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Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model

Technologies de l'information — Modèle de référence de base pour l'interconnexion de systèmes ouverts (OSI): Le modèle de base

Reference number
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Contents

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 7498-1 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.200.

This second edition, along with parts 2, 3 and 4, cancels and replaces the first edition (ISO 7498:1984), which has been technically revised.

ISO/IEC 7498 consists of the following parts, under the general title *Information technology — Open Systems Interconnection — Basic Reference Model*:

- *Part 1: The Basic Model*
- *Part 2: Security Architecture*
- *Part 3: Naming and addressing*
- *Part 4: Management framework*

Annex B forms an integral part of this part of ISO/IEC 7498. Annex A is for information only.

Introduction

This reference model provides a common basis for the coordination of standards development for the purpose of systems interconnection, while allowing existing standards to be placed into perspective within the overall reference model. It also identifies areas for developing and improving standards and provides a common reference for maintaining consistency among all related standards. The text was developed jointly with ITU-T and the main intent of this revision is to introduce the joint text, which incorporates inclusion of the concept of connectionless transmission, in addition to a number of technical and editorial refinements.

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INTERNATIONAL STANDARD

CCITT RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – BASIC REFERENCE MODEL: THE BASIC MODEL

1 Scope

1.1 The purpose of this Reference Model of Open Systems Interconnection is to provide a common basis for the coordination of standards development for the purpose of systems interconnection, while allowing existing standards to be placed into perspective within the overall Reference Model.

1.2 The term Open Systems Interconnection (OSI) qualifies standards for the exchange of information among systems that are "open" to one another for this purpose by virtue of their mutual use of the applicable standards.

1.3 The fact that a system is open does not imply any particular systems implementation, technology or means of interconnection, but refers to the mutual recognition and support of the applicable standards.

1.4 It is also the purpose of this Reference Model to identify areas for developing or improving standards, and to provide a common reference for maintaining consistency of all related standards. It is not the intent of this Reference Model either to serve as an implementation specification, or to be a basis for appraising the conformance of actual implementations, or to provide a sufficient level of detail to define precisely the services and protocols of the interconnection architecture. Rather, this Reference Model provides a conceptual and functional framework which allows international teams of experts to work productively and independently on the development of standards for each layer of the Reference Model for OSI.

1.5 The Reference Model has sufficient flexibility to accommodate advances in technology and expansion in user demands. This flexibility is also intended to allow the phased transition from existing implementations to OSI standards.

1.6 While the scope of the general architectural principles required for OSI is very broad, this Reference Model is primarily concerned with systems comprising terminals, computers, and associated devices and the means for transferring information between such systems. Other aspects of OSI requiring attention are described briefly (see 4.2).

1.7 The description of the Basic Reference Model of OSI is developed in stages:

1.8 Clause 4 establishes the reasons for Open Systems Interconnection, defines what is being connected, the scope of the interconnection, and describes the modelling principles used in OSI.

1.9 Clause 5 describes the general nature of the architecture of the Reference Model; namely that it is layered, what layering means, and the principles used to describe layers.

1.10 Clause 6 names, and introduces the specific layers of the architecture.

1.11 Clause 7 provides the description of the specific layers.

1.12 Clause 8 provides the description of Management Aspects of OSI.

1.13 Clause 9 specifies compliance and consistency with the OSI Reference Model.

1.14 An indication of how the layers were chosen is given in Annex A to this Basic Reference Model.

1.15 Additional aspects of this Reference Model beyond the basic aspects are described in several parts. The first part describes the Basic Reference Model. The second part describes the architecture for OSI Security. The third part describes OSI Naming and Addressing. The fourth describes OSI System Management.

1.16 The Basic Reference Model serves as a framework for the definition of services and protocols which fit within the boundaries established by the Reference Model.

1.17 In those few cases where a feature is explicitly marked (optional) in the Basic Reference Model it should remain optional in the corresponding service or protocol (even if at a given instant the two cases of the option are not yet documented).

1.18 This Reference Model does not specify services and protocols for OSI. It is neither an implementation specification for systems, nor a basis for appraising the conformance of implementations.

1.19 For standards which meet the OSI requirements, a small number of practical subsets are defined from optional functions, to facilitate implementation and compatibility.

