value 0.

13.11.4 Variable part

There is no variable part for this TPDU type.

13.12 TPDU error (ER) TPDU

13.12.1 Structure

1	2	3	4	5	6 ... p
LI	ER 0111 0000	DST-REF		REJECT CAUSE	Variable part

13.12.2 LI

See 13.2.1.

13.12.3 Fixed part

The fixed part shall contain the following parameters:

a) ER: TPDU Error code: 0111 0000;

b) DST-REF: See 13.4.3;

c) REJECT CAUSE:

0000 0000	Reason not specified
0000 0001	Invalid parameter code
0000 0010	Invalid TPDU type
0000 0011	Invalid parameter value.

13.12.4 Variable part

The variable part may contain the following parameters:

a) Invalid TPDU

Parameter code: 1100 0001

Parameter length: number of octets of the value field

Parameter value: contains the bit pattern of the rejected TPDU header up to and including the octet which caused the rejection. This parameter is mandatory in class 0.

b) Checksum

This parameter shall be present if the condition in 13.2.3.1 applies.

Section Three: Conformance

14 Conformance

14.1 A system claiming to implement the procedures specified in this International Standard shall comply with the requirements in 14.2 to 14.5.

14.2 The system shall implement class 0 or class 2 or both. This implies operation over CONS.

14.3 If the system implements class 3 or class 4, it shall also implement class 2.

14.4 If the system implements class 1, it shall also implement class 0.

14.5 For each class which the system claims to implement, the system shall be capable of

a) initiating CR TPDUs or responding to CR TPDUs with CC TPDUs or both;

b) responding to any other TPDU and operating network service in accordance with the procedures for the class;

c) operating all the procedures for the class listed as mandatory in table 9;

d) operating those procedures for the class listed as optional in table 9 for which conformance is claimed;

e) handling all TPDUs of lengths up to the lesser value of

1) the maximum length for the class if the preferred maximum TPDU size parameter is not implemented [see 13.3.4b)];

2) the maximum for which conformance is claimed (see note 2);

NOTES

1 The procedures for classes 0 to 4 are specified in clauses 8 to 12 respectively. The procedures refer to the elements of procedures specified in clause 6.

2 The requirement in 14.5 e) indicates that TPDU size of 128 octets is always implemented.

14.6 Claims of conformance shall state

a) which class or classes of protocol are implemented;

b) whether class 4 can be operated over the connectionless-mode network service;

c) whether the system is capable of initiating or responding to CR TPDUs or both;

d) which of the procedures listed as optional in table 9 are implemented;

e) for each class, the maximum size of TPDU implemented [see 13.3.4 b) and 13.3.4 c)]. If the preferred maximum TPDU size parameter is not implemented the value shall be chosen from the following list and all values in the list which are less than this maximum shall be implemented:

128, 256, 512, 1 024, 2 048, 4 096 or 8 192 octets.

If the preferred maximum TPDU size parameter is implemented, any maximum size of TPDU that is a multiple of 128 octets is allowed. All values, except 0, that are a multiple of 128 octets, less than the maximum claimed shall be implemented.

14.7 The supplier of a protocol implementation which is claimed to conform to this International Standard shall complete a copy of the PICS proforma provided in Annex D and shall provide the information necessary to identify both the supplier and the implementation.

Table 9 – Provision of options

Procedure	class 0	class 1	class 2	class 3	class 4
TPDU with checksum TPDU without checksum	not applicable mandatory	not applicable mandatory	not applicable mandatory	not applicable mandatory	mandatory optional
Expedited data transfer No expedited data transfer	not applicable mandatory	mandatory mandatory	mandatory mandatory	mandatory mandatory	mandatory mandatory
Flow control in class 2 No flow control in class 2	not applicable not applicable	not applicable not applicable	mandatory optional	not applicable not applicable	not applicable not applicable
Normal formats Extended formats	mandatory not applicable	mandatory not applicable	mandatory optional	mandatory optional	mandatory optional
Use of receipt confirmation in class 1 No use of re-ceipt confirma-tion in class 1	not applicable not applicable	optional mandatory	not applicable not applicable	not applicable not applicable	not applicable not applicable
Use of network expedited in class 1 No use of net-work expedited in class 1	not applicable not applicable	optional mandatory	not applicable not applicable	not applicable not applicable	not applicable not applicable
Use of selective acknowledgement in class 4	not applicable	not applicable	not applicable	not applicable	optional
Use of request of acknowledgement in classes 1, 3, 4	not applicable	optional	not applicable	optional	optional