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Information processing systems — Open Systems Interconnection — Internal organization of the Network Layer

*Systèmes de traitement de l'information — Interconnexion de systèmes ouverts — Organisation
interne de la Couche Réseau*

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8648 was prepared by Technical Committee ISO/TC 97, *Information processing systems*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Information processing systems — Open Systems Interconnection — Internal organization of the Network Layer

0 Introduction

This International Standard defines an architectural organization of the Network Layer of the OSI Reference Model. It is concerned with the functional organization of Network Layer entities in open systems, and with the ways in which this organization can be mapped to "real world" components (e.g. "real" networks, switches, transmission media, etc.). This International Standard relates those "real world" objects which must be dealt with to a set of abstract elements. There may be a variety of mappings between an abstract element and the physical equipment used to realize it. The description of such mappings requires a clear distinction between architectural terms and real world terms.

The architectural organization defined in this International Standard identifies and categorizes the way in which functions can be performed within the Network Layer by Network Layer protocols. In so doing, it provides a uniform framework for describing how different Network Layer protocols, operating either individually or cooperatively, can be used to provide the OSI Network Service. By focusing attention on the common functional elements of Network Layer protocols, this framework is intended to

- a) simplify the use of Network Layer protocols to provide the Network Service in different situations;
- b) limit the uncoordinated proliferation of Network Layer protocols with overlapping functions; and
- c) clarify the requirements for, and guide the development of, future Network Layer protocol standards.

This detailed internal structure is necessary in the case of the Network Layer for two reasons:

1. The Network Layer provides its users with a uniform Network Service, regardless of potentially wide variations in underlying "real-world" network services, technologies, and administrative organization. It is important to understand how the underlying components are organized and interact within the Network Layer, and how they can be efficiently and effectively used.
2. ISO 7498 specifies that the Network Layer performs routing and relaying functions and may contain entities residing in intermediate systems as well as in end systems. It is necessary to describe events that take place within

the Network Layer in both types of entities; i.e. in end systems (within which the Network Service is provided to NS users) and in intermediate systems (within which network-entities providing these relay and routing functions do not provide the Network Service to NS users).

1 Scope and field of application

This International Standard provides an architectural model of the OSI Network Layer as a framework for OSI Network Layer standardization, allowing incorporation of existing networks within the OSI architecture.

This framework encourages the design of real subnetworks that fully support the OSI Network Service whilst accommodating the participation, in the OSI environment, of other subnetworks that do not fully support the OSI Network Service.

This International Standard is intended for use both in the design and application of Network Layer protocols, operating between network-entities either in end systems providing the OSI Network Service, or in intermediate systems providing the routing and relay functions.

It shall be used to

- a) provide a common set of concepts and terminology for use in Network Layer standards (such standards shall reference this International Standard);
- b) analyse Network Layer functionality and classify Network Layer protocols;
- c) specify how "real networks" should be used in supporting or providing the OSI Network Service, in particular, in circumstances where multiple "real networks" are to be interconnected and used.

The organization defined herein does not address Network Layer management; in particular it is not concerned with the relationships among Network Layer entities which may be required for Network Layer management purposes. In addition, this International Standard does not specify the operational requirements for relay functions in intermediate systems, nor address how specific combinations of permitted functions might be practically and efficiently utilized.

2 References

ISO 7498, *Information processing systems - Open Systems Interconnection - Basic Reference Model*

Note - See also CCITT Recommendation X.200 *Reference Model of Open Systems Interconnection for CCITT Applications*.

ISO 7498/Add. 1, *Information processing systems - Open Systems Interconnection - Basic Reference Model Addendum 1: Connectionless-mode transmission*.

ISO 8208, *Information processing systems - Data communications - X.25 Packet Level Protocol for Data Terminal Equipment*.

ISO 8348, *Information processing systems - Data communications - Network service definition*

Note - See also CCITT Recommendation X.213 *Network Service Definition for Open Systems Interconnection (OSI) for CCITT Applications*.