2 Definitions

Definitions of terms are included at the beginning of individual clauses and sub-clauses. An index of these terms is provided in Annex B for easy reference.

3 Notation

3.1 Layers are introduced in clause 5. An (N)-, (N+1)- and (N–1)- notation is used to identify and relate adjacent layers:

(N)-layer: any specific layer;

(N+1)-layer: the next higher layer;

(N–1)-layer: the next lower layer.

This notation is also used for other concepts in the model which are related to these layers, for example (N)-protocol, (N+1)-service.

3.2 Clause 6 introduces names for individual layers. When referring to these layers by name, the (N)-, (N+1)- and (N–1)- prefixes are replaced by the names of the layers, for example transport-protocol, session-entity, and network-service.

4 Introduction to Open Systems Interconnection (OSI)

NOTE – The general principles described in clauses 4 and 5 hold for all layers of the Reference Model, unless layer specific statements to the contrary are made in clauses 6 and 7.

4.1 Definitions

4.1.1 **real system:** A set of one or more computers, the associated software, peripherals, terminals, human operators, physical processes, information transfer means, etc., that forms an autonomous whole capable of performing information processing and/or information transfer.

4.1.2 **real open system:** A real system which complies with the requirements of OSI standards in its communication with other real systems.

4.1.3 **open system:** The representation within the Reference Model of those aspects of a real open system that are pertinent to OSI.

4.1.4 **application process:** An element within a real open system which performs the information processing for a particular application.

4.1.5 **Open System Interconnection Environment (OSIE):** An abstract representation of the set of concepts, elements, functions, services, protocols, etc., as defined by the OSI Reference Model and the derived specific standards which, when applied, enable communications among open systems.

4.1.6 **Local System Environment (LSE):** An abstract representation of that part of the real system that is not pertinent to OSI.

NOTE – The LSE may include functions necessary for non-OSI communication.

4.1.7 **application-process-invocation:** A specific utilization of part or all of the capabilities of a given application process in support of a specific occasion of information processing.

4.1.8 **application-process-type:** A description of a class of application processes in terms of a set of information processing capabilities.

4.2 Open System Interconnection Environment

4.2.1 In the concept of OSI, a real system is a set of one or more computers, associated software, peripherals, terminals, human operators, physical processes, information transfer means, etc., that forms an autonomous whole capable of performing information processing and/or information transfer.

4.2.2 An application process is an element within a real open system which performs the information processing for a particular application.

4.2.3 Application processes can represent manual processes, computerized processes or physical processes.

4.2.4 Some examples of application processes that are applicable to this open system definition are the following:

a) a person operating a banking terminal is a manual application-process;

b) a FORTRAN program executing in a computer center and accessing a remote database is a computerized application-process; the remote database management systems server is also an application-process; and

c) a process control program executing in a dedicated computer attached to some industrial equipment and linked into a plant control system is a physical application-process.

4.2.5 An application process represents a set of resources, including processing resources, within a real open system that may be used to perform a particular information processing activity. An application process may organize its interactions with other application processes in whatever way is necessary to achieve a particular information processing goal: no constraints are imposed by this Reference Model either on the form of these interactions or on the possible relationships that may exist between them.

4.2.6 The activity of a given application process is represented by one or more application process invocations. Cooperation between application processes takes place via relationships established among application process invocations. At a particular time, an application process may be represented by none, one or more application process invocations. An application process invocation is responsible for coordinating its interactions with other application process invocations. Such coordination is outside the scope of this Reference Model.

4.2.7 OSI is concerned with the exchange of information between open systems (and not the internal functioning of each individual real open system).

4.2.8 As shown in Figure 1, the physical media for Open Systems Interconnection provides the means for the transfer of information between open systems.

