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Information processing systems — Open Systems Interconnection — Basic Reference Model

Systèmes de traitement de l'information — Interconnexion de systèmes ouverts — Modèle de Référence de base

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International Standard ISO 7498 was prepared by Technical Committee ISO/TC 97, *Information processing systems*.

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NOTE — Possible questions arising using International Standard ISO 7498 should be directed to subcommittee ISO/TC 97/SC 21 — Information Processing Systems — Information Retrieval, Transfer and Management for Open Systems Interconnection — through its Secretariat (ANSI). Subcommittee ISO/TC 97/SC 21 handles such questions and maintains a register of answers to questions of general interest.

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Contents

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Annexes

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Information processing systems — Open Systems Interconnection — Basic Reference Model

0 Introduction

0.1 About this standard

The purpose of this International Standard 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.

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.

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.

It is also the purpose of this International Standard 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 International Standard 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 International Standard 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 of OSI.

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.

NOTE — The Reference Model is expected to be subject to future expansion. Some anticipated directions of expansion are indicated by notes or footnotes in this International Standard.

While the scope of the general architectural principles required for OSI is very broad, this International Standard 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).

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The justification for development of standards shall follow normal administrative procedures even though such standards are identified in the Reference Model.

As standards emerge to meet the OSI requirements, a small number of practical subsets should be defined by the standards developers from optional functions, to facilitate implementation and compatibility.

The description of the Reference Model of OSI given in this International Standard is developed in stages :

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;

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;

Clause 6 names, and introduces the specific layers of the architecture; and

Clause 7 provides the description of the specific layers.

An indication of how the layers were chosen is given in annex A to this International Standard.

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

In those few cases where a feature is explicitly marked (optional) in the 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).

0.2 Related OSI standards

Concurrently with the preparation of this International Standard, work is in progress within ISO on the development of OSI standards in the following areas :

a) virtual terminal protocols;

b) file transfer, access and management protocols;

c) job transfer and manipulation protocols;

d) common application services and protocols;

e) presentation layer services and protocols;

f) Session Layer services and protocols;

g) Transport Layer services and protocols;

h) Network Layer services and protocols;

j) Data Link Layer services and protocols;

k) Physical Layer services and protocols; and

m) OSI management protocols.

The first five items in this list relate to the Application and Presentation Layers of the Reference Model.

In addition, liaison is maintained with CCITT in the development of OSI standards.

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1 Scope and field of application

This International Standard describes the Reference Model of Open Systems Interconnection. It establishes a framework for coordinating the development of existing and future standards for the interconnection of systems and is provided for reference by those standards.

This International Standard 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.

2 Definitions

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

3 Notation

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.

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.

4.2 Open Systems Interconnection environment

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.

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

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

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 centre and accessing a remote database is a computerised 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.

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

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

NOTE — At this point, only telecommunications media have been considered. The use of other interconnection media is for further study.

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

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".

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.

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Figure 1 — Open systems connected by physical media

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 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 International Standard covers the elements of OSI aspects of these activities which are essential for early development of OSI standards.

4.3 Modelling the OSI environment

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 behaviour 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 behaviour of these open systems. Only the external behaviour of open systems is retained as the standard of behaviour of real open systems. The description of the internal behaviour of open systems is provided in the 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.

This abstract modelling is used in two steps.

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

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

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

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 similar appearance to concepts commonly found in real systems. Therefore real open systems need not be implemented as described by the Model.

Throughout the remainder of this International Standard, only the aspects of real systems and application-processes which lie within the OSI environment are considered. Their interconnection is illustrated throughout this International Standard as depicted in figure 2.

5 Concepts of a layered architecture

5.1 Introduction

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.

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.

