TECHNICAL REPORT

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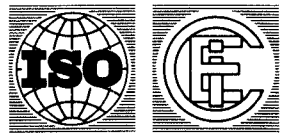
Information technology — Telecommunications and information exchange between systems — OSI Routeing Framework

Technologies de l'information — Communication de données et échange d'information entre systèmes — Cadre général de routage OSI



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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) together form a system for worldwide standardization as a whole. 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.

The main task of a technical committee is to prepare International Standards but in exceptional circumstances, the publication of a Technical Report of one of the following types may be proposed:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC/TR 9575, which is a Technical Report of type 3, was prepared by ISO/IEC JTC1, *Information technology.*

Introduction

In the OSI environment (OSIE), the possibility exists for any End System (ES) to communicate with any other ES. The physical path (or paths) over which this communication takes place may

- include multiple Intermediate Systems (IS);
- include multiple subnetwork types; and
- traverse multiple, independent organisations.

Furthermore, one instance of communications may follow a different path from another instance of communications.

Within the Network Layer, the *Internal Organisation of the Network Layer* (ISO 8648) identifies two functions, **Routeing** and **Relaying**, as being central to the ability for End Systems to communicate through an arbitrary concatenation of subnetworks and Intermediate Systems.

Part of the overall function of routeing and relaying is to allow ESs and ISs to find an appropriate path between two or more ESs for a given instance of communications.

Relaying is concerned primarily with the actual transformation and manipulation of Network Protocol Data Units (NPDUs) as they transit Intermediate Systems. Routeing, on the other hand, is primarily concerned with the maintenance and selection of paths through multiple subnetworks and Intermediate Systems which allow NPDUs to flow smoothly between End Systems.

There are four important aspects to routeing, i.e.:

a) the information required by ESs and ISs (5.1.1),

b) the techniques used by ESs and ISs to collect that information (5.1.2),

c) the techniques used by ESs and ISs to distribute that information (5.1.3), and

d) the functions executed by ESs and ISs on that information to determine the paths over which NPDUs flow between pairs of NSAPs (5.1.4).

This Technical Report discusses these aspects of routeing, and describes how various protocols may be employed to effect the OSI routeing functions. It does not discuss relaying, except where relaying functions are closely allied with routeing functions.

Information technology — Telecommunications and information exchange between systems — OSI Routeing Framework

1 Scope

This Technical Report provides a framework in which OSI protocols for routeing may be developed and to expedite the progression of routeing protocols through the standardisation process.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7498:1984, *Information processing systems — Open Systems Interconnection — Basic Reference Model.*

ISO 7498/Add.1:1984, *Information processing systems — Open Systems Interconnection — Basic Reference Model — Addendum 1: Connectionless-mode Transmission.*

ISO 7498/Add.3:1989, *Information processing systems — Open Systems Interconnection — Basic Reference Model — Addendum 3: Naming, including Addressing.*

ISO 7498/Add.4:1989, *Information processing systems — Open Systems Interconnection — Basic Reference Model — Addendum 4: Management Framework.*

ISO 8348:1987, *Information processing systems — Data communications — Network Service Definition.*

ISO 8348/Add.1:1987, *Information processing systems — Data communications — Network Service Definition — Addendum 1: Connectionless-mode transmission.*

ISO 8348/Add.2:1988, *Information processing systems — Data communications — Network Service Definition — Addendum 2: Network layer addressing.*

ISO 8473:1988, *Information processing systems — Data communications — Protocol for providing the connectionless-mode network service.*

ISO 8648:1988, *Information processing systems — Open Systems Interconnection — Internal organisation of the Network Layer.*

ISO 9542:1988, *Information processing systems – Telecommunications and information exchange between systems — End system to Intermediate system Routeing exchange protocol for use in conjunction with the protocol for providing the connectionless -mode network service (ISO 8473).*

3 Definitions

3.1 Reference Model definitions

This Technical Report makes use of the following terms defined in ISO 7498:

a) Network Layer
b) Network Service access point
c) Network Service access point address
d) Network entity
e) Routeing
f) Network protocol
g) Network relay
h) Network protocol data unit
i) System management
j) Layer management

3.2 Network Layer architecture definitions

This Technical Report makes use of the following terms defined in ISO 8648:

a) Subnetwork
b) End system
c) Intermediate system
d) Subnetwork service

3.3 Network Layer addressing definitions

This Technical Report makes use of the following terms defined in ISO 8348/Add.2:

a) Subnetwork address
b) Subnetwork point of attachment

3.4 Routeing framework definitions

For the purpose of this Technical Report the following definitions apply.

3.4.1 **Administrative Domain:** A collection of End systems, Intermediate systems, and subnetworks operated by a single organisation or administrative authority.