ISO 8348/Add. 1, *Information processing systems - Data communications - Network service definition Addendum 1: Connectionless-mode transmission*.

ISO/TR 8509, *Information processing systems - Open Systems Interconnection - Service conventions*.

Note - See also CCITT Recommendation X.210 *Open Systems Interconnection (OSI) Layer Service Definition Conventions*.

ISO 8802 - Part 2, *Information processing systems - Data Communications - Local Area Networks - Logical Link Control*.¹

- Part 3, *Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*.¹

- Part 4, *Token-Passing Bus Access Method and Physical Layer Specifications*.¹

- Part 5, *Token Ring Access Method and Physical Layer Specifications*.¹

- Part 7, *Slotted Ring Access Method and Physical Layer Specifications*.¹

CCITT Recommendation X.21, *General purpose interface between data terminal equipment and data circuit-terminating equipment for synchronous operation on public data networks*.

CCITT Recommendation X.25, *Interface between data terminal equipment and data circuit-terminating equipment for terminals operating in the packet mode on public data networks*.

3 Definitions

3.1 Reference model definitions

This International Standard makes use of the following terms defined in ISO 7498:

- a) OSI Network Layer
- b) OSI Network Service
- c) OSI network-service-access-point
- d) OSI network-service-access-point-address (network-address)
- e) OSI network-entity
- f) network-relay
- g) routing
- h) service
- j) protocol
- k) protocol-control-information

3.2 Service conventions definitions

This International Standard makes use of the following terms defined in ISO/TR 8509:

- l) service user
- m) service provider

3.3 Network Layer architecture definitions

For the purpose of this International Standard, the following definitions apply:

n) **real subnetwork**: A collection of equipment and physical media which forms an autonomous whole and which can be used to interconnect real systems for purposes of communication.

p) **subnetwork**: An abstraction of a real subnetwork.

q) **interworking unit**: One or more items of equipment, or a part of an item of equipment, whose operation provides a network-relay function (that is, a real system which receives data from one correspondent network-entity and forwards it to another correspondent network-entity).

Note - Such equipment may be integrated into a real subnetwork which is being interconnected.

r) **relay system**: An abstraction of the equipment forming an interworking unit.

s) **intermediate system**: An abstraction of a real system providing a network-relay function.

t) **data transmission service**: The set of capabilities available from a real subnetwork which may be utilized by users of the real subnetwork for the purpose of sending and receiving data.

Note - This service is defined between the points where each user is connected to and accesses the real subnetwork; e.g. a DTE/DCE interface, and should not be confused with the notion of a service at a layer boundary as defined in ISO 7498.

¹ At present at the stage of draft; publication anticipated in due course

4 Abbreviations

For the purpose of this International Standard, the following abbreviations apply:

CO-NS	Connection-Mode Network Service
CL-NS	Connectionless-Mode Network Service
DCE	Data Circuit-terminating Equipment
DTE	Data Terminal Equipment
IWU	Interworking Unit
LAN	Local Area Network
NL	Network Layer
NSAP	Network-service-access-point
PCI	Protocol-control-information
SNACp	Subnetwork Access Protocol
SNDP	Subnetwork Dependent Convergence Protocol
SNICP	Subnetwork Independent Convergence Protocol

5 Network Layer concepts and terminology

This clause gives precise meaning to a number of terms used in the OSI Network Layer standards which have a range of interpretation in more general usage.

5.1 Real world objects and abstract elements

Throughout this sub-clause and in clause 8, diagrams are used to illustrate various configurations of interest in the Network Layer. Each diagram has two components. Real world objects are depicted at the top of each diagram, while representation of the corresponding abstract element is depicted at the bottom. Table 1 shows the graphical representations of the real world objects and abstract elements used in the diagrams.

In figures 2, 3 and 4, the basic combinations of interconnection of real world objects (and thus their corresponding abstract elements) are depicted. From this basic set of interconnections, an arbitrary number of permitted interconnections can be built up through the repeated and/or recursive invocation of the basic interconnections shown in figures 2, 3 and 4.