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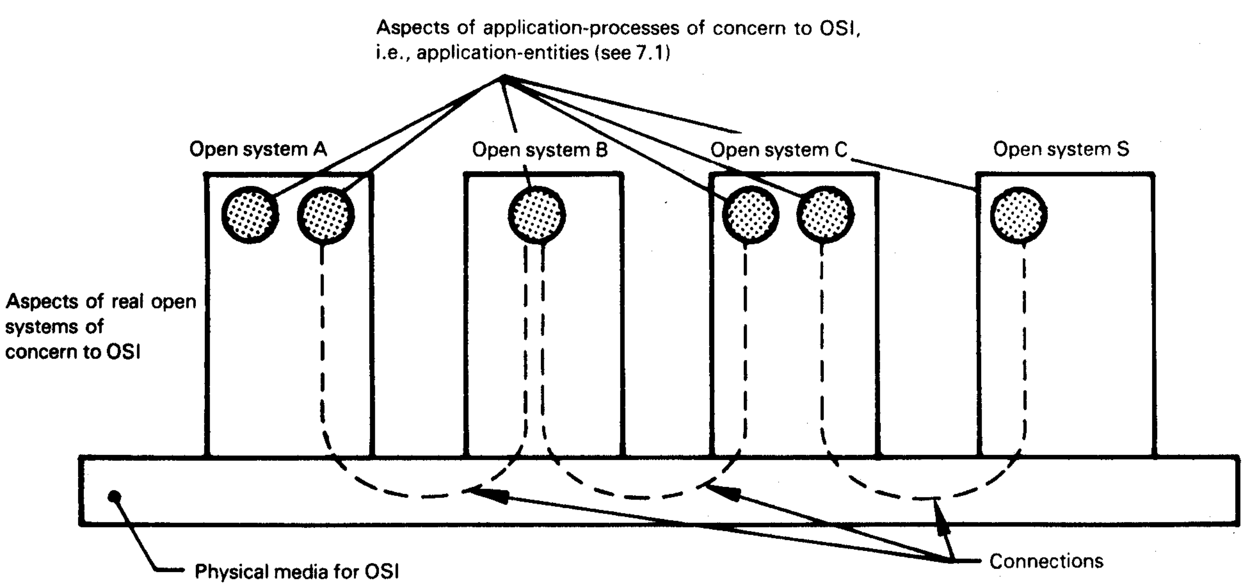

Figure 2 — Basic elements of OSI

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

a) open systems;

b) the application-entities which exist within the OSI environment;

c) the connections (see 5.3) which join the application-entities and permit them to exchange information (see note 1); and

d) the physical media for OSI.

NOTES

1 This Basic Reference Model of Open Systems Interconnection is based on the assumption that a connection is required for the transfer of data. An addendum to this International Standard is currently being developed to extend the description to cover the connectionless forms of data transmission which may be found in a wide variety of data communications techniques (for example local area networks, digital radio, etc.) and applications (for example remote sensing and banking).

2 Security aspects which are also general architectural elements of protocols are not discussed in this International Standard.

5.2 Principles of layering

5.2.1 Definitions

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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 (N)-entity : An active element within an (N)-subsystem.

5.2.1.4 peer-entities : Entities within the same layer.

5.2.1.5 sublayer : A subdivision of a layer.

5.2.1.6 (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.

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

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

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

5.2.1.10 (N)-protocol : A set of rules and formats (semantic and syntatic) which determines the communication behaviour of (N)-entities in the performance of (N)-functions.

5.2.2 Description

The basic structuring technique in the Reference Model of Open Systems Interconnection is layering. According to this technique, each open system is viewed as being logically composed of an ordered set of subsystems, represented for convenience in the vertical sequence shown in figure 3. Adjacent subsystems communicate through their common boundary. Subsystems of the same rank (N) collectively form the (N)-layer of the Reference Model of Open Systems Interconnection. An (N)-subsystem consists of one or several (N)-entities. Entities exist in each layer. Entities in the same layer are termed peer-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.

