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DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

OPEN SYSTEMS INTERCONNECTION – SERVICE DEFINITIONS

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – TRANSPORT SERVICE DEFINITION

ITU-T Recommendation X.214

(Previously "CCITT Recommendation")

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. Some 179 member countries, 84 telecom operating entities, 145 scientific and industrial organizations and 38 international organizations participate in ITU-T which is the body which sets world telecommunications standards (Recommendations).

The approval of Recommendations by the Members of ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, 1993). In addition, the World Telecommunication Standardization Conference (WTSC), which meets every four years, approves Recommendations submitted to it and establishes the study programme for the following period.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC. The text of ITU-T Recommendation X.214 was approved on 21st of November 1995. The identical text is also published as ISO/IEC International Standard 8072.

NOTE

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

ITU-T X-SERIES RECOMMENDATIONS

DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

(February 1994)

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Summary

This Recommendation | International Standard defines the service provided by the transport layer to the session layer at the boundary between the transport and session layers of the OSI reference model, which includes:

a) the primitive actions and events of the service;

b) the parameter data associated with each primitive action and event; and

c) the relationship between, and the valid sequence of, these actions and events.

Introduction

This Recommendation | International Standard is one of a set of Recommendations | International Standards produced to facilitate the interconnection of computer systems. It is related to other Recommendations | International Standards in the set as defined by the Reference Model of Open Systems Interconnection (OSI). The OSI Reference Model (see ITU-T Rec. X.200 | ISO/IEC 7498-1) subdivides the area of standardization for interconnection into a series of layers of specification, each of manageable size.

This Recommendation | International Standard defines the Service provided by the Transport Layer to the Session Layer at the boundary between the Transport and Session Layers of the Reference Model. It provides for the designers of Session Protocols a definition of the Transport Service existing to support the Session Protocol and for designers of Transport Protocols a definition of the services to be made available through the action of the Transport Protocol over the underlying service. This relationship is illustrated in Figure Intro.1.

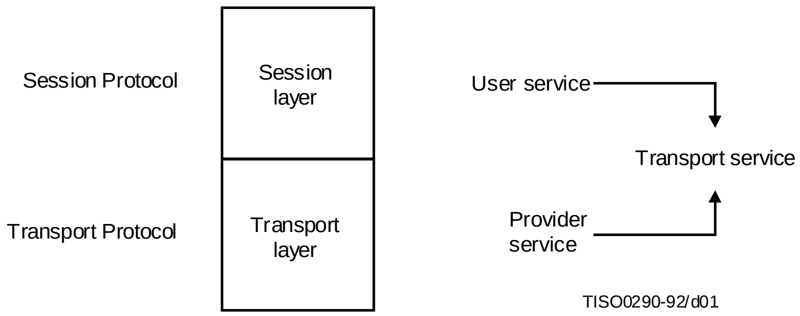


Figure Intro. 1 – Relationship of the Transport Service to OSI Transport and Session Protocols

Throughout the set of OSI Recommendations | International Standards, the term "Service" refers to the abstract capability provided by one layer of the OSI Reference Model to the layer above it. Thus, the Transport Service defined in this Recommendation | International Standard is a conceptual architectural Service, independent of administrative divisions.

NOTE – It is important to distinguish the specialized use of the term "Service" within the set of OSI Recommendations | International Standards from its use elsewhere to describe the provision of a service by an organization (such as the provision of a service, as defined in other Recommendations, by an Administration).

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – TRANSPORT SERVICE DEFINITION

SECTION 1 – GENERAL

1 Scope

This Recommendation | International Standard defines in an abstract way the externally visible service provided by the OSI Transport Layer in terms of:

a) the primitive actions and events of the service;

b) the parameter data associated with each primitive action and event;

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

The service defined in this Recommendation | International Standard is that which is provided by all OSI Transport Protocols (in conjunction with the Network Service) and which may be used by any OSI Session Protocol.

This Recommendation | International Standard does not specify individual implementations or products, nor does it constrain the implementation of entities and interfaces within a system. Conformance of equipment to this Recommendation | International Standard is achieved by conformance to the protocols specified to fulfil the Transport Service defined in this Recommendation | International Standard.

2 Normative references

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

2.1 Identical Recommendations | International Standards

– ITU-T Recommendation X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*.

– ITU-T Recommendation X.210 (1993) | ISO/IEC 10731:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: Conventions for the definition of OSI services*.

3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply.

3.1 Reference Model definitions

This Service Definition is based on the concepts developed in the OSI Reference Model (see ITU-T Rec. X.200 | ISO/IEC 7498-1), and makes use of the following terms defined in it:

a) expedited transport-service-data-unit;

b) transport-connection;

c) transport-connection endpoint;

d) Transport Layer;

e) Transport Service;

f) transport-service-access-point;

g) transport-service-access-point address;

h) transport-service-data-unit;

i) Network Layer;

j) Network Service;

k) network-connection;

l) interface flow control.

3.2 Service (Definition) conventions

This Service Definition also makes use of the following terms defined in ITU-T Rec. X.210 | ISO/IEC 10731, as they apply to the Transport Layer:

a) service-user;

b) service-provider;

c) primitive;

d) request;

e) indication;

f) response;

g) confirm.

3.3 Transport Service Definitions

For the purpose of this Service Definition, the following definitions also apply.

3.3.1 transport connection: An association established by a Transport Layer between two TS users for the transfer of data, which provides explicit identification of a set of transport data transmissions and agreement concerning the services to be provided for the set.

NOTE – This definition clarifies that given in ITU-T Rec. X.200 | ISO 7498-1.

3.3.2 calling TS user: A Transport Service user that initiates a transport connection establishment request.

3.3.3 called TS user: A Transport Service user with whom a calling TS user wishes to establish a transport connection.

NOTE – Calling TS users and called TS users are defined with respect to a single connection. A Transport Service user can be both a calling and a called TS user simultaneously.

3.3.4 transport connection-mode data transmission: The transfer of a TSDU from a source TSAP to a destination TSAP within the context of a TC that has previously been established.

3.3.5 transport connectionless-mode data transmission: The transmission of a TSDU from a source TSAP to one or more destination TSAPs outside the context of a TC and without any requirement to maintain any logical relationship among multiple TSDUs.

3.3.6 sending TS user: A Transport Service user that acts as a source of data during the data transfer phase of a transport-connection, or during a particular instance of transport connectionless-mode data transmission.

3.3.7 receiving TS user: A Transport Service user that acts as a sink of data during the data transfer phase of a transport-connection, or during a particular instance of transport connectionless-mode data transmission.

NOTE – A Transport Service user can be both a sending and a receiving TS user simultaneously.

3.3.8 group transport address: An address that identifies a particular group of TSAPs. A group Transport address may only be used to identify destination addresses.

4 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply:

TS	Transport Service
TC	Transport-connection
TSAP	Transport-service-access-point
TSDU	Transport-service-data-unit
QOS	Quality of Service

5 Conventions

5.1 General conventions

This Service Definition uses the descriptive conventions given in ITU-T Rec. X.210 | ISO/IEC 10731.

5.2 Parameters

The available parameters for each group of primitives are set out in tables in clauses 12 to 14 and 19. Each "X" in the tables indicates that the primitive labelling the column in which it falls may carry the parameter labelling the row in which it falls.

Some entries are further qualified by items in brackets. These may be:

a) *Indications that the parameter is optional in some way:*

(U) indicates that the inclusion of the parameter is a choice made by the user.

b) *A parameter specific constraints:*

(=) indicating that the value supplied in an indication or confirm primitive is always identical to that supplied in the previous request or response primitive issued at the peer service access point.

6 Overview and general characteristics

The Transport Service provides transparent transfer of data between TS users. It relieves these TS users from any concern about the detailed way in which supporting communications media are utilized to achieve this transfer.

The Transport Service provides for the following:

a) *Quality of Service selection:*

The Transport Layer is required to optimize the use of available communications resources to provide the Quality of Service required by communicating TS users at minimum cost. Quality of Service is specified through the selection of values for Quality of Service parameters representing characteristics such as throughput, transit delay, residual error rate and failure probability.

b) *Independence of underlying communications resources:*

The Transport Service hides from TS users the difference in the Quality of Service provided by the Network Service. This difference in Quality of Service arises from the use of a variety of communications media by the Network Layer to provide the Network Service.

c) *End-to-end significance:*

The Transport Service provides for the transfer of data between two TS users in the case of the connection-mode Transport Service or between two or more TS users in the case of the connectionless-mode Transport Service in end systems.

d) *Transparency of transferred information:*

The Transport Service provides for the transparent transfer of octet-aligned TS user-data and/or control information. It does neither restrict the content, format, or coding of the information, nor does it ever need to interpret its structure or meaning.

e) *TS user addressing:*

The Transport Service utilizes a system of addressing which is mapped into the addressing scheme of the supporting Network Service. Transport-addresses can be used by TS users to refer unambiguously to TSAPs or a specific group of TSAPs.