Note - In figure 5, and those which follow it, the graphical representation of abstract elements contains additional detail (e.g. to illustrate OSI layers, protocol roles, etc.).

5.2 End systems and intermediate systems

End systems and intermediate systems are abstractions of equipment which fulfil the requirements of the OSI standards necessary to provide the function of an open system (see ISO 7498). An intermediate system performs only functions allocated to the lowest three layers of the Reference Model. Interworking units and real subnetworks are real world examples of equipment fulfilling the intermediate system role. An end system must additionally provide the functions of the layers above the Network Layer. A real end system is any piece of equipment or collection of pieces of equipment which fulfils this end system role. Network Layer entities within end systems shall provide the same Network Layer inter-system communication functions as those provided by Network Layer entities in intermediate systems, with the exception of relaying functions which are performed by intermediate systems only.

The same collection of physical equipment may be capable of operating as a real end system or as an interworking unit, or as both simultaneously, depending on the circumstances of its use. In a particular circumstance the functions being invoked correspond to those of an abstract end system or an intermediate system.

5.2.1 End system considerations

An end system can communicate with another end system either

- a) directly, without an intervening intermediate system (see figure 1); or
- b) through one or more intervening intermediate systems (see figure 2).

In this context, "directly" refers to that which involves only the network-entities in the two communicating end systems. Communication "through one or more intermediate systems" refers to communication that involves the performance of a network-relay function by one or more network-entities, in addition to the network-entities in the two communicating end systems.

In either case no constraints are placed on the way in which relays at lower layers (e.g. data-link-relays or physical-relays) might be used to provide communication between network-entities.

For example, the real subnetwork which directly connects two end systems, as depicted in figure 1, may be as simple as a direct point-to-point link between the two end systems, or as complex as an interconnected set of Local Area Networks (LANs).

5.2.2 Intermediate system considerations

An intermediate system is an abstraction of

- a) a real subnetwork (e.g. see 5.3 and figure 2) other than one which is directly connected as in 5.2.1;
- b) an interworking unit, connecting two or more real subnetworks (see 5.4 and figure 4 where only the case of two real subnetworks is shown); or
- c) a real subnetwork with an associated interworking unit (see 5.4 and figure 3).

Any combination of the above may be referred to as an intermediate system.

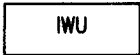
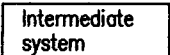
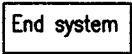
In some cases, it may be useful to identify and distinguish the abstract functionality of a real subnetwork from that of an interworking unit. In such circumstances, the abstract terms "subnetwork" and "relay system" may be used, respectively, to refer to these specific types of intermediate systems. (As described in following 5.3 and 5.4.)

5.3 Real subnetworks and subnetworks

A real subnetwork is a collection of equipment and physical media which forms an autonomous whole and which can be used to interconnect other real systems for purposes of communication (see figure 2). Examples of real subnetworks include

- commonly recognized, carrier supplied public networks;
- privately supplied and utilized networks;
- local area networks (LANs);
- any of the above, with associated interfacing equipment and/or interworking unit(s), considered together as forming a real subnetwork.

Table 1 – Correspondence between real world objects and abstract elements

Real world object	Graphical representation of real world object	Corresponding abstract element	Graphical Representation of abstract element
Real system		System	
Real open system		Open system	
Interworking unit		Relay system	
Real subnetwork		Subnetwork	
Real end system		End system	

* Note – For end systems which are directly connected (see 5.2.1) their interconnection will be graphically depicted as a single link and not as an intermediate system.

All the pieces of equipment comprising such a real subnetwork can be represented by a single abstract subnetwork. It is important to note that a collection of physical equipment of the types listed above, and represented here as a "subnetwork", is commonly called a "network".