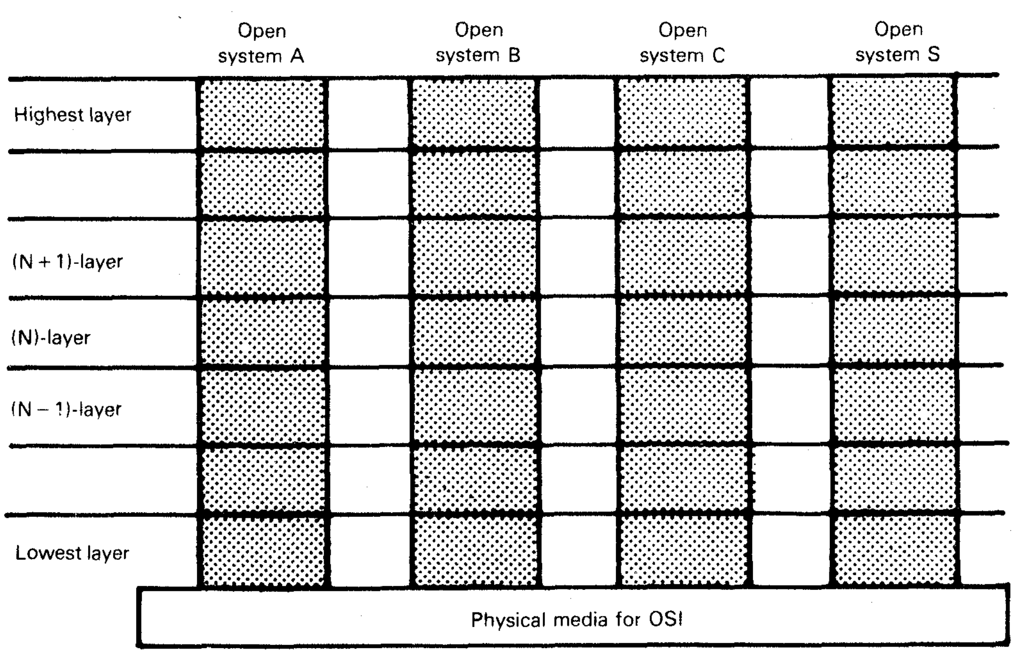

Figure 3 — Layering in co-operating open systems

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).

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 should 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 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.

Consider now an (N)-entity in the OSI context. It too, has two aspects, a type and a collection of instances. The type of an (N)-entity is defined by the specific set of (N)-layer functions it is able to perform. An instance 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)-entity types refer only to the properties of an association between peer (N)-entities, while an (N)-entity instance refers to the specific, dynamic occasions of actual information exchange.

It is important to note that actual communication occurs only between (N)-entity instances at all layers. It is only at connection establishment time (or its logical equivalent during a recovery process) that (N)-entity types are explicitly relevant. Actual connections are always made to specific (N)-entity instances, although a request for connection may well be made for arbitrary (N)-entity instances of a specified type. Nothing in this International Standard, however, precludes the request for a connection with a specific (named) instance of a peer (N)-entity. If an (N)-entity instance is aware of the name of its peer (N)-entity instance, it should be able to request another connection to that (N)-entity instance.

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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 connections of its layer. The detailed definition or additional characteristics of a sublayer are for further study.

Except for the highest layer, each (N)-layer provides (N+1)-entities in the (N+1)-layer with (N)-services. The highest layer is assumed to represent all possible uses of the services which are provided by the lower layers.

NOTES

1 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 figures 6 and 13).

2 Classes of service may be defined within the (N)-services. The precise definition of the term "classes of service" is for further study.

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.

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.

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).

Co-operation between (N)-entities is governed by one or more (N)-protocols. The entities and protocols within a layer are illustrated in figure 5.