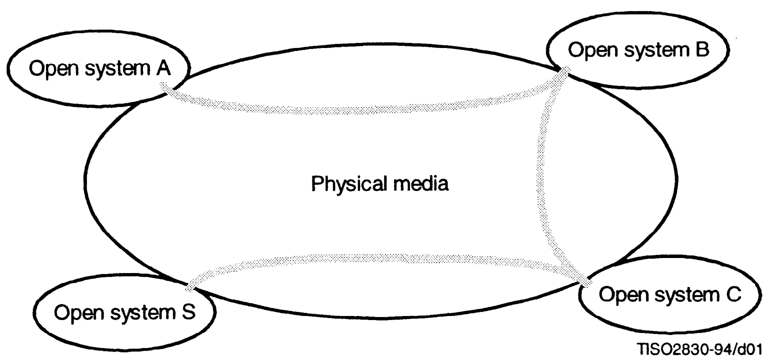

Figure 1 – Open systems connected by physical media

4.2.9 OSI is concerned only with the interconnection of systems. All other aspects of systems which are not related to interconnection are outside the scope of OSI.

4.2.10 OSI is concerned not only with the transfer of information between systems, i.e. transmission, but also with their capability to interwork to achieve a common (distributed) task. In other words, OSI is concerned with the interconnection aspects of cooperation[1)] between systems, which is implied by the expression "systems interconnection."

4.2.11 The objective of OSI is to define a set of standards to enable real open systems to cooperate. A system which complies with the requirements of applicable OSI standards in its cooperation with other systems is termed a real open system.

4.2.12 The design intent of the OSI standards is to specify a set of standards that make it possible for autonomous systems to communicate. Any equipment which communicates in conformance with all applicable OSI protocol standards is a real world equivalent of the model concept "open system". Equipment that is in the "terminal" category, that is, one that requires human intervention for the dominant parts of information processing, may satisfy the conditions of the previous sentences when the appropriate OSI standards are employed in communication with other open systems.

4.3 Modelling the OSI Environment

4.3.1 The development of OSI standards, i.e. standards for the interconnection of real open systems, is assisted by the use of abstract models. To specify the external behavior of interconnected real open systems, each real open system is replaced by a functionally equivalent abstract model of a real open system called an open system. Only the interconnection aspects of these open systems would strictly need to be described. However to accomplish this, it is necessary to describe both the internal and external behavior of these open systems. Only the external behavior of open systems is retained for the definition of standards for real open systems. The description of the internal behavior of open systems is provided in the Basic Reference Model only to support the definition of the interconnection aspects. Any real system which behaves externally as an open system can be considered to be a real open system.

4.3.2 This abstract modelling is used in two steps.

4.3.3 First, basic elements of open systems and some key decisions concerning their organization and functioning, are developed. This constitutes the Basic Reference Model of Open Systems Interconnection described in this Recommendation | Part of this International Standard.

4.3.4 Then, the detailed and precise description of the functioning of the open system is developed in the framework formed by the Basic Reference Model. This constitutes the services and protocols for OSI which are the subject of other Recommendations and/or International Standards.

4.3.5 It should be emphasized that the Basic Reference Model does not, by itself, specify the detailed and precise functioning of the open system and, therefore, it does not specify the external behavior of real open systems and does not imply the structure of the implementation of a real open system.

4.3.6 The reader not familiar with the technique of abstract modelling is cautioned that those concepts introduced in the description of open systems constitute an abstraction despite a similiar appearance to concepts commonly found in real systems. Therefore, real open systems need not be implemented as described by the Model.

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1) Cooperation among open systems involves a broad range of activities of which the following have been identified:

a) interprocess communication, which concerns the exchange of information and the synchronization of activity between OSI application processes;

b) data representation, which concerns all aspects of the creation and maintenance of data descriptions and data transformations for reformatting data exchanged between open systems;

c) data storage, which concerns storage media, and file and database systems for managing and providing access to data stored on the media;

d) process and resource management, which concerns the means by which OSI application processes are declared, initiated and controlled, and the means by which they acquire OSI resources;

e) integrity and security, which concern information processing constraints that have to be preserved or assured during the operation of the open systems; and

f) program support, which concerns the definition, compilation, linking, testing, storage, transfer, and access to the programs executed by OSI application-processes.

Some of these activities may imply exchange of information between the interconnected open systems and their interconnection aspects may, therefore, be of concern to OSI.

This Basic Reference Model covers the elements of OSI aspects of these activities which are essential for early development of OSI standards.

4.3.7 Throughout the remainder of this Basic Reference Model, only the aspects of real systems and application-processes which lie within the OSI Environment (OSIE) are considered. Their interconnection is illustrated throughout this Reference Model as depicted in Figure 2.