The externally visible properties of some real subnetworks are described by separate standards and Recommendations such as the CCITT X.21 circuit-switching and X.25 packet-switching Recommendations, or the ISO Local Area Network standards. More than one real subnetwork may be involved in an interconnection of other real systems. The term "subnetwork" may be applied recursively to collections of subnetworks interconnected in such a way that, to an attaching system, they can be viewed and treated as a single subnetwork.

A real subnetwork may be realized in such a way that it fully supports the OSI Network Service; that is, the functions supplied by the real subnetwork, suitably exploited by the real end systems that are attached to it, are fully equivalent in the abstract to those of the OSI Network Service (see 5.5). A real subnetwork which has this property is referred to as a subnetwork which supports all elements of the OSI Network Service. In having the capability to fully support the OSI Network Service, a real subnetwork must supply all mandatory elements of the OSI Network Service. It may additionally supply any provider option of the OSI Network Service but is not required to do so.

5.4 Relay systems and interworking units

A relay system is an abstraction of a piece of equipment (or collection of equipment) commonly referred to in the real world as an interworking unit. The purpose of an interworking unit is to facilitate the interconnection of distinct real subnetworks.

An interworking unit may reside within the authority of a real subnetwork supplier or may be administered by some other party. In cases where an interworking unit is physically separate from the real subnetworks it interconnects, the interworking unit may be represented as a separate intermediate system (see figure 4). An interworking unit may also be incorporated as an integral part of each real subnetwork being interconnected. In such a case, each real subnetwork and its associated interworking unit may be represented as a single intermediate system (see figure 3a). Alternatively each real subnetwork individually may be represented as an intermediate system connected by another intermediate system which represents the functionality of the combined intervening interworking units (figure 3b).

5.5 Data transmission service and subnetwork service

Any real subnetwork supplies a certain collection of functions to the real systems which use it. Some real subnetworks perform functions which are defined to be above the Network Layer of the OSI architecture (or outside of OSI entirely); such functions are outside of the scope of this International Standard. The abstraction of the set of capabilities available at the boundary between a real end system and a real subnetwork is a data transmission service. Different types of data transmission services are available, corresponding to different types of real subnetworks (for example, a packet-switched or circuit-switched data transmission service as defined by CCITT).

In the context of the OSI Network Layer, the abstraction of the subnetwork-provided functions along with the functions performed within open systems needed to exploit the subnetwork-provided functions is the subnetwork service. The subnetwork service incorporates the data transmission service, or a subset thereof. (See figure 5.)

A subnetwork service may therefore be

- a) identical to the OSI Network Service in all instances of use (see 5.3);
- b) different from the OSI Network Service in all instances of use;
- c) different from the OSI Network Service in some instances of use but identical to the OSI Network Service in other instances.

When a real subnetwork supports a subnetwork service of type b) or c), it is necessary to perform additional Network Layer functions in order to provide the full OSI Network Service in all instances. These additional functions are performed in the end systems and/or relay systems invoking the subnetwork service on that real subnetwork.

A particular case of a subnetwork connection-mode service of type c) as defined in 5.5 is one in which a real subnetwork is defined so that its access protocol contains the functions needed to support the establishment and release of network-connections, but not all the functions needed to support data transfer on network-connections. Enhancement protocols will, therefore, be required for such a subnetwork during the data transfer phase but not during the establishment or release phases.

5.6 Service types

The OSI Network Service includes two basic service types:

- a) a connection-mode service (CO-NS); and
- b) a connectionless-mode service (CL-NS) (see ISO 8348 and ISO 8348/Add. 1).

Similarly, a subnetwork may provide either a connection-mode or connectionless-mode service or both. The operation of Network Layer protocols may enable either the CO- or the CL-NS or both to be provided using interconnected subnetworks that may provide either type of service in any combination (see clause 8 and table 2).

For a given instance of communication, the same service (i.e. connection-mode or connectionless-mode) is provided to both NS users. Choice of provision of connection-mode or connectionless-mode Network Service is provided in accordance with clause 6.2 of ISO 7498/Add. 1.