7 Classes and types of Transport Service

There are two types of Transport Service:

a) a connection-mode service (defined in clauses 8 to 14); and

b) a connectionless-mode service (defined in clauses 15 to 19).

When referring to this Service Definition, a user or provider of TS shall state which type(s) of service it expects to use or provide.

There are no distinct classes of Transport Service defined.

SECTION 2 – DEFINITION OF THE CONNECTION-MODE SERVICE

8 Features of the connection-mode Transport Service

The connection-mode Transport Service offers the following features to a TS user:

a) The means to establish a TC with another TS user for the purpose of exchanging TSDUs. More than one TC may exist between the same pair of TS users.

b) Associated with each TC at its time of establishment, the opportunity to request, negotiate, and have agreed by the TS provider a certain Quality of Service as specified by means of Quality of Service parameters.

c) The means of transferring TSDUs on a TC. The transfer of TSDUs which consist of an integral number of octets is transparent, in that the boundaries of TSDUs and the contents of TSDUs are preserved unchanged by the TS provider and there are no constraints on the TSDU content imposed by the TS provider.

d) The means by which the receiving TS user may control the rate at which the sending TS user may send octets of data.

e) The means of transferring separate expedited TSDUs when agreed to by both TS users. Expedited TSDUs transfer is subject to a different flow control from normal data across the TSAP.

f) The unconditional and therefore possible destructive release of a TC.

9 Model of the connection-mode Transport Service

9.1 General

This Service Definition uses the abstract model for a layer service defined in ITU-T Rec. X.210 | ISO/IEC 10731. The model defines the interactions between the TS users and the TS provider which take place at the two TSAPs. Information is passed between a TS user and the TS provider by service primitives, which may convey parameters.

The primitives are abstract representations of TSAP interactions. They are solely descriptive and do not represent a specification for implementation.

9.2 Model of a Transport Connection

The operation of a TC is modelled in an abstract way by a pair of queues linking the two TSAPs. There is one queue for each direction of information flow (see Figure 1). Each TC is modelled by a separate pair of queues.

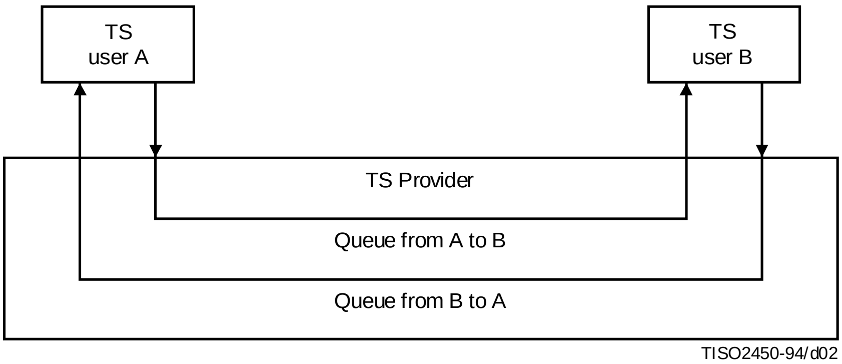


Figure 1 – Abstract model of a Transport Connection

The queue model is used to introduce the flow control feature. The ability of a TS user to add objects to a queue will be determined by the behaviour of the TS user removing objects from that queue and the state of the queue. Objects are entered and removed from the queue as a result of interactions at the two TSAPs.

The pair of queues is considered to be available for each potential TC.

The objects which may be placed in a queue by a TS user (see clauses 12 to 14) are:

a) connect objects (each representing all parameters contained in a T-CONNECT request or T-CONNECT response primitive);

b) octets of normal data;

c) indications of end-of-TSDU (completion of a T-DATA primitive);

d) expedited TSDUs (representing all parameters of a T-EXPEDITED-DATA primitive);

e) disconnect objects (each representing all parameters contained in a T-DISCONNECT primitive).

NOTES

1 Normal and expedited TSDU transfer will result in different objects being entered into the queue.

2 The description of flow control requires a less abstract description than that used for describing sequences of primitives in clauses 11 to 14. Each TSDU associated with a T-DATA primitive is here subdivided conceptually into a sequence of octets of data followed by an end-of-TSDU indication. The T-DATA request primitive occurs when the end-of-TSDU indication is entered into the queue. The T-DATA indication primitive occurs when the end-of-TSDU indication is removed from the queue. This does not imply any particular subdivision in any real interface.

The only objects which can be placed in a queue by the TS provider are disconnect objects (representing T-DISCONNECT primitives and their parameters).

TS user A, who initiates connection establishment by entering a connect object (representing a T-CONNECT request primitive) into the queue from A to B, is not allowed to enter any other object than a disconnect object into this queue until after the connect object representing the T-CONNECT confirm has been removed. In the queue from TS user B to TS user A, objects other than a disconnect object can be entered by TS user B only after TS user B has entered a connect object corresponding to a T-CONNECT response. The insertion of a disconnect object represents the initiation of the release procedure. The release procedure may be initiated at the times permitted in clause 14 and in the manner described in 11.2. The release procedure may be destructive with respect to other objects in the two queues.

A queue relates an ordered set of distinct objects in the following ways:

a) Queues are empty before a connect object has been added and can be returned to this state, with loss of their contents, by the TS provider under the circumstances as described in h) below.

b) Objects are added to the queue, subject of control by the TS provider.

c) Objects are normally removed from the queue, subject to control by the receiving TS user.

d) Objects are normally removed in the same order that they were added [but see g) and h) below].

e) A queue has a limited capacity, but this capacity is not necessarily either fixed or determinable.

f) The management of the queue capacity shall be such that normal data and end-of-TSDU indications cannot be added to the queue when its addition would prevent addition of an expedited TSDU or disconnect object. Similarly expedited TSDUs cannot be added if their addition would prevent the addition of a disconnect object.

In addition the TS provider may manipulate pairs of adjacent objects in the queue to allow:

g) *Reordering:*

The order of any pair of objects may be reversed if, and only if, the following object is of a type defined to take precedence over the preceding object. Expedited TSDUs take precedence over octets of normal data and end-of-TSDU indications (see Table 1).

h) *Deletion:*

Disconnect objects take precedence over any other object. Any object other than a disconnect object may be deleted by the TS provider if, and only if, the following one is a disconnect object (see Table 1).

If a connect object associated with a T-CONNECT request primitive is deleted in this manner, the disconnect object is also deleted. If a connect object associated with a T-CONNECT response primitive is deleted, the disconnect object is not deleted.

Whether the TS provider performs actions of types g) and h) or not, will depend on the behaviour of the TS users and on the agreed Quality of Service. In general, if the objects are not removed from the queue due to flow control expressed by the receiving TS user, the TS provider shall, after some unspecified period of time, perform all permitted actions of types g) and h).

NOTES

1 The internal mechanisms which support the operation of a queue are not visible in the Transport Service. A queue is one particular way of expressing the mutual interaction between primitives at different TSAPs. There may also be, for example:

a) constraints on the local ability to invoke primitives;

b) service procedures defining particular sequencing constraints on some primitives.

2 A TC endpoint identification mechanism must be provided locally if the TS user and the TS provider need to distinguish between several TCs at a TSAP. All primitives must then make use of this identification mechanism to identify the TC to which they apply. This implicit identification is not shown as a parameter of the TS primitives, and must not be confused with the address parameters of the T-CONNECT primitives.

Table 1 – Precedence table

The queue object x / has precedence over queue object y	Connect object	Octets of normal data	End-of-TSDU indication	Expedited TSDU	Disconnect object
Connect object	–	No	-	No	Yes [see h)]
Octets of normal data	–	No	No	Yes [see g)]	Yes [see h)]
End-of-TSDU indication	–	No	No	Yes [see g)]	Yes [see h)]
Expedited TSDU	–	No	No	No	Yes [see h)]
Disconnect object	–	–	–	–	No [see h)]
– Not applicable. No No precedence exists. Yes Precedence exists.					