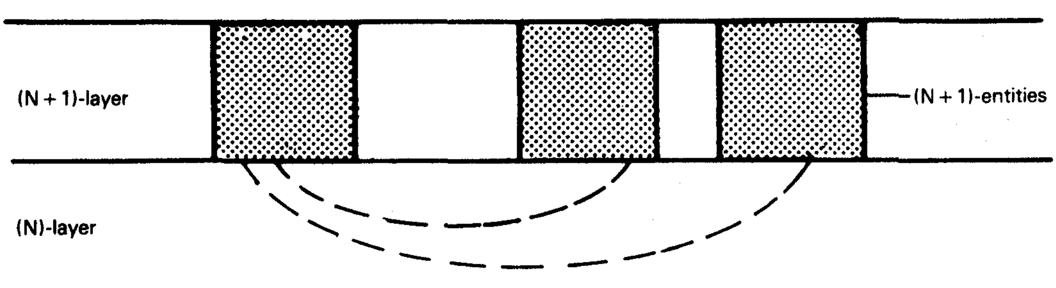

Figure 4 — (N+1)-entities in the (N+1)-layer communicate through the (N)-layer

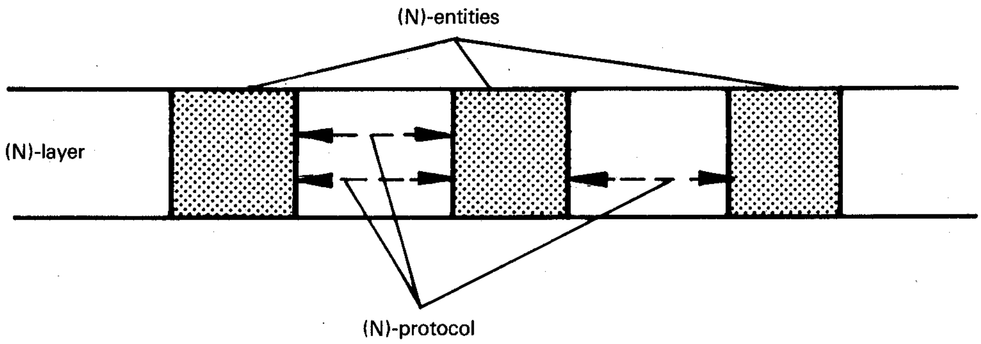

Figure 5 — (N)-protocols between (N)-entities

5.3 Communication between peer-entities

5.3.1 Definitions

5.3.1.1 (N)-connection : An association established by the (N)-layer between two or more (N + 1)-entities for the transfer of data.

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

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

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5.3.1.4 correspondent (N)-entities : (N)-entities with an (N − 1)-connection between them.

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

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

5.3.1.7 (N)-data-sink : An (N)-entity that receives (N − 1)-service-data-units on an (N − 1)-connection.[1]

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

5.3.1.9 (N)-duplex-transmission : (N)-data transmission in both directions at the same time.[1]

5.3.1.10 (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.[1]

5.3.1.11 (N)-simplex-transmission : (N)-data-transmission in one pre-assigned direction.[1]

5.3.1.12 (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.[1]

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

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

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

5.3.2 Description

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

NOTE — Classes of protocols may be defined within the (N)-protocols. The precise definition of the term "classes of protocols" is for further study.

This association is called an (N)-connection. (N)-connections are provided by the (N)-layer between two or more (N)-service-access-points. The terminator of an (N)-connection at an (N)-service-access-point is called an (N)-connection-endpoint. A connection with more than two connection-endpoints is termed a multi-endpoint-connection. (N)-entities with a connection between them are termed correspondent (N)-entities.

(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)-entity can act as a relay between them (see figure 6).

The fact that communication is relayed by a chain of (N + 1)-entities is known neither by the (N)-layer nor by the (N + 2)-layer.

1) These definitions are not for use in this International Standard but are for use in future OSI standards.

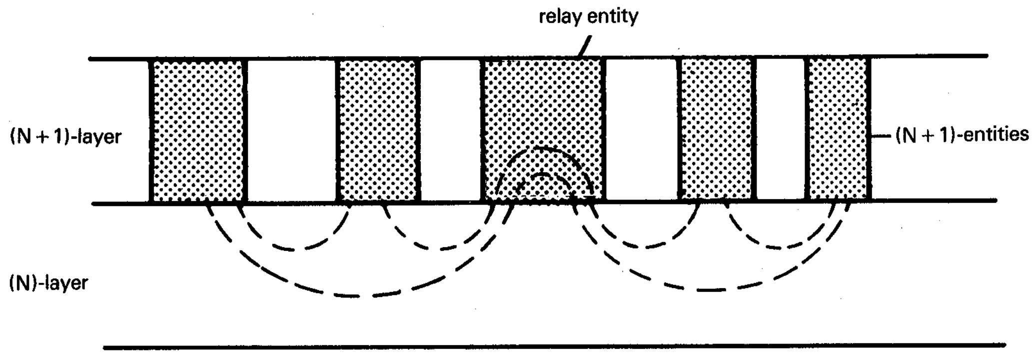

Figure 6 — Communication through a relay

5.4 Identifiers

5.4.1 Definitions

5.4.1.1 title : A permanent identifier for an entity.