4.3.8 The extent of the application of the OSIE concept through the use of OSI standards may result in subsets of the OSIE which corresponds to partially disjoint sets of real open systems, which are not physically capable of OSI communication between them.

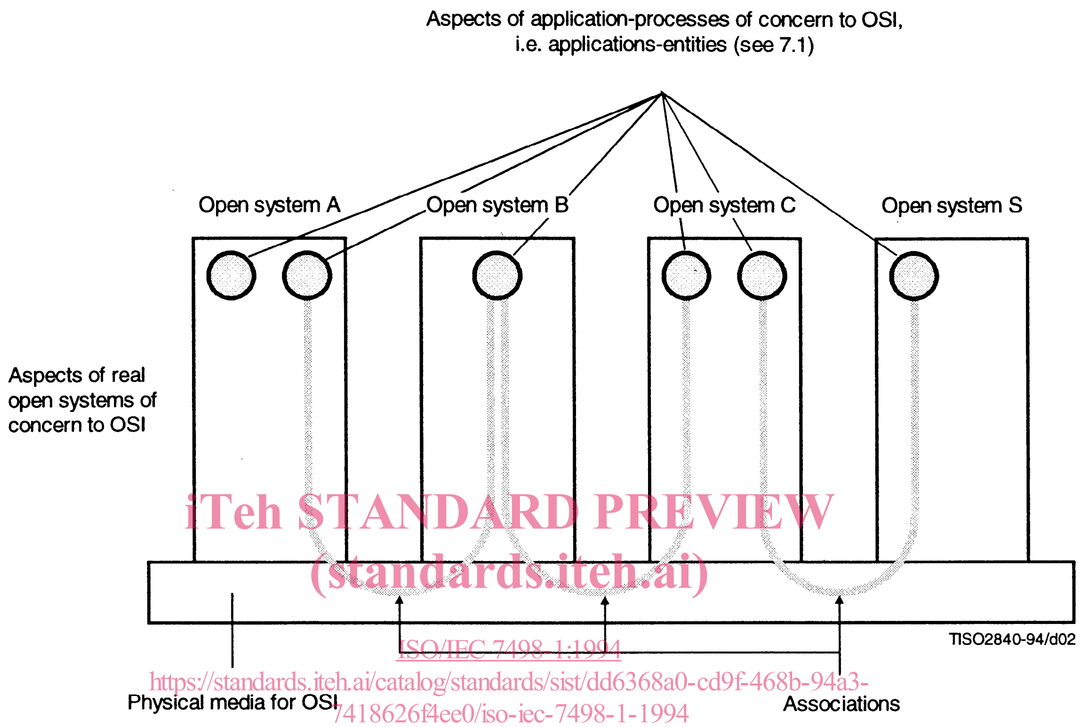

Figure 2 – Basic elements of OSI

5 Concepts of a layered architecture

5.1 Introduction

5.1.1 Clause 5 sets forth the architectural concepts that are applied in the development of the Reference Model of Open Systems Interconnection. Firstly, the concept of a layered architecture (with layers, entities, service-access-points, protocols, connections, etc.) is described. Secondly, identifiers are introduced for entities, service-access-points, and connections. Thirdly, service-access-points and data-units are described. Fourthly, elements of layer operation are described including connections, transmission of data, and error functions. Then, routing aspects are introduced and finally, management aspects are discussed.

5.1.2 The concepts described in clause 5 are those required to describe the Reference Model of Open Systems Interconnection. However, not all of the concepts described are employed in each layer of the Reference Model.

5.1.3 Four elements are basic to the Reference Model (see Figure 2):

a) open systems;

b) the application-entities which exist within the OSI Environment (see 7.1);

c) the associations (see 5.3) which join the application-entities and permit them to exchange information; and

d) the physical media for OSI.

NOTE – Security aspects which are also general architectural elements of protocols are discussed in CCITT Rec. X.800 | ISO 7498-2.

5.2 Principles of layering

5.2.1 Definitions

5.2.1.1 (N)-subsystem: An element in a hierarchical division of an open system which interacts directly only with elements in the next higher division or the next lower division of that open system.