10 Quality of connection-mode Transport Service

The term Quality of Service (QOS) refers to certain characteristics of a TC as observed between the endpoints.

QOS is described in terms of QOS parameters.

These parameters give TS users a method of specifying their needs, and give the TS provider a basis for protocol selection.

The QOS is normally negotiated between the TS users and the TS provider on a per TC basis, using the T-CONNECT request, indication, response, and confirm TS primitives defined in clause 11. The QOS requested by the calling TS user may be made poorer either by the TS provider following the T-CONNECT request, or by the called TS user, following the T-CONNECT indication. In applying this to some QOS parameters this may mean that:

a) a delay becomes longer;

b) a throughput becomes lower;

c) the error rate becomes higher;

d) the priority becomes lower;

e) the failure probability becomes higher.

f) TC protection provided by the TS provider need not be that requested by the TS user.

The so negotiated QOS values then apply throughout the lifetime of the TC.

NOTE – Users of the Transport Service should be aware that there is no guarantee that the originally negotiated QOS will be maintained throughout the Transport Connection lifetime, and that changes in QOS are not explicitly signalled by the Transport Service provider.

The view of QOS at each end of an established TC is always the same.

This clause does not specify particular values, or classes of values, for the QOS parameters. Possible choices and default values for each parameter will normally be specified at the time of initial TS provider installation. The values for any or all parameters may be fixed for a given TS provider, in which case QOS negotiation on a per TC basis is not required. When a QOS value is specified; the TS user may also indicate whether the request is an absolute requirement or whether a degraded value is acceptable.

The QOS parameters include parameters which express TS performance and parameters which express other TS characteristics.

The QOS parameters specified in this clause are defined below. A classification of the performance QOS parameters is shown in Table 2.

Table 2 – Classification of performance QOS parameters

Phase	Performance criterion	
	Speed	Accuracy/Reliability
TC establishment	TC establishment delay	TC establishment failure probability (misconnection/TC refusal)
Data transfer	Throughput Transit delay	Residual error rate (corruption, duplication/loss) Resilience of the TC Transfer failure probability
TC release	TC release delay	TC release failure probability

10.1 TC establishment delay

TC establishment delay is the maximum acceptable delay between a T-CONNECT request and the corresponding T-CONNECT confirm primitive.

NOTE – This delay includes TS user dependent components.

10.2 TC establishment failure probability

TC establishment failure probability is the ratio of total TC establishment failures to total TC establishment attempts in a measurement sample.

A TC establishment failure is defined to occur when a requested TC is not established within the specified maximum acceptable TC establishment delay as a result of misconnection, TC refusal, or excessive delay on the part of the TS provider. TC establishment attempts which fail as a result of error, TC refusal, or excessive delay on the part of a TS user are excluded in calculating the TC establishment failure probability.

10.3 Throughput

Throughput is defined, for each direction of transfer, in terms of a sequence of at least two successfully transferred TSDUs. Given such a sequence of *n* TSDUs, where *n* is greater than or equal to two, the throughput is defined to be the smaller of:

a) the number of TS user data octets contained in the last *n*-1 TSDUs divided by the time between the first and last T-DATA requests in the sequence; and

b) the number of TS user data octets contained in the last *n*-1 TSDUs divided by the time between the first and last T-DATA indications in the sequence.

Successful transfer of the octets in a transmitted TSDU is defined to occur when the octets are delivered to the intended receiving TS user without error, in the proper sequence, prior to release of the TC by the receiving TS user.

Throughput is only meaningful for a sequence of complete TSDUs and each specification is based on a previously stated average TSDU size.

Throughput is specified separately for each direction of transfer on a TC. In each direction, a specification of throughput will consist of a *maximum throughput* and an *average throughput* value. The *maximum throughput* value represents the maximum rate at which the TS provider can continuously accept and deliver TSDUs, in the absence of sending TS user input delays or flow control applied by the receiving TS user. Thus, the sequence of TSDUs in the calculation above are defined to be presented continuously at the maximum rate. The *average throughput* value represents the expected transfer rate on a TC including the effects of expected user-attributable delays (e.g. non-continuous TSDU input, receiving TS user flow control). Thus, the sequence of TSDUs in the calculation above is defined to be presented at a rate which includes components representing *average* user delays.

It is possible for either the input or the output of a sequence of TSDUs to be excessively delayed by the TS users. Such occurrences are excluded in calculating *average throughput* values.

For each direction of transfer, and for each of the *maximum throughput* and *average throughput* specifications, the throughput QOS for a particular TC will be negotiated among the TS users and the TS provider (see 12.2.6).

10.4 Transit delay

Transit delay is the elapsed time between a T-DATA request and the corresponding T-DATA indication. Elapsed time values are calculated only on TSDUs that are successfully transferred.

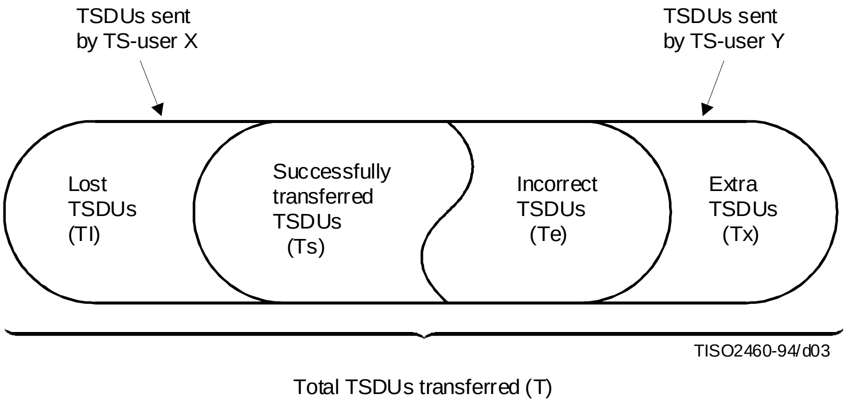
Successful transfer of a TSDU is defined to occur when the TSDU is transferred from the sending TS user to the intended receiving TS user without error, in the proper sequence, prior to release of the TC by the receiving TS user.

Transit delay is specified independently for each direction of transfer. In general, each transit delay specification will define both the average value and the maximum value expected for a TC. Each specification will be based on a previously stated average TSDU size.

The transit delay for an individual TSDU may be greatly increased if the receiving TS user exercises interface flow control. Such occurrences are excluded in calculating both average and maximum transit delay values.

10.5 Residual error rate

Residual error rate is the ratio of total incorrect, lost and duplicate TSDUs to total TSDUs transferred across the TS boundary during a measurement period. The relationship among these quantities is defined for a particular TS user pair, as shown in Figure 2.



$$\text{Residual Error Rate (RER)} = \frac{Te + Tl + Tx}{T}$$

Figure 2 – Components of residual error rate

10.6 Transfer failure probability

Transfer failure probability is the ratio of total transfer failures to total transfer samples observed during a performance measurement.

A transfer sample is a discrete observation of TS provider performance in transferring TSDUs between a specified sending and receiving TS user. A transfer sample begins on input of a selected TSDU at the sending TS user boundary, and continues until the outcome of a given number of TSDU transfer attempts has been determined. A transfer sample will normally correspond to the duration of an individual TC.

A transfer failure is a transfer sample in which the observed performance is worse than a specified minimum acceptable level. Transfer failures are identified by comparing the measured values for three supported performance parameters with specified transfer failure thresholds. The three supported performance parameters are throughput, transit delay and residual error rate.

In systems where Transport Service QOS is reliably monitored by the TS provider, transfer failure probability can be estimated by the probability of a TS provider initiated release during a transfer sample.

10.7 TC release delay

TC release delay is the maximum acceptable delay between a TS user initiated T-DISCONNECT request and the successful release of the TC at the peer TS user. TC release delay is normally specified independently for each TS user. TC release delay does not apply in cases where release is initiated by the TS provider.

Issuance of a T-DISCONNECT request by either TS user starts the counting of TC release delay for the other user. Successful release is signalled to the TS user not initiating the T-DISCONNECT request by a T-DISCONNECT indication.

10.8 TC release failure probability

TC release failure probability is the ratio of total TC release requests resulting in release failure to total release requests included in a measurement sample. TC release failure probability is normally specified independently for each TS user.

A release failure is defined to occur, for a particular TS user, if that user does not receive a T-DISCONNECT indication within the specified maximum TC release delay of the TS user issuing the T-DlSCONNECT request (given that the former TS user had not itself issued a T-DISCONNECT request).