The components which make up the domain are assumed to interoperate with a significant degree of mutual trust among themselves, but interoperate with other Administrative Domains in a mutually suspicious manner.

NOTE - The term *Administrative Domain* is not intended to have any particular relationship to an *Administration* as defined by the CCITT. A CCITT Administration may in fact operate an Administrative Domain, but this would be no different from an Administrative Domain operated by any organisation from the point of view of this Routeing Framework.

3.4.2 **routeing domain:** A set of End Systems and Intermediate Systems which operate according to the same routeing procedures and which is wholly contained within a single Administrative Domain.

See 8.2.1 for a precise formal definition of this concept.

3.4.3 **common domain:** An Administrative Domain which is not a member of a higher level domain.

A common domain is the highest level in the routeing hierarchy. There is no single domain above the common domain. in this sense, the routeing hierarchy is in fact multiple hierarchies, with the common domain as the highest element of each hierarchy.

Where there are multiple common domains, they co-operate as peers to make it possible to route to any NSAP in the OSIE.

3.4.4 **hop:** The traversal of a single subnetwork by a PDU.

3.4.5 **black hole:** A situation in which an Intermediate System, due to a breakdown of the routeing procedures, malicious intent, or lack of information, discards or otherwise refuses to forward all traffic directed to it.

A black hole may also be formed on a connectionless subnetwork when the intended recipient of traffic is unavailable.

3.4.6 **subnetwork address resolution entity:** A network layer entity available on a subnetwork which acts as a repository for, and source of, routeing information for that subnetwork.

4 Symbols and abbreviations

ES	End System
IS	Intermediate System
LAN	Local Area Network
NPDU	Network Protocol Data Unit
NSAP	Network Service Access Point
OSIE	Open System Interconnection Environment
PDU	Protocol Data Unit
QoS	Quality of Service
SN	Subnetwork
SNARE	Subnetwork Address Resolution Entity
SNPA	Subnetwork Point of Attachment
OSIE	Open Systems Interconnection Environment
WAN	Wide Area Network

5 Routeing Concepts

5.1 Functional decomposition of routeing

OSI Routeing can be decomposed into four different but interrelated aspects. The purposes of this division are to

- conceptually clarify the functions of routeing;
- simplify the design of routeing protocols by breaking routeing into its component parts; and
- make the routeing functions as flexible as is practical by allowing for degrees of freedom in each aspect.

The four aspects are described in the following clauses. Figure 1 below illustrates the relationship among these four aspects of routeing

5.1.1 Routeing Information Base

The Routeing Information Base comprises the complete information required by a particular ES or IS to accomplish routeing. Such information might include:

- Next hop routeing tables. These are tables which relate destination NSAPs to the potential next subnetwork hops (e.g. local and remote SNPAs) which might be used to forward the PDU closer to its destination.
- Lists of neighbour ESs and ISs. These lists enable an ES or IS to ascertain the local topology.
- Measured QoS characteristics of a datalink or subnetwork path. These measurements allow the routeing functions to adapt to QoS changes.
- Network maps. These are complete topological graphs of a portion of the global network. Such maps can be used