5.2.1.2 (N)-layer: A subdivision of the OSI architecture, constituted by subsystems of the same rank (N).

5.2.1.3 peer-(N)-entities: Entities within the same (N)-layer.

5.2.1.4 sublayer: A subdivision of a layer.

5.2.1.5 (N)-service: A capability of the (N)-layer and the layers beneath it, which is provided to (N+1)-entities at the boundary between the (N)-layer and the (N+1)-layer.

5.2.1.6 (N)-facility: A part of an (N)-service.

5.2.1.7 (N)-function: A part of the activity of (N)-entities.

5.2.1.8 (N)-service-access-point, (N)-SAP: The point at which (N)-services are provided by an (N)-entity to an (N+1)-entity.

5.2.1.9 (N)-protocol: A set of rules and formats (semantic and syntactic) which determines the communication behavior of (N)-entities in the performance of (N)-functions.

5.2.1.10 (N)-entity-type: A description of a class of (N)-entities in terms of a set of capabilities defined for the (N)-layer.

5.2.1.11 (N)-entity: An active element within an (N)-subsystem embodying a set of capabilities defined for the (N)-layer that corresponds to a specific (N)-entity-type (without any extra capabilities being used).

5.2.1.12 (N)-entity-invocation: A specific utilization of part or all of the capabilities of a given (N)-entity (without any extra capabilities being used).

5.2.2 Description

5.2.2.1 The basic structuring technique in the Reference Model of Open Systems Interconnection is layering. According to this technique, each open system is viewed as logically composed of an ordered set of (N)-subsystems, represented for convenience in the vertical sequence shown in Figure 3. Adjacent (N)-subsystems communicate through their common boundary. (N)-subsystems of the same rank (N) collectively form the (N)-layer of the Reference Model of Open Systems Interconnection. There is one and only one (N)-subsystem in an open system for layer N. An (N)-subsystem consists of one or several (N)-entities. Entities exist in each (N)-layer. Entities in the same (N)-layer are termed peer-(N)-entities. Note that the highest layer does not have an (N+1)-layer above it and the lowest layer does not have an (N–1)-layer below it.

5.2.2.2 Not all peer-(N)-entities need or even can communicate. There may be conditions which prevent this communication (for example: they are not in interconnected open systems, or they do not support the same protocol subsets). Communication among peer-(N)-entities which reside in the same (N)-subsystem is provided by the LSE and therefore is out of the scope of OSI.

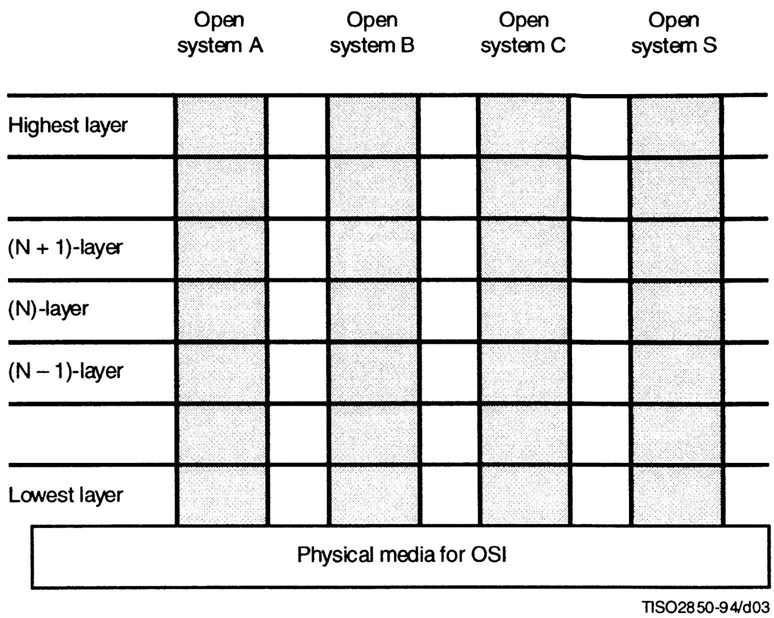

Figure 3 – Layering in cooperating open systems

NOTES

1 The distinction between the type of some object and an instance of that object is a distinction of significance for OSI. A type is a description of a class of objects. An instance of this type is any object that conforms to this description. The instances of the same type constitute a class. A type, and any instances of this type can be referred to by an individual name. Each nameable instance and the type to which this instance belongs carry distinguishable names.