10.9 TC protection

Protection QOS is the degree to which the TS provider attempts to counter security threats to the Transport Service using security services applied to the Transport, Network, Data Link or Physical layers.

The handling of protection QOS parameters is a local matter controlled according to the security policy in force.

NOTE – For further information on the provision of security in the lower layers and the handling of protection QOS, see ITU-T Rec. X.802 | ISO/IEC TR 13594.

10.10 TC priority

The specification of TC priority is concerned with the relationship between TCs. This parameter specifies the relative importance of a TC with respect to:

a) the order in which TCs are to have their QOS degraded, if necessary; and

b) the order in which TCs are to be broken to recover resources, if necessary.

This parameter only has meaning in the context of some management entity or structure able to judge relative importance. The number of priority levels is limited.

10.11 Resilience of the TC

Probability of a TS provider initiated TC release (i.e. issuance of a T-DISCONNECT indication with no prior T-DISCONNECT request) during a specified time interval (e.g. 1 s).

11 Sequence of Transport Service primitives

This clause defines the constraints on the sequences in which the TS primitives may occur. The constraints determine the order in which TS primitives occur, but do not fully specify when they may occur. Other constraints, such as flow control of data, will affect the ability of a TS user or TS provider to issue a TS primitive at any particular time.

Clauses 12 to 14 describe the TS primitives which are associated with one of the three phases of a TC, establishment, data transfer, or release. A complete listing of TS primitives appears in Table 3.

Table 3 – Transport Service primitives

Phase	Service	Primitive	Parameters
TC establishment	TC establishment	T-CONNECT request	(Called address, calling address, expedited data option, Quality of Service, TS user-data)
		T-CONNECT indication	(Called address, calling address, expedited data option, Quality of Service, TS user-data)
		T-CONNECT response	(Quality of Service, responding address, expedited data option, TS user-data)
		T-CONNECT confirm	(Quality of Service, responding address, expedited data option, TS user-data)
Data transfer	Normal data transfer	T-DATA request	(TS user-data)
		T-DATA indication	(TS user-data)
	Expedited data transfer [a)]	T-EXPEDITED-DATA request	(TS user-data)
		T-EXPEDITED-DATA indication	(TS user-data)
TC release	TC release	T-DISCONNECT request	(TS user-data)
		T-DISCONNECT indication	(Disconnect reason, TS user-data)
a) User option provided only upon TS user request.			

11.1 Relation of TS primitives at the two TC endpoints

A TS primitive issued at one TC endpoint will, in general, have consequences at the other TC endpoint. The relations of TS primitives of each type to TS primitives at the other TC endpoint are defined in the appropriate subclause in clauses 12 to 14; all these relations are summarized in Figure 3 (see ITU-T Rec. X.210 | ISO/IEC 10731, for the definition of time sequence diagrams). However, a T-DISCONNECT request or indication TS primitive may terminate any of the other sequences before completion.

11.2 Sequence of TS primitives at one TC endpoint

The possible overall allowed sequences of TS primitives at a TC endpoint are defined in the following state transition diagram (see Figure 4) and in an alternative tabular representation (see Table 4).

In Figure 4:

a) The idle state (1) reflects the absence of a TC. It is the initial and final state of any sequence and once it has been re-entered, the TC is released.

b) A TC release procedure can be initiated at any point during the TC establishment or data transfer phase.

c) Procedures other than the TC release procedure cannot be initiated within the establishment phase.

d) Any action to be taken on the occurrence of a non-allowed sequence of TS primitives is a local matter.

e) The use of a state transition diagram to describe the allowable sequences of TS primitives does not impose any requirement or constraint on the internal organization of any implementation of the Transport Service.

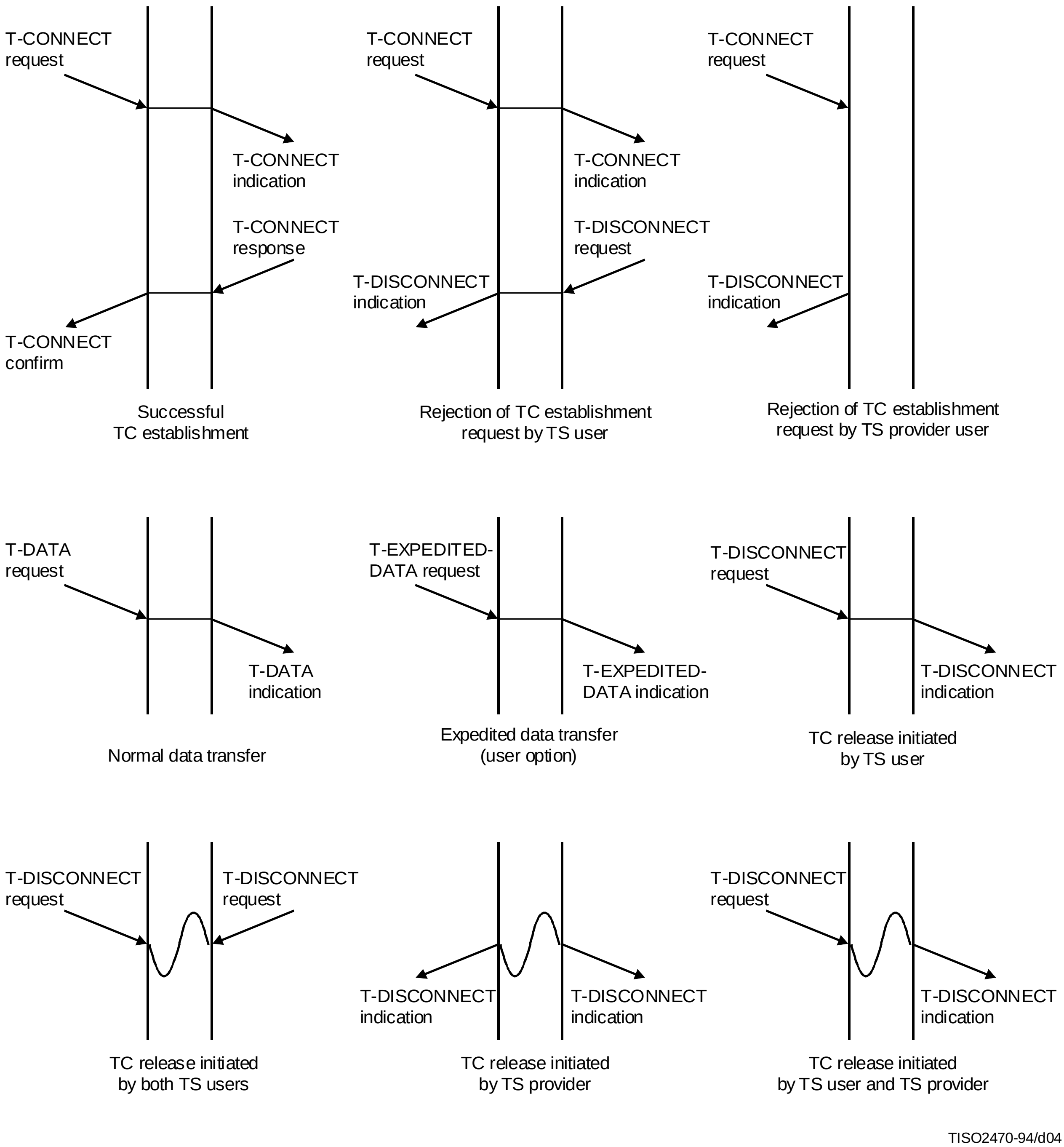


Figure 3 – Summary of Transport Service primitive time sequence diagrams

Table 4 – Sequences of TS primitives at one end of a TC

The TS primitive x may be followed by the TS primitive y	T-CONNECT request	T-CONNECT confirm	T-CONNECT indication	T-CONNECT response	T-DATA request	T-DATA indication	T-EXPEDITED-DATA request	T-EXPEDITED-DATA indication	T-DISCONNECT request	T-DISCONNECT indication
T-CONNECT request										
T-CONNECT confirm	+									
T-CONNECT indication										
T-CONNECT response			+							
T-DATA request		+		+	+	+	+	+		
T-DATA indication		+		+	+	+	+	+		
T-EXPEDITED-DATA request		+		+	+	+	+	+		
T-EXPEDITED-DATA indication		+		+	+	+	+	+		
T-DISCONNECT request	+	+	+	+	+	+	+	+		
T-DISCONNECT indication	+	+	+	+	+	+	+	+		