5.4.1.2 title-domain : A subset of the title space of the OSI environment.

5.4.1.3 title-domain-name : An identifier which uniquely identifies a title-domain within the OSI environment.

NOTE — Title-domains of primary importance are the layers. In this specific case, the title-domain-name identifies the (N)-layer.

5.4.1.4 local-title : A title which is unique within a title-domain.

5.4.1.5 global-title : A title which is unique within the OSI environment and comprises two parts, a title-domain-name and a local-title.

5.4.1.6 (N)-address; (N)-service-access-point-address : An identifier which tells where an (N)-service-access-point may be found.

5.4.1.7 (N)-directory : An (N)-function by which the global title of an (N)-entity is translated into the (N − 1)-address of an (N − 1)-service-access-point to which the (N)-entity is attached.

5.4.1.8 (N)-address-mapping : An (N)-function which provides the mapping between the (N)-addresses and the (N − 1)-addresses associated with an (N)-entity.

5.4.1.9 routing : A function within a layer which translates the title of an entity or the service-access-point-address to which the entity is attached into a path by which the entity can be reached.

5.4.1.10 (N)-connection-endpoint-identifier : An identifier of an (N)-connection-endpoint which can be used to identify the corresponding (N)-connection at an (N)-service-access-point.

5.4.1.11 (N)-connection-endpoint-suffix : A part of an (N)-connection-endpoint-identifier which is unique within the scope of an (N)-service-access-point.

5.4.1.12 multi-connection-endpoint-identifier : An identifier which specifies the connection-endpoint of a multi-endpoint-connection which should accept the data that is being transferred.

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5.4.1.13 (N)-service-connection-identifier : An identifier which uniquely specifies an (N)-connection within the environment of the correspondent (N + 1)-entities.

5.4.1.14 (N)-protocol-connection-identifier : An identifier which uniquely specifies an individual (N)-connection within the environment of the multiplexed (N − 1)-connection.

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5.4.1.15 (N)-suffix : A part of an (N)-address which is unique within the (N)-service-access-point.

5.4.2 Description

An (N)-service-access-point-address, or (N)-address for short, identifies a particular (N)-service-access-point to which an (N + 1)-entity is attached (see figure 7). When the (N + 1)-entity is detached from the (N)-service-access-point, the (N)-address no longer provides access to the (N + 1)-entity. If the (N)-service-access-point is reattached to a different (N + 1)-entity, then the (N)-address identifies the new (N + 1)-entity and not the old one.

The use of an (N)-address to identify an (N + 1)-entity is the most efficient mechanism if the permanence of attachment between the (N + 1)-entity and the (N)-service-access-point can be assured. If there is a requirement to identify an (N + 1)-entity regardless of its current location, then the global-title assures correct identification.

An (N)-directory is an (N)-function which translates global-titles of peer (N)-entities into the (N − 1)-addresses through which they cooperate.

Interpretation of the correspondence between the (N)-addresses served by an (N)-entity and the (N − 1)-addresses used for accessing (N − 1)-services is performed by an (N)-address-mapping function.

Two particular kinds of (N)-address-mapping functions may exist within a layer :

a) hierarchical (N)-address-mapping; and

b) (N)-address-mapping by tables.

If an (N)-address is always mapped into only one (N – 1)-address then hierarchical construction of addresses can be used (see figure 8). The (N)-address-mapping function need only recognize the hierarchical structure of an (N)-address and extract the (N – 1)-address it contains.

