INTERNATIONAL STANDARD

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

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

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Foreword

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

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

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

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

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

Introduction

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

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

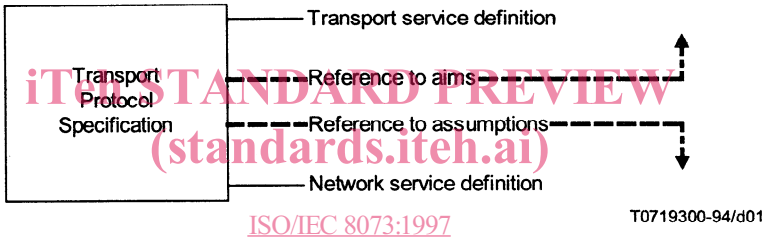

Figure Intro. 1 – Relationship between the Transport Protocol and adjacent services

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

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

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

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

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

a) different throughput;

b) different error rates;

c) integrity of data requirements;

d) reliability requirements.

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

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

a) as a guide for implementors and designers;

b) for use in the testing and procurement of equipment;

c) as part of an agreement for the admittance of systems into the open systems environment;

d) as a refinement of the understanding of OSI.

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

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

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

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

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INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

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

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

1 Scope

This Recommendation | International Standard specifies:

a) five classes of procedures when operating over the connection-mode network service:

   1) class 0: simple class;

   2) class 1: basic error recovery class;

   3) class 2: multiplexing class;

   4) class 3: error recovery and multiplexing class;

   5) class 4: error detection and recovery class;

   for the connection-mode transfer of data and control information from one transport entity to a peer transport entity;

b) one class (class 4) of procedure when operating over the connectionless-mode network service;

c) the means of negotiating the class of procedures to be used by the transport entities;

d) the structure and encoding of the transport protocol data units used for the transfer of data and control information.

The procedures are defined in terms of:

i) the interactions between peer transport entities through the exchange of transport protocol data units;

ii) the interactions between a transport entity and the transport service user in the same system through the exchange of transport service primitives;

iii) the interactions between a transport entity and the network service provider through the exchange of network service primitives.

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

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

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

2 References

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

2.1 Identical Recommendations | International Standards

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

2.2 Paired Recommendations | International Standards equivalent in technical content

- CCITT Recommendation X.200 (1988), *Reference model of Open Systems Interconnection for CCITT applications.*

  ISO 7498:1984, *Information processing systems – Open Systems Interconnection – Basic Reference Model.*
- ITU-T Recommendation X.264 (1993), *Transport protocol identification mechanism.*

  ISO/IEC 11570:1992, *Information technology – Telecommunications and information exchange between systems – Open Systems Interconnection – Transport protocol identification mechanism.*
- CCITT Recommendation X.290 (1992), *OSI Conformance testing methodology and framework for protocol Recommendations for CCITT applications – General concepts.*

  ISO/IEC 9646-1:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 1: General concepts.*
- CCITT Recommendation X.291 (1992), *OSI conformance testing methodology and framework for protocol Recommendations for CCITT applications – Abstract test suite specification.*

  ISO/IEC 9646-2:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 2: Abstract Test Suite specification.*
- CCITT Recommendation X.650 (1992), *Open Systems Interconnections (OSI) – Reference Model for naming and addressing.*

  ISO 7498-3:1989, *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 3: Naming and addressing.*

3 Definitions

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

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

a) concatenation and separation;

b) segmenting and reassembling;

c) multiplexing and demultiplexing;

d) splitting and recombining;

e) flow control;

f) connectionless-mode transmission;

g) transport selector;

h) nil selector value.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.2.18 sequence number:

a) the number in the TPDU-NR field of a DT-TPDU that indicates the order in which the DT-TPDU was transmitted by a transport entity;

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

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

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

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

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

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

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

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

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

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

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

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

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

a) connection-mode network service;

b) connectionless-mode network service.

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

a) PICS proforma;

b) Protocol Implementation Conformance Statement (PICS).

4 Abbreviations

4.1 Data units

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

4.2 Types of Transport Protocol data units

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

4.3 TPDU fields

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

4.4 Times and associated variables

T1	Local Retransmission Time
N	The Maximum Number of Transmissions
L	Time Bound on Reference and Sequence Number
I	Inactivity Time

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

4.5 Miscellaneous

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

5 Overview of the Transport Protocol

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

5.1 Service provided by the Transport Layer

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

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

5.2 Service assumed from the Network Layer

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

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

NOTES

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

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

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

Table 1 – Transport service primitives

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

5.3 Functions of the Transport Layer

5.3.1 Overview of functions

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

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

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

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

a) encryption;

b) accounting mechanisms;

c) status exchanges and monitoring of QOS;

d) blocking;

e) temporary release of network connections;

f) alternative checksum algorithm.

5.3.1.1 Functions used at all times

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

a) *Transmission of TPDUs* (see 6.2 and 6.9).

b) *Multiplexing and demultiplexing* (see 6.15) – A function used only when operating over CONS to share a single network connection between two or more transport connections.

c) *Error detections* (see 6.10, 6.13 and 6.17) – A function used to detect the loss, corruption, duplication, misordering, or misdelivery of TPDUs.

d) *Error recovery* (see 6.12, 6.14, 6.18, 6.19, 6.20, 6.21, and 6.22) – A function used to recover from detected and signalled errors.

Table 2a) – Connection-mode network service primitives

Primitives		X/Y	Parameters	W/X/Y/Z
N-CONNECT	request	X	Called address	X
			Calling address	X
	indication	X	Receipt confirmation selection	Y
			Expedited data selection	Y
			QOS parameter set	X
			NS-user-data	Z
N-CONNECT	response	X	Responding address	X
	confirm	X	Receipt confirmation selection	Y
			Expedited data selection	Y
			QOS parameter set	X
			NS-user-data	Z
N-DATA	request	X	N-user-data	X
	indication	X	Confirmation request	Y
N-DATA ACKNOWLEDGE				
	request	Y		
	indication	Y		
N-EXPEDITED DATA	request	Y	N-user-data	Y
	indication	Y		
N-RESET	request	X	Reason	W
	indication	X	Originator	W
			Reason	W
N-RESET	response	X	–	
	confirm	X	–	
N-DISCONNECT	request	X	Reason	W
			NS-user-data	Z
			Responding address	Z
	indication	X	Originator	W
			Reason	W
			NS-user-data	Z
			Responding address	Z

W The usage of this parameter is a local matter, e.g. for diagnostic or to decide whether to attempt resynchronization.

X The Transport Protocol assumes that this facility is provided in all networks.

Y The Transport Protocol assumes that this facility is provided in some networks and a mechanism is provided to optionally use the facility.

Z The Transport Protocol does not use this parameter.

Table 2b) – Connectionless-mode network service primitives

Primitives		X/Y	Parameters	W/X/Y/Z
N-UNIT-DATA	request	X	Source address	X
			Destination address	X
			Quality of service	X
			NS-user-data	X
	indication	X	Source address	X
			Destination address	X
			Quality of service	X
			NS-user-data	X

W The usage of this parameter is a local matter, e.g. for diagnostic or to decide whether to attempt resynchronization.

X The Transport Protocol assumes that this facility is provided in all networks.

Y The Transport Protocol assumes that this facility is provided in some networks and a mechanism is provided to optionally use the facility.

Z The Transport Protocol does not use this parameter.