\+ Possible
Blank Not possible

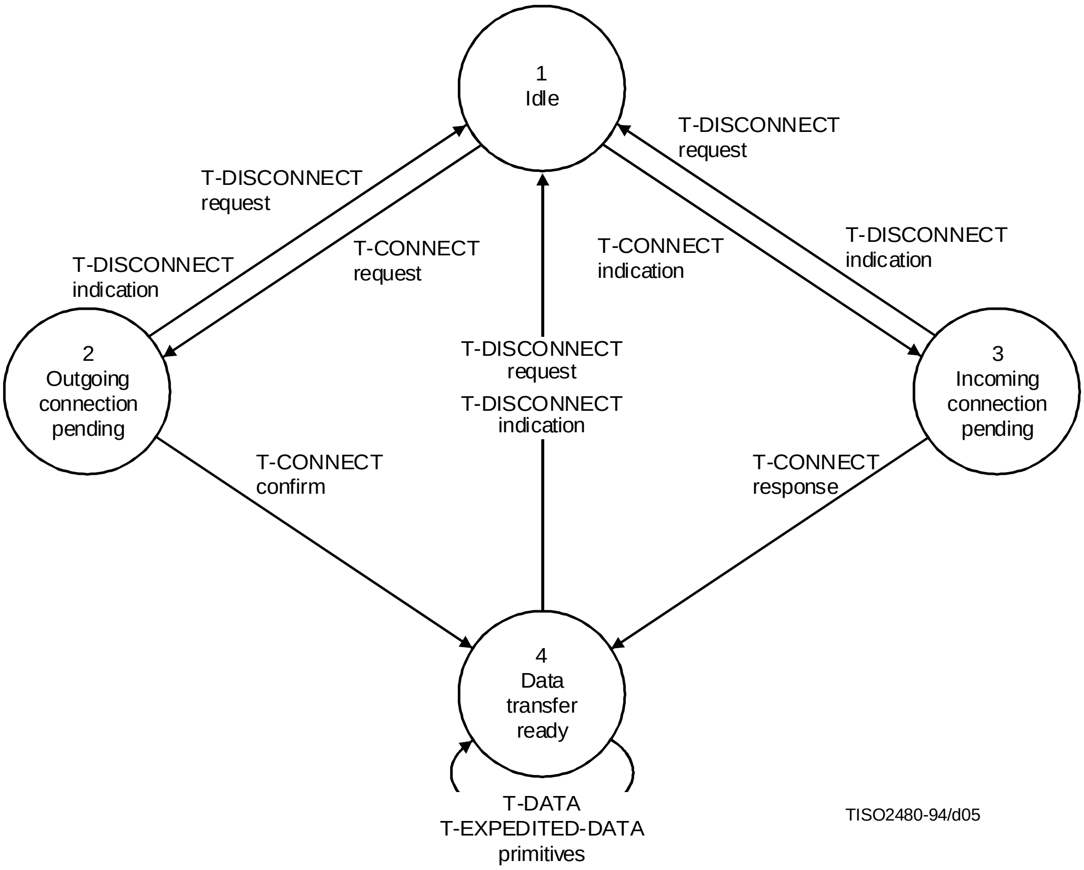


Figure 4 – State transition diagram for possible allowed sequence of TS primitives at a TC endpoint

12 Transport Connection establishment phase

12.1 Function

The TC establishment TS primitives can be used to establish a TC, provided the TS users exist and are known to the TS provider.

Simultaneous T-CONNECT requests at the two TSAPs are handled independently by the TS provider.

NOTE – Simultaneous T-CONNECT requests typically result in a corresponding number of TCs.

12.2 Types of TS primitives and parameters

Table 5 indicates the types of TS primitives and the parameters needed for TC establishment.

12.2.1 Addresses

The parameters which take addresses as values (see 12.2.2 to 12.2.4) all refer to TSAPs. These addresses are unique within the scope of TSAP addresses.

12.2.2 Called Address

The Called Address parameter conveys the address of the TSAP to which the TC is to be established.

Table 5 – TC establishment primitives and parameters

Parameter	TS primitive			
	T-CONNECT request	T-CONNECT indication	T-CONNECT response	T-CONNECT confirm
Called Address	X	X(=)		
Calling Address	X	X(=)		
Responding Address			X	X(=)
Expedited data option	X	X(=)	X	X(=)
Quality of Service	X	X	X	X(=)
TS user-data	X(U)	X(=)	X(U)	X(=)

X Mandatory parameter.
(=) The value of that parameter is identical to the value of the corresponding parameter of the preceding TS primitive.
(U) Use of this parameter is a TS user option.

12.2.3 Calling Address

The Calling Address parameter conveys the address of the TSAP from which the TC has been requested.

12.2.4 Responding Address

The Responding Address parameter conveys the address of the TSAP to which the TC has been established.

NOTE – Implementors should note that there are instances where the Responding Address may be different from the Called Address. For example, using Transport Protocol over X.25 subnetworks using hunt group optional user facility.

12.2.5 Expedited Data option

The Expedited Data option parameter indicates whether the expedited data option is to be available on the TC. If this service is declared not available, it cannot be used on the TC. The value of the parameter is either "Expedited Data Service selected" or "Expedited Data Service not selected" (see 12.4). The values of the various primitives are related such that:

a) in the T-CONNECT request primitive, either of the defined values may occur;

b) in the T-CONNECT indication primitive, the value is equal to the value in the T-CONNECT request primitive;

c) in the T-CONNECT response primitive, the value is either "Expedited Data Service not selected" or is equal to the value in the T-CONNECT indication primitive;

d) in the T-CONNECT confirm primitive, the value is equal to the value in the T-CONNECT response primitive.

12.2.6 Quality of Service

Quality of Service is a list of parameters (see clause 10). For each parameter, the values in the various TS primitives are related so that:

a) in the T-CONNECT request primitive, any defined value is allowed;

b) in the T-CONNECT indication primitive, the QOS parameter value is equal to or poorer than the value in the T-CONNECT request primitive, except for the TC protection, which must have the same value as specified in the T-CONNECT request primitive;

c) in the T-CONNECT response primitive, the QOS parameter value indicated is equal to or poorer than the value in the T-CONNECT indication primitive;

d) in the T-CONNECT confirm primitive, the QOS parameter value indicated is equal to the value in the T-CONNECT response primitive.

12.2.7 TS user-data

This parameter allows the transfer of TS user-data between TS users without modification by the TS provider. The TS user-data parameter shall be an integral number of octets in length between 1 and 32 inclusive.

NOTES

1 The called TS user may use the information conveyed to determine whether or not the TC should be accepted.

2 The QOS associated with TS user-data on the T-CONNECT primitive may be lower than that for TS user-data in the T-DATA primitive once the TC is established.

12.3 Sequence of TS primitives

The sequence of TS primitives in a successful TC establishment is defined by the following time sequence diagram (see Figure 5):

The TC establishment procedure may fail either due to the inability of the TS provider to establish a TC or due to the unwillingness of the called TS user to accept a T-CONNECT indication. These cases are described in 14.4 and 14.5. The TC establishment procedure may also fail due to either of the TS users releasing the TC before the T-CONNECT confirm has been delivered to the calling TS user.

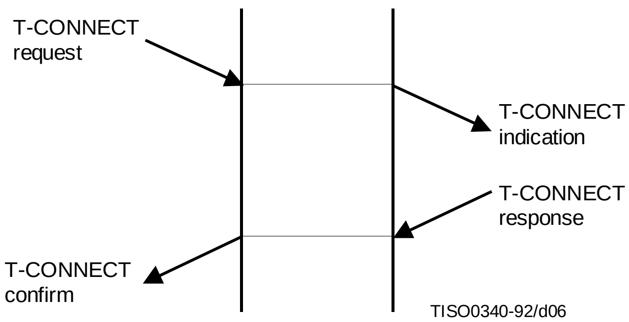


Figure 5 – Sequence of primitives in successful TC establishment

12.4 Negotiation of expedited data transfer service

The expedited TSDU transfer is only made available when specifically requested and agreed to by both TS users when the TC is established. When available this service is always bidirectional. The procedure for negotiating the use of the expedited TSDU transfer is as follows:

a) The calling TS user may request or not request the use of the expedited TSDU transfer feature.

b) If the calling TS user does not request the use of the expedited TSDU transfer feature, the called TS user is not allowed to request its use.

c) If the calling TS user does request the use of the expedited TSDU transfer feature, the called TS user may agree to the use of expedited TSDU transfer on the TC, in which case the TS provider is required to provide it. The called TS user may refuse the use of expedited TSDU transfer in which case the service will not be used on that TC.