6 Organization of the Network Layer

There are circumstances in which, among real subnetworks which are interconnected, there are some real subnetworks that do not fully support the OSI Network Service. As a result, it is necessary to describe a Network Layer architectural framework for the provision of the OSI Network Service using such subnetworks. This International Standard provides such a framework which can be used in the development and application of standards related to real subnetwork interconnection.

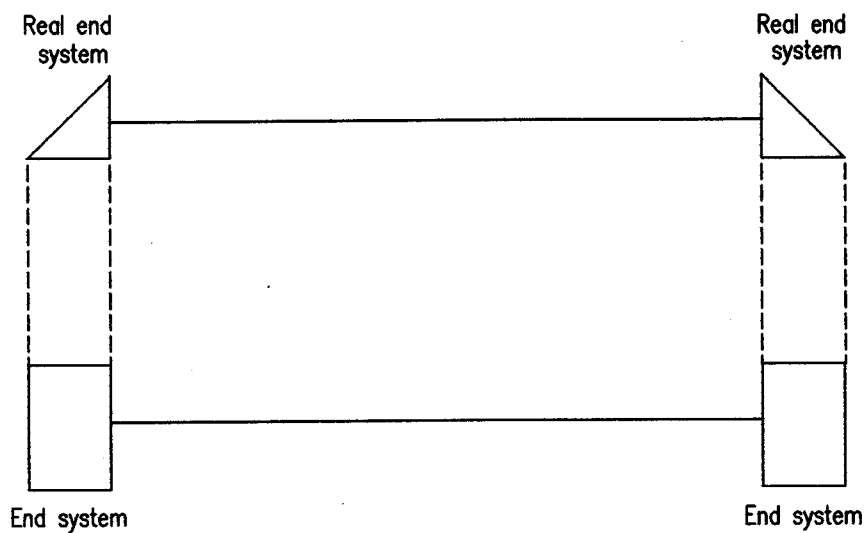


Figure 1 — “Direct” communication between end systems (without an intermediate system)