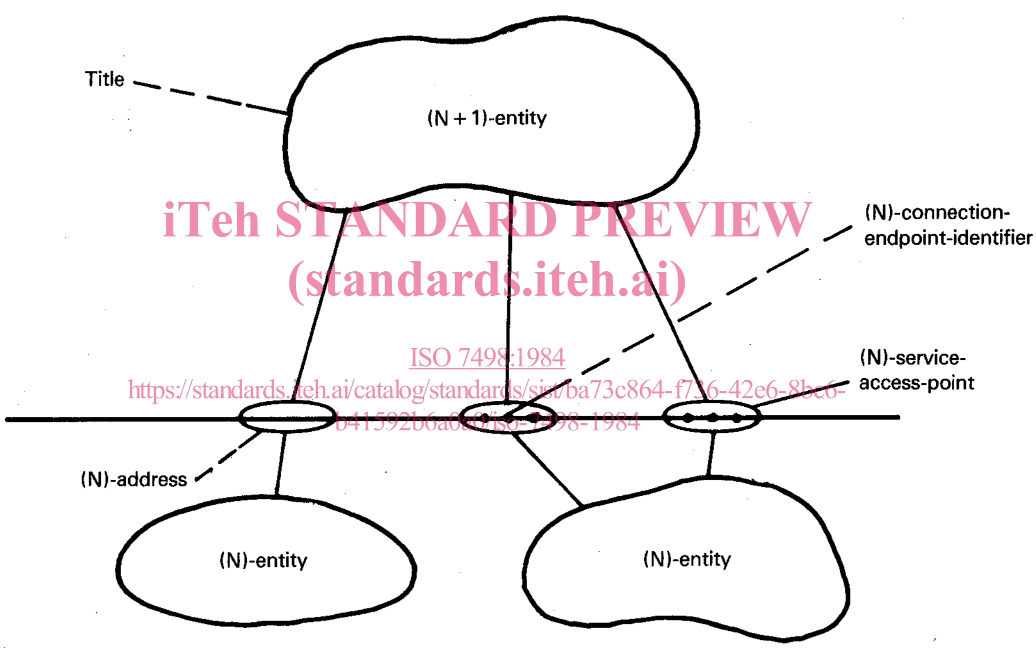
In this case, an (N)-address consists of two parts :

a) an (N – 1)-address of the (N)-entity which is supporting the current (N)-service-access-point of the (N + 1)-entity;

b) an (N)-suffix which makes the (N)-service-access-point uniquely identifiable within the scope of the (N – 1)-address.

Within a given layer, a hierarchical structure of addresses simplifies (N)-address-mapping functions because of the permanent nature of the mapping it presupposes. It is not imposed by the model in all layers in order to allow more flexibility in (N)-address-mappings and to cover the case where an (N)-entity attached to more than one (N – 1)-service-access-point supports only one (N)-service-access-point.

If the previous condition is not true, i.e. either an (N)-address can be mapped into several (N – 1)-addresses, or an (N)-address is not permanently mapped into the same (N – 1)-address, then hierarchical construction of an address is not possible and the (N)-address-mapping function may use tables to translate (N)-addresses into (N – 1)-addresses.



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NOTE — Dashed arrows refer to identifiers.

Figure 7 — Entities, service-access-points, and identifiers

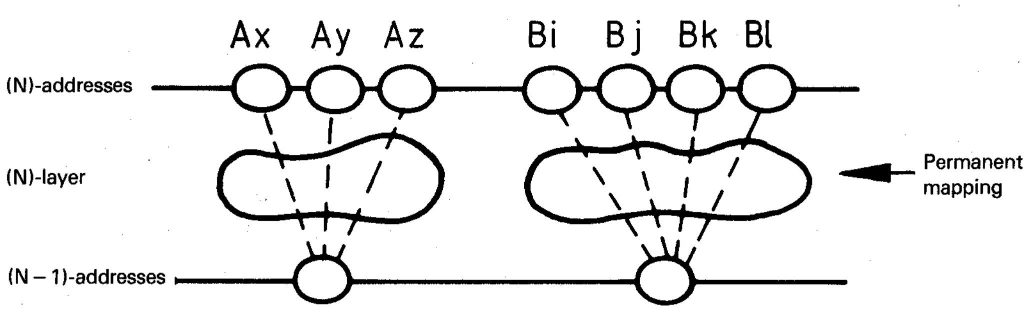

Figure 8 — Hierarchical (N)-address-mapping