13 Data transfer phase

13.1 Data Transfer Service

13.1.1 Function

The TS provider provides for an exchange of TSDUs, in both directions simultaneously. The TS provider preserves the integrity, the sequence and boundaries of the TSDUs.

NOTE – Designers of higher layer protocols should realize that the requested QOS applies to complete TSDUs, and that division of data into small TSDUs may have cost implications, because of the impact on cost optimization mechanisms operated by the TS provider.

13.1.2 Types of TS primitives and parameters

Table 6 indicates the types of TS primitives and the parameters needed for data transfer.

Table 6 – Data transfer primitives and parameters

Parameter	Primitive	
	T-DATA request	T-DATA indication
TS user-data	X	X(=)

X Mandatory parameter.
(=) The value of that parameter is identical to the value of the corresponding parameter of the preceding TS primitive.

13.1.2.1 TS user-data

The TS user-data parameter is a TSDU. A TSDU consists of an integral number of octets greater than zero.

13.1.3 Sequence of TS primitives

The operation of the TS provider in transferring TS user-data can be modelled as a queue of unknown size within the TS provider (see clause 9). The ability of a TS user to issue a T-DATA request depends on the state of the queue. The ability of the TS provider to issue a T-DATA indication depends on the receiving TS user.

The sequence of TS primitives in a successful data transfer is defined in the following time sequence diagram (see Figure 6).

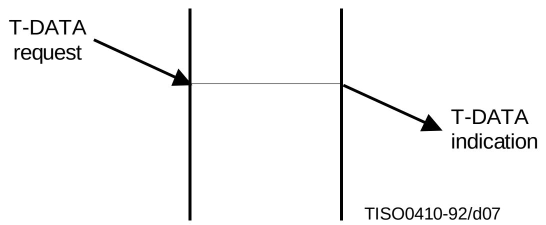


Figure 6 – Sequence of primitives in data transfer

13.2 Expedited data transfer service

13.2.1 Function

The expedited data transfer service provides a further means of information exchange on a TC in both directions simultaneously. The transfer of expedited TSDUs is subject to different QOS and separate flow control from that applying to TS user-data of the data transfer service.

The TS provider guarantees that an expedited TSDU will not be delivered after any subsequently submitted normal TSDU or expedited TSDU on that TC.

The relationship between normal and expedited data flow is modelled by the operation of reordering within queues as described in clause 9. In particular expedited data will be delivered when the receiving TS user is not accepting normal data. However, the amount of normal data bypassed by such reordering cannot be predicted.

13.2.2 Types of TS primitives and parameters

Table 7 indicates the types of TS primitives and the parameters needed for expedited data transfer.

Table 7 – Expedited TS primitives and parameters

Parameter	Primitive	
	T-EXPEDITED-DATA request	T-EXPEDITED-DATA indication
TS user-data	X	X(=)

X Mandatory parameter.
(=) The value of the parameter is identical to the value of the corresponding parameter of the preceding TS primitive.

13.2.2.1 TS user-data

The TS user-data parameter is an expedited TSDU. An expedited TSDU consists of an integral number of octets between 1 and 16 inclusive.

13.2.3 Sequence of TS primitives

The sequence of TS primitives in a successful expedited data transfer is defined in the following time sequence diagram (see Figure 7).

NOTE – Use of the expedited data transfer service must be requested by the calling TS user and agreed to by the called TS user when the TC is established (see 12.2.5).

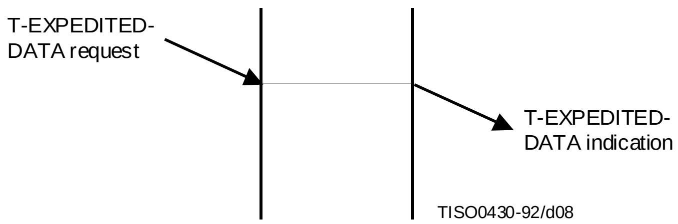


Figure 7 – Sequence of primitives in expedited data transfer

14 Transport Connection release phase

14.1 Function

The TC release TS primitives are used to release a TC. The release may be performed:

a) by either or both of the TS users to release an established TC;

b) by the TS provider to release an established TC; all failures to maintain a TC are indicated in this way;

c) by either or both the TS users to abandon TC establishment;

d) by the TS provider, to indicate its inability to establish a requested TC.

TC release is permitted at any time regardless of the current TC phase. A request for release cannot be rejected. The Transport Service does not guarantee delivery of any TS user-data once the release phase is entered.

14.2 Types of TS primitives and parameters

Table 8 indicates the types of TS primitives and the parameters needed for TC release.

Table 8 – TC release primitives and parameters

Parameter	Primitive	
	T-DISCONNECT request	T-DISCONNECT indication
Reason		X
TS user-data	X(U)	X(=)

X Mandatory parameter.
(=) The value of the parameter is identical to the value of the corresponding parameter of the preceding TS primitive.
(U) Use of this parameter is a TS user option.

14.2.1 Reason

The Reason parameter gives information indicating the cause of the TC release. The reason is one of the following:

– Remote TS user invoked.

NOTE 1 – Additional information may be given in the TS user-data parameter.

– TS provider invoked. This reason may be of transient or permanent nature.

NOTE 2 – The following examples are given:

a) lack of local or remote resources of the TS provider;

b) QOS below minimum level;

c) misbehaviour of TS provider;

d) called TS user unknown;

e) called TS user unavailable;

f) unknown reason.

14.2.2 TS user-data

The TS user-data parameter allows the transfer of TS user-data between TS users, without modification by the TS provider. The TS user-data may be lost in particular if the TS provider initiates TC release before the T-DISCONNECT indication is delivered, or if both TS users initiate a T-DISCONNECT simultaneously. Therefore, the parameter is only present if the TC release was originated by a TS user. The TS user-data parameter, if present, shall be an integral number of octets in length between 1 and 64 inclusive.

NOTES

1 The TS provider may provide additional information (e.g. accounting) for management purposes.

2 The QOS associated with the TS user-data on the T-DISCONNECT primitives may be lower than the QOS for TS user-data transferred by the T-DATA primitive. TS user-data may be lost without any notice to the TS user receiving the T-DISCONNECT indication, even when initiated by the remote TS user.

14.3 Sequence of TS primitives when releasing an established transport connection

The sequence of TS primitives depends on the origin or origins of the TC release action. The sequence may be:

a) invoked by one TS user, with a T-DISCONNECT request from that TS user leading to a T-DISCONNECT indication to the other;

b) invoked by both TS users, with a T-DISCONNECT request from each of the TS users;

c) invoked by the TS provider, with a T-DISCONNECT indication to each of the TS users;

d) invoked independently by one TS user and the TS provider, with a T-DISCONNECT request from the initiating TS user and a T-DISCONNECT indication to the other.

The sequence of TS primitives in these four cases are expressed in the following time sequence diagrams (see Figures 8 to 11).

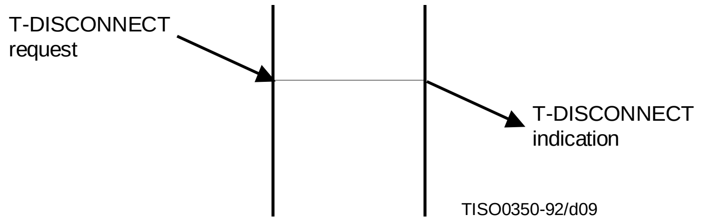


Figure 8 – Sequence of primitives in TS user invoked release

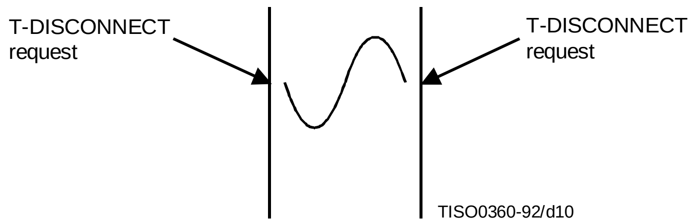


Figure 9 – Sequence of primitives in simultaneous TS users invoked release

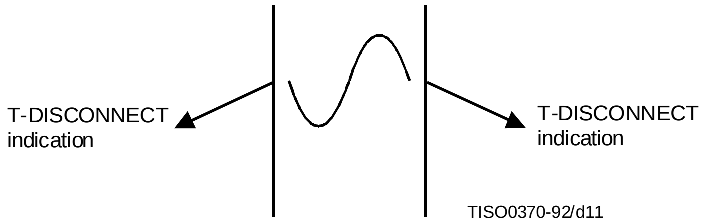


Figure 10 – Sequence of primitives in a TS provider invoked release

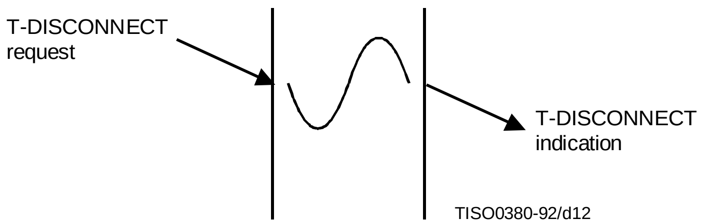


Figure 11 – Sequence of primitives in a simultaneous TS user and TS provider invoked release

14.4 Sequence of TS primitives in TS user rejection of a TC establishment

A TS user may reject a TC establishment attempt by a T-DISCONNECT request. In the T-DISCONNECT indication the reason parameter will indicate that the called TS user initiated the disconnection. The sequence of events is defined in the following time sequence diagram (see Figure 12).