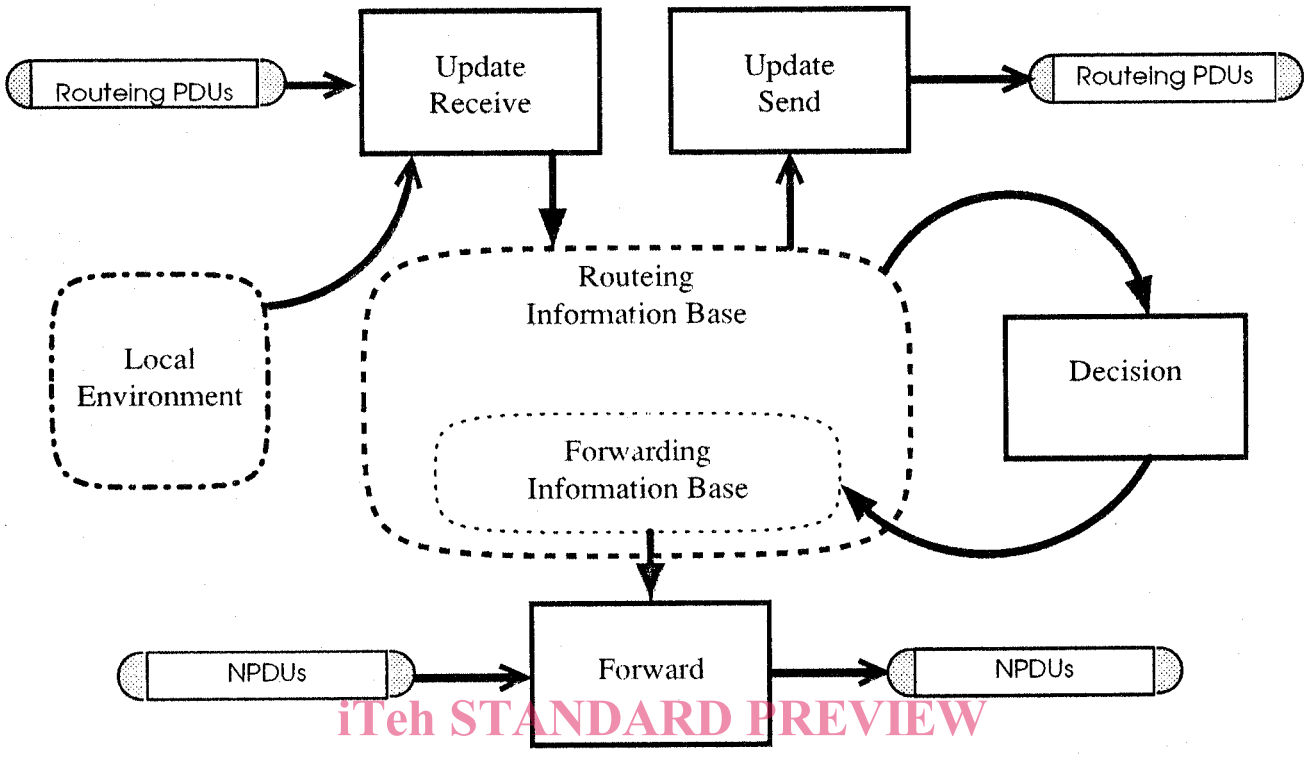

Figure 1 - Decomposition of the routeing function

to compute shortest paths to destination NSAPs using any of a number of routeing metrics.

5.1.2 Information collection

ESs and ISs build up their routeing information bases by collecting information from their local environment and from other systems. Some example sources of information are: measurement protocols, policy input from System Management, directory lookup functions, and routeing protocols. The information collection function is illustrated in figure 1 by the box labelled *Update Receive*.

5.1.3 Information Distribution

Systems may inform other systems of pertinent information in their local routeing information base by distributing this information. Some examples of information distribution techniques include: routeing protocols and interactions through the management information bases. The information distribution function is illustrated in figure 1 by the box labelled *Update Send*.

5.1.4 Route calculation and maintenance

These are the internal functions executed by ESs and ISs on the routeing information base to accomplish routeing. The major function in this category is the generation of the forwarding information base which is used to actually relay NPDUs. This function is illustrated in figure 1 by the box labelled *Decision*. Other examples of these internal functions include: timing functions such as ageing old routeing information base entries, and the functions F1 and F2 described below.

5.1.4.1 Functions F1 and F2

The functions F1 and F2 are two functions required by every ES and IS to route an NPDU. The inputs to F1 are

a) the called or destination NSAP address;

b) the calling or source NSAP address;

c) a source route (optional). A source route is a sequence of network entity titles which identify Network relay systems. See, for example, the source routing function of ISO 8473. In a complete source route the next network entity title in the sequence is the output of F1. In a partial source route, the next network entity title in the sequence is used to determine the network entity title of a Network relay system used to reach the Network relay identified by the source route.

d) Quality of service (QoS) parameters (optional);

e) the Forwarding Information Base.

For each NPDU that is routed, F1 determines

f) The Network entity title of a Network relay system on the path to the destination NSAP or else,

g) The title of the destination Network entity, if no relay function is necessary to reach the destination. The title may be the same as the destination NSAP address.

The inputs to F2 are

h) The network entity title of the Network relay or destination End system determined by F1.

i) QoS.

j) the Forwarding information base.

This function is performed after F1 to determine which subnetwork point of attachment (SNPA) to use when sending an NPDU to the Network relay or destination network entity. The information yielded by this function is

k) identification of the selected SNPA.

l) values of parameters which are input to the subnetwork service provider associated with that SNPA.

5.2 Relationship of routeing to OSI Management

Operation of the Network Layer, in fulfilment of the role assigned to it in the OSI Reference Model, requires shared knowledge concerning the location of NSAPs and routes through the available subnetworks.

As shown in figures 2 and 1, the routeing function intersects with OSI management through information stored in, and retrieved from, the management information base (the boxes labelled *Local Information Base* in the figures). Routeing information is placed in the management information base either through interaction with Network Layer entities or through interaction with System Management (the box labelled *OSI Management Application*).