For example, given that a programmer has written a computer program, that programmer has generated a type of something where instances of that type are created every time that particular program is invoked into execution by a computer. Thus, a FORTRAN compiler is a type and each occasion where a copy of that program is invoked in a data processing machine one displays an instance of that program.

The general concept of instantiation applies within OSI: Consider now an (N)-entity in the OSI context. It too, has two aspects, a type and a collection of invocations. The type of an (N)-entity is defined by description of the specific set of (N)-layer functions it is able to perform. An invocation of that type of (N)-entity is a specific invocation of whatever it is within the relevant open system that provides the (N)-layer functions called for by its type for a particular occasion of communication. It follows from these observations that (N)-entities refer only to the properties of an association between peer (N)-entities, while an (N)-entity-invocation refers to the specific, dynamic occasions of actual information exchange.

It is important to note that actual communication occurs only between (N)-entity-invocations at all layers. In the connection-mode (see 5.3.3), it is only at connection establishment time (or its logical equivalent during a recovery process) that (N)-entities are explicitly relevant. An actual connection is always made with a specific (N)-entity-invocation, although the request for connection is often made to an arbitrary (N)-entity (of a specific type). If an (N)-entity-invocation is aware of the name of its peer-(N)-entity-invocation, it is able to request another connection to that (N)-entity-invocation.

2 It may be necessary to further divide a layer into small substructures called sublayers and to extend the technique of layering to cover other dimensions of OSI. A sublayer is defined as a grouping of functions in a layer which may be bypassed. The bypassing of all the sublayers of a layer is not allowed. A sublayer uses the entities and communication services of the layer. The detailed definition or additional characteristics of a sublayer are for further study.

5.2.2.3 Except for the highest layer, each (N)-layer provides (N+1)-entities in the (N+1)-layer with an (N)-service at (N)-SAP(s). The properties of (N)-SAPs are described in 5.5. The highest layer is assumed to represent all possible uses of the (N)-service which are provided by the lower layers.

NOTE – Not all open systems provide the initial source or final destination of data. Such open systems need not contain the higher layers of the architecture (see Figure 12).

5.2.2.4 Each service provided by an (N)-layer may be tailored by the selection of one or more (N)-facilities which determine the attributes of that service. When a single (N)-entity cannot by itself fully support a service requested by an (N+1)-entity it calls upon the co-operation of other (N)-entities to help complete the service request. In order to co-operate, (N)-entities in any layer, other than those in the lowest layer, communicate by means of the set of services provided by the (N–1)-layer (see Figure 4). The entities in the lowest layer are assumed to communicate directly via the physical media which connect them.

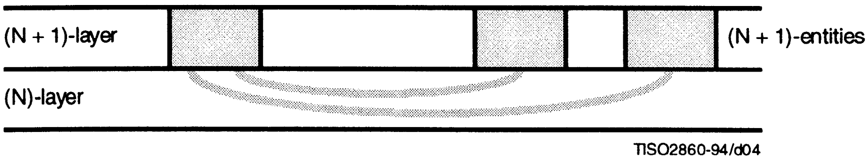

Figure 4 – (N + 1)-entities in the (N + 1)-layer communicate through the (N)-layer

5.2.2.5 The services of an (N)-layer are provided to the (N+1)-layer using the (N)-functions performed within the (N)-layer and as necessary the services available from the (N–1)-layer.

NOTE – This does not preclude the case where no protocol action is required in the (N)-layer to support a given (N)-facility because it is already available at the (N–1)-service boundary. However, null functionality of the complete (N)-protocol is not allowed.

5.2.2.6 An (N)-entity may provide services to one or more (N+1)-entities and use the services of one or more (N–1)-entities. An (N)-service-access-point is the point at which a pair of entities in adjacent layers use or provide services (see Figure 7).

5.2.2.7 Cooperation between (N)-entities is governed by one or more (N)-protocols. The entities and protocols within a layer are illustrated in Figure 5.