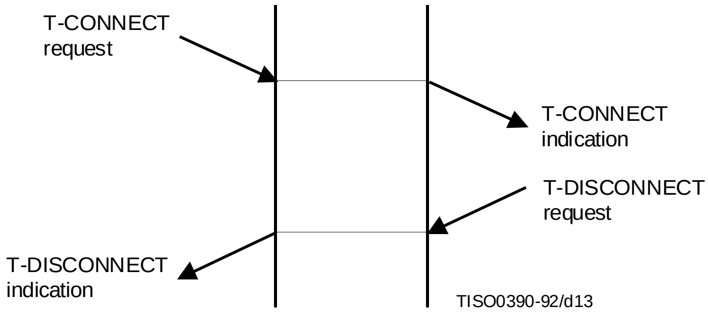


Figure 12 – Sequence of primitives in a TS user rejection of a TC establishment attempt

14.5 Sequence of TS primitives in a TS provider rejection of a TC Establishment attempt

If the TS provider is unable to establish a TC, it indicates this to the calling TS user by a T-DISCONNECT indication. The reason parameter indicates that the TS provider is the source of the T-DISCONNECT indication. The sequence of events is defined in the following time sequence diagram (see Figure 13).

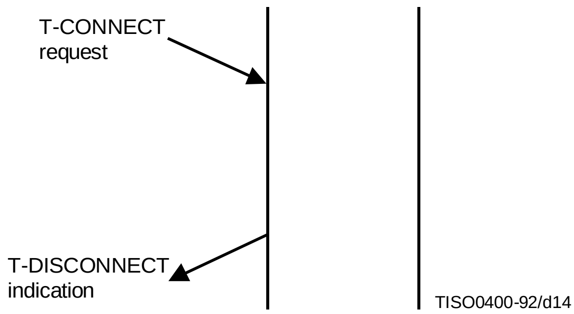


Figure 13 – Sequence of primitives in a TS provider rejection of a TC establishment attempt

SECTION 3 – DEFINITION OF THE CONNECTIONLESS-MODE SERVICE

15 Features of the connectionless-mode Transport Service

The connectionless-mode Transport Service provides the following features to the TS user:

a) a means by which TSDUs of restricted length are delimited and transparently transmitted from one source TSAP to one or more destination TSAPs in a single Transport Service access, without first establishing or later releasing a transport connection; and

b) associated with each instance of connectionless-mode transmission, certain measures of quality which are agreed between the TS provider and the sending TS user when a connectionless-mode transmission is initiated.

16 Model of the connectionless-mode Transport Service

16.1 General

This Recommendation | International Standard uses the abstract model for a Layer Service defined in ITU-T Rec. X.210 | ISO/IEC 10731. The model defines the interactions between the TS users and the TS provider which take place at the source and the destination TSAP or group of TSAPs. Information is passed between the TS user and the TS provider by service primitives, which may convey parameters.

16.2 Model of transport connectionless-mode transmission

A defining characteristic of transport connectionless-mode transmission is the independent nature of each invocation of the connectionless-mode Transport Service.

As a descriptive aid, the connectionless-mode Transport Service can be modelled in the abstract as a permanent association between the source TSAP and the destination TSAP or group of TSAPs.

Only one type of object, the unitdata object, can be passed to the service provider via a TSAP. In Figure 14a, TS user A represents the TS user which passes objects to the service provider. TS user B represents the TS user which accepts objects from the service provider.

In Figure 14b, the multicast counterpart is shown where users B, C (and others) represent the TS users which accept multicast objects from the service provider.

In general, the TS provider may perform any or all of the following actions:

a) discard objects;

b) duplicate objects; and

c) change the order of objects (any order of independent service requests may be changed into a different order of service indications).

However, with respect to a given association, some characteristics of the nature and type of service beyond those attributed to the basic connectionless-mode Transport Service may be related to the TS user.

The existence of the association does not depend on the behaviour of the TS users, but the set of actions which are performed by the TS provider on a particular association may do so. Awareness of the characteristics of the association is part of the TS users *a priori* knowledge of the OSI environment.

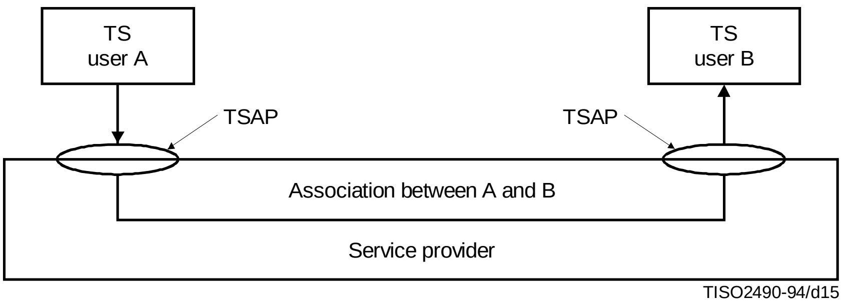


Figure 14a – Model for a connectionless-mode transmission

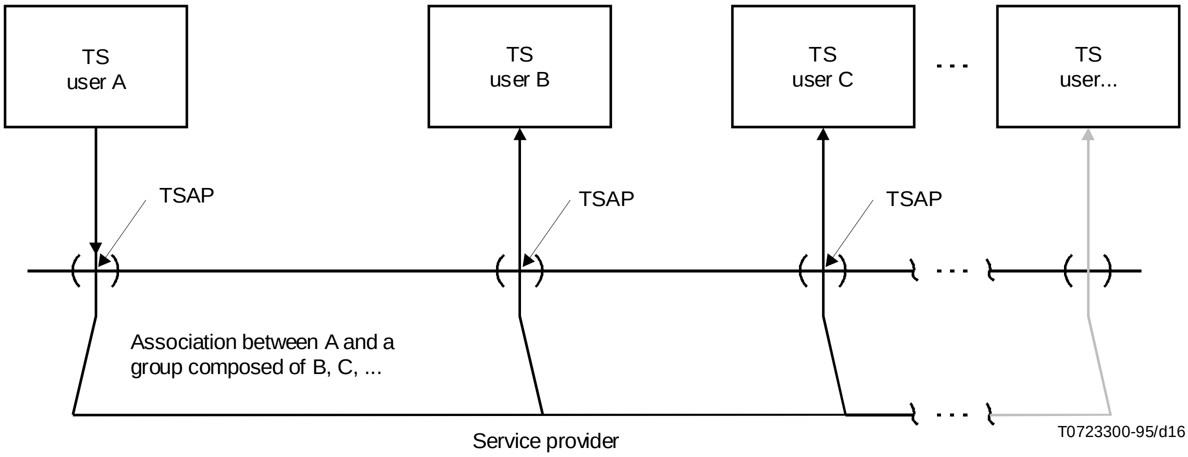


Figure 14b – Model of a multicast-connectionless-mode transmission

17 Quality of connectionless-mode Transport Service

The term "Quality of Service" (QOS) refers to certain characteristics of a connectionless-mode transmission as observed between the Transport-Service-access-points. QOS describes aspects of a connectionless-mode transmission which are attributable solely to the TS provider; QOS should be determined independently of the service user behaviour (which is beyond the control of the TS provider).