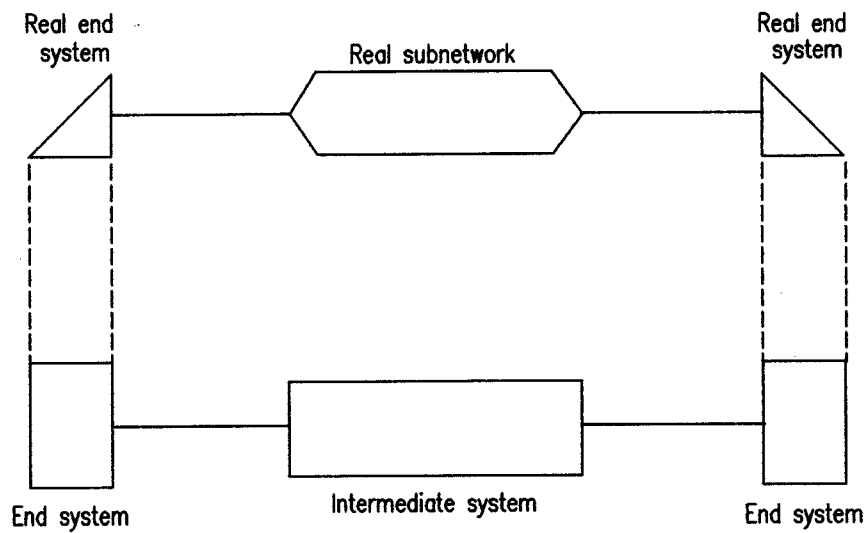
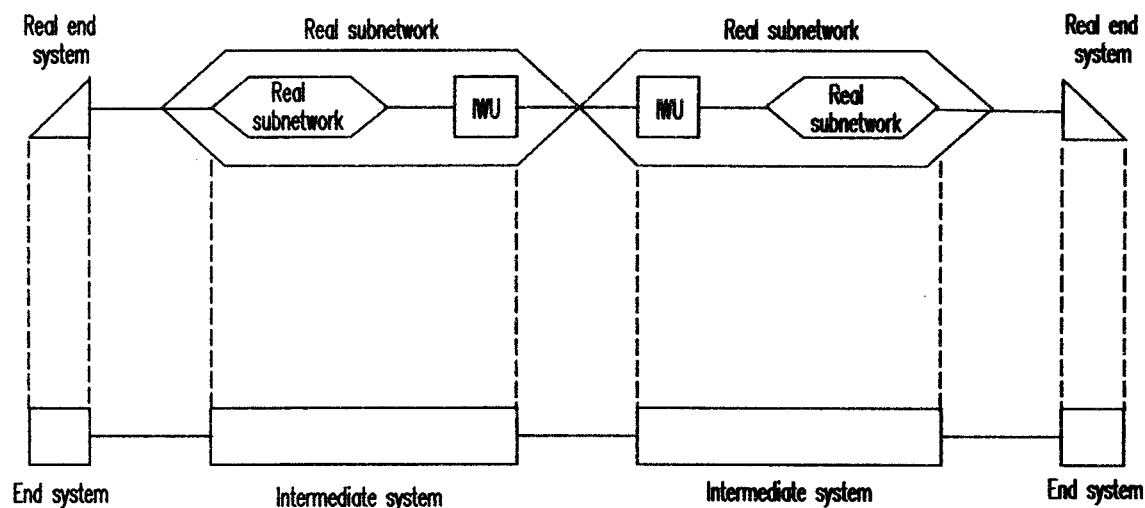
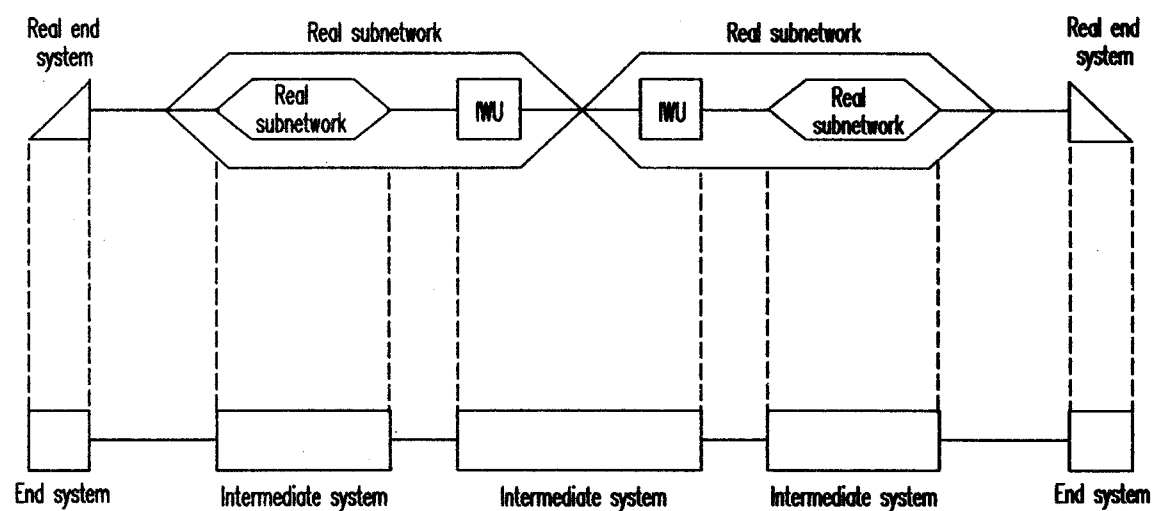


Figure 2 — End systems communicating through an intermediate system



a) Representation of each real subnetwork and interworking function as an intermediate system.



b) Representation of combined interworking functions as a separate intermediate system.