It may be desirable to collect and distribute routeing information automatically through the operation of OSI Routeing protocols; these protocols may be located at the Network Layer

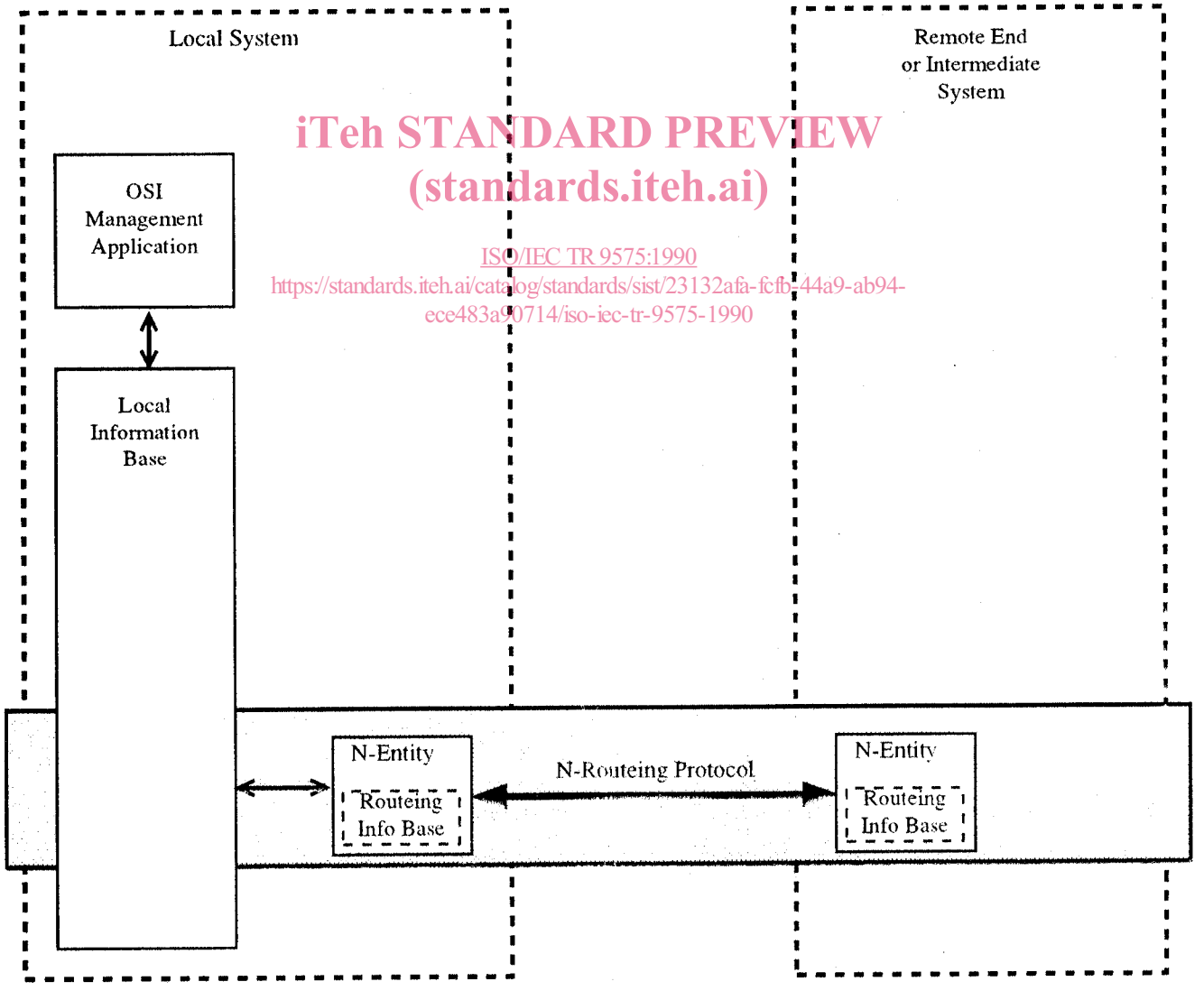

Figure 2 - Routeing Exchange using Network layer protocols

(Layer management) or the application layer (System management).

The use of a "network layer routeing information exchange protocol" has (among others) the following advantages:

- it confines the generation, exchange, and synchronisation of routeing information within the Network layer. This keeps routeing a "closed system" and avoids difficult issues in cross-layer co-ordination.

- capabilities existing in the lower layers but not available in the upper layers, can be used (e.g. multicast).

Figure 2 illustrates the use of a layer management protocol to exchange routeing information

Use of an "application layer routeing information exchange protocol" has (among others) the following advantage:

- context negotiation and the establishment of management associations over a reliable end-to-end transport service is possible.

Figure 1 illustrates the use of a system management protocol to exchange routeing information.

In general, it is likely that a complete and realistic solution to the