Whether the view of the QOS during each instance of use of a connectionless-mode transmission is the same to each TS user associated with the service, depends on the nature of their association and the type of information concerning the nature of the service made available to the TS user(s) by the TS provider prior to the invocation of the service.

17.1 Determination of QOS

A basic characteristic of a connectionless-mode service is that no negotiation of the Quality of Service for a transmission takes place at the time the service is accessed. Unlike a connection-mode service, no dynamic association is set up between the parties involved as occurs during a connection establishment; thus, characteristics of the service to be provided during the transfer are not negotiated. Some means are available by which the TS user is provided with knowledge of the characteristics of the service (in terms of parameters) currently available outside of any instance of the invocation of the service.

Thus, the TS user has not only knowledge of the parties with which it may communicate, but additionally has explicit knowledge of the characteristics of the service it can expect to be provided with each invocation of the service.

17.2 Definition of connectionless-mode QOS parameters

The QOS parameters identified for transport connectionless-mode transmission are defined below.

17.2.1 Transit delay

For connectionless-mode unicast transmission, transit delay is the elapsed time between a T-UNIT-DATA request and the corresponding T-UNIT-DATA indication. For connectionless-mode multicast transmission, transit delay is not defined. Transit delay is specified independently for each transport connectionless-mode transmission.

Transit delay defines the maximum value expected during the transmission of the TSDU. Its specification will be based on a TSDU size of 128 octets.

NOTE – Occurrences of local flow control are excluded in calculating transit delay values.

17.2.2 Protection

Protection QOS is the degree to which the TS provider attempts to counter security threats to the Transport Service using security services applied to the Transport, Network, Data Link or Physical layers.

The handling of protection QOS parameters is a local matter controlled according to the security policy in force.

NOTE – For further information on the provision of security in the lower layers and the handling of protection QOS, see ITU-T Rec. X.802 | ISO/IEC TR 13594.

17.2.3 Residual error probability

For connectionless-mode unicast transmission, residual error probability describes the likelihood that a particular TSDU will be lost, duplicated, or corrupted. It is estimated as the ratio of lost, duplicated or corrupted TSDUs to total TSDUs transmitted between the TS users between which the association exists during the measurement period. For connectionless-mode multicast transmission, residual error probability is not defined.

17.2.4 Priority

This parameter allows the TS user to specify the relative priority of a TSDU in relation to any other TSDUs acted upon by the TS provider. A TSDU of higher priority is serviced by the TS provider before one of lower priority. The priority information is conveyed to the receiving TS user.

This parameter specifies the relative importance of connectionless-mode transmissions with respect to:

a) the order in which TSDUs are to have their associated Quality of Service degraded, if necessary; and

b) the order in which TSDUs are to be discarded to recover resources, if necessary.

This parameter only has meaning in the context of some management entity or structure able to judge relative importance. The number of priority levels is limited.

18 Sequence of connectionless-mode primitives at one TSAP

The possible overall allowed sequences of primitives at a TSAP are defined in the state transition diagram in Figure 15.

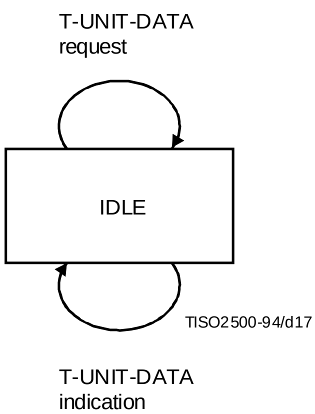


Figure 15 – State transition diagram for sequences of connectionless-mode primitives at one TSAP

19 Data transfer

19.1 Function

Transport connectionless-mode transmission service primitives can be used to transmit an independent, self-contained TSDU from one TSAP to another TSAP or to a group of TSAPs in a single TS access. The TSDU is independent in the sense that it bears no relationship to any other TSDU transmitted through the invocation of the connectionless-mode service or the connection-mode service. It is self-contained in that all of the information required to deliver the TSDU is presented to the TS provider, together with the user data to be transmitted, in a single service access; thus no initial establishment or subsequent release of a TC is required. Transport connectionless-mode transmission may only take place provided that the TS users exist and are known to the TS provider.

The TS provider transfers individual TSDUs within the range of its QOS. The TS provider does not necessarily deliver TSDUs to the receiving TS user(s) in the order in which they were presented by the sending TS user.

The TS provider is not required to maintain any state information relative to any aspect of the flow of information between specific combinations of TSAPs.

NOTE – Peer-to-peer flow control between a sending and a receiving TS user is not a feature of the connectionless-mode Transport Service. Flow control exerted by the TS provider upon the sending TS user or by the receiving TS user(s) upon the TS provider can only be described in terms of interface flow control.

19.2 Types of primitives and parameters

Table 9 indicates the types of primitives and the parameters needed for the transport connectionless-mode transmission service.

Table 9 – Transport connectionless-mode transmission service primitives and parameters

Parameter	Primitive	
	T-UNIT-DATA request	T-UNIT-DATA indication
Source address	X	X(=)
Destination address	X	X(=)
Quality of Service	X	X
TS user data	X	X(=)

X Mandatory parameter.
(=) The value of the parameter is identical to the value of the corresponding parameter of the preceding TS primitive.

19.2.1 Addresses

The addresses referred to in Table 9 are all TSAP addresses with the exception of the destination address for the multicast connectionless-mode case where the address refers to a group Transport address. The connection-mode and connectionless-mode Transport Services both use the same TSAP addressing scheme as described here and in 12.2.1 through 12.2.3 and are unique within the scope of TSAP addresses..

For multicast transfer, the destination address must be a group Transport address.

19.2.2 Quality of Service

The value of the QOS parameter is a list of subparameters.

The definition of the subparameters related to the quality of the connectionless-mode Transport Service is found in clause 17.

19.2.3 TS user data

This parameter allows the transmission of a TSDU between TS users. The TS user may transmit any integral number of octets greater than zero up to a limit of 63 488 octets.

NOTE – This value is an amount which is 1 K less than the maximum size allowed for a connectionless-mode NSDU.

19.3 Sequence of primitives

The sequence of primitives in a successful non-multicast transport connectionless-mode transmission is defined in the transport service time sequence diagram in Figure 16a. The sequence of primitives in a successful multicast transport connectionless-mode transmission is defined in the transport service multicast primitive time sequence diagram in Figure 16b. The T-UNIT-DATA indications for the multicast transmission case arrive in an arbitrary order that is not simultaneous and in addition there is no deterministic ordering of T-UNIT-DATA indications arriving at any particular receiving TSAP resulting from separate T-UNIT-DATA requests.

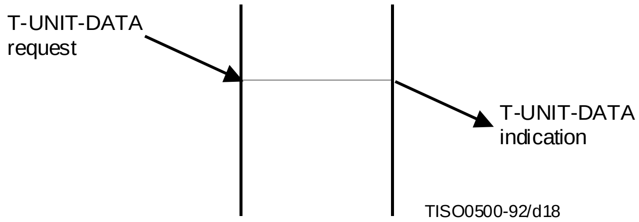


Figure 16a – Sequence of primitives in a successful non-multicast transport connectionless-mode data transfer

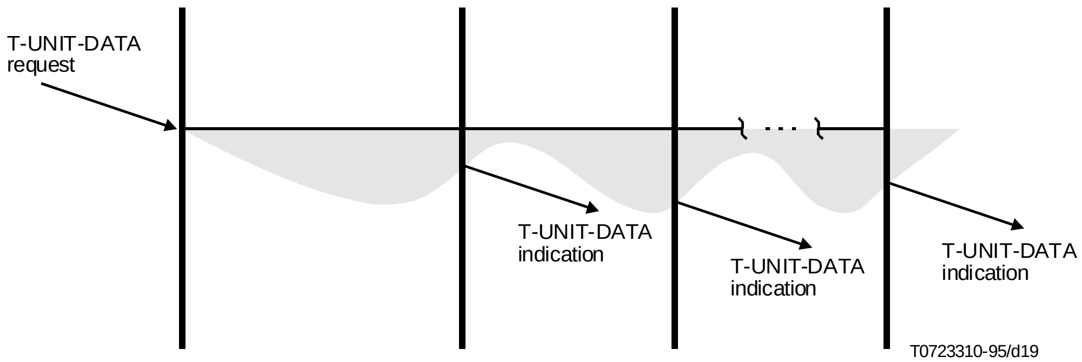


Figure 16b – Sequence of primitives in a successful multicast transport connectionless-mode transmission