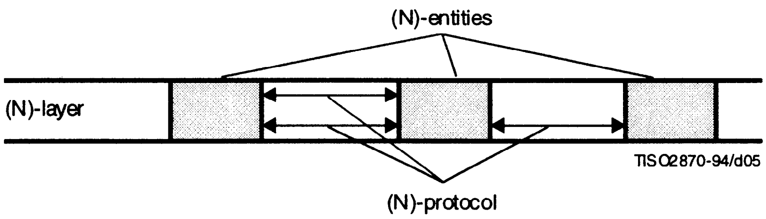

Figure 5 – (N)-protocols between (N)-entities

5.3 Communication between peer-entities

5.3.1 Definitions

5.3.1.1 (N)-association: A cooperative relationship among (N)-entity-invocations.

5.3.1.2 (N)-connection: An association requested by an (N+1)-entity for the transfer of data betweeen two or more (N+1)-entities. The association is established by the (N)-layer and provides explicit identification of a set of (N)-data-transmissions and agreement concerning the (N)-data-transmission services to be provided for the set.

5.3.1.3 (N)-connection-endpoint: A terminator at one end of an (N)-connection within an (N)-service-access-point.

5.3.1.4 multi-endpoint-connection: A connection with more than two connection-endpoints.

5.3.1.5 correspondent (N)-entities: (N)-entities with an (N–1)-connection between them.

5.3.1.6 (N)-relay: An (N)-function by means of which an (N)-entity forwards data received from one peer-(N)-entity to another peer-(N)-entity.

5.3.1.7 (N)-data-source: An (N)-entity that sends (N–1)-service-data-units (see 5.6.1.7) on an (N–1)-connection.[2)]

5.3.1.8 (N)-data-sink: An (N)-entity that receives (N–1)-service-data-units on an (N–1)-connnection[2)]

5.3.1.9 (N)-data-transmission: An (N)-facility which conveys (N)-service-data-units from one (N+1)-entity to one or more (N+1)-entities.

5.3.1.10 (N)-duplex-transmission: (N)-data-transmission in both directions at the same time.[2)]

5.3.1.11 (N)-half-duplex-transmission: (N)-data-transmission in either direction, one direction at a time; the choice of direction is controlled by an (N+1)-entity.[2)]

5.3.1.12 (N)-simplex-transmission: (N)-data-transmission in one pre-assigned direction.[2)]

5.3.1.13 (N)-data-communication: An (N)-function which transfers (N)-protocol-data-units (see 5.6.1.3) according to an (N)-protocol, over one or more (N–1)-connections.[2)]

5.3.1.14 (N)-two-way-simultaneous-communication: (N)-data-communication in both directions at the same time.

5.3.1.15 (N)-two-way-alternate-communication: (N)-data-communication in both directions, one direction at a time.

5.3.1.16 (N)-one-way-communication: (N)-data-communication in one pre-assigned direction.

5.3.1.17 (N)-connection-mode transmission: (N)-data-transmission in the context of an (N)-connection.

5.3.1.18 (N)-connectionless-mode transmission: (N)-data-transmission not in the context of an (N)-connection and not required to maintain any logical relationship between (N)-service-data-units.

5.3.2 Description

5.3.2.1 For information to be exchanged between two or more (N+1)-entities, an association is established between them in the (N)-layer using an (N)-protocol.

NOTE – Classes of protocols may be defined within the (N)-protocols.

5.3.2.2 The rules and formats of an (N)-protocol are instantiated in an (N)-subsystem by an (N)-entity. An (N)-entity may support one or more (N)-protocols. (N)-entities may support (N)-protocols which are connection-mode or connectionless-mode or both. (N)-entities when supporting connection-mode maintain the binding of (N)-connections to the appropriate (N+1)-entities at the appropriate (N)-SAPs. (N)-entities when supporting connectionless-mode maintain a binding with the appropriate (N)-SAPs for delivering the connectionless data to the (N+1)-entities.

5.3.2.3 (N+1)-entities can communicate only by using the services of the (N)-layer. There are instances where services provided by the (N)-layer do not permit direct access between all of the (N+1)-entities which have to communicate. If this is the case communication can still occur if some other (N+1)-entities can act as relays between them (see Figure 6).

[2)] These definitions are not for use in this Basic Reference Model, but are for use in other OSI standards.