Figure 3 — Interconnection of real subnetworks that include integral interworking unit functionality

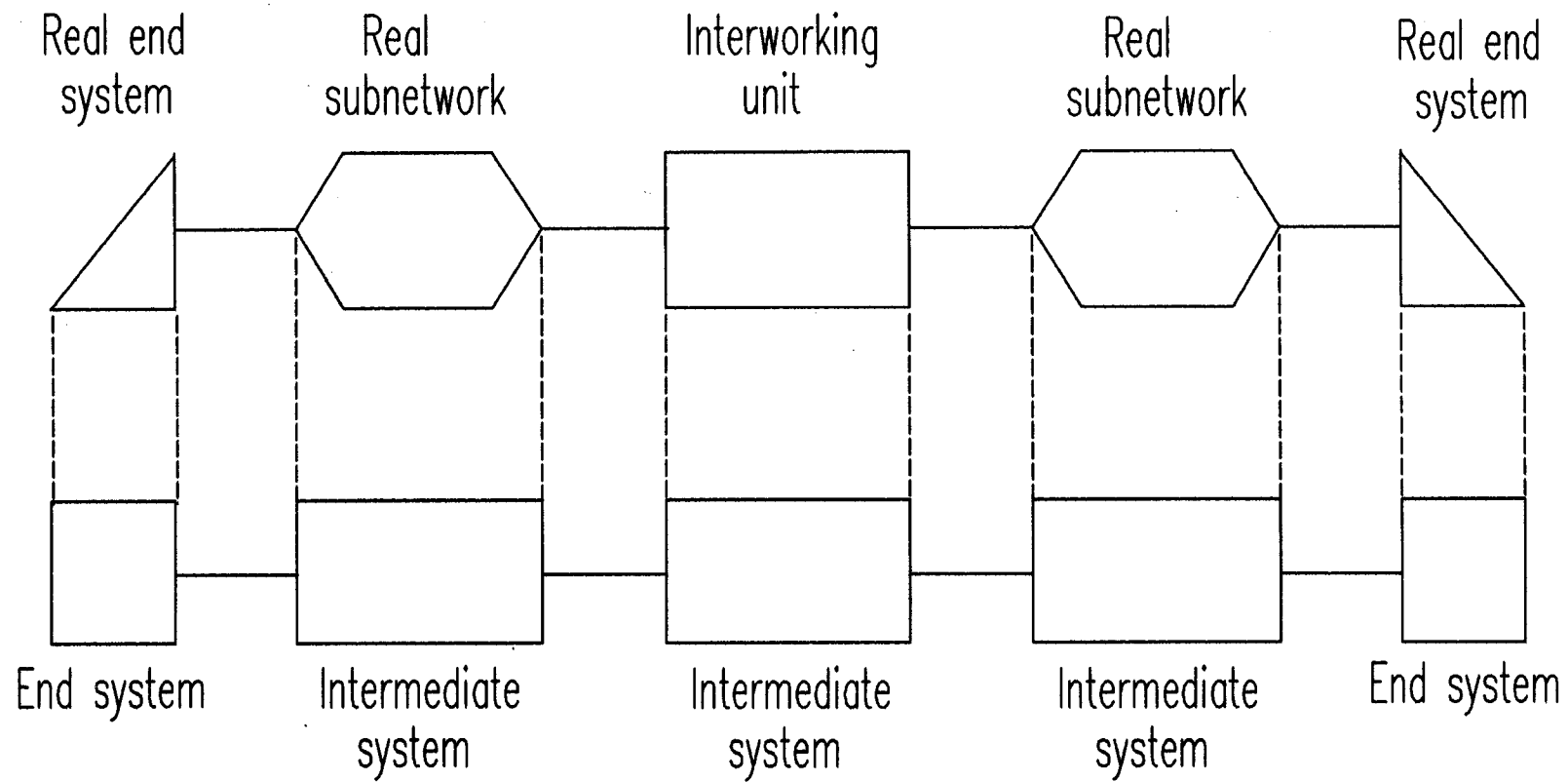


Figure 4 — Interconnection of real subnetworks by a separate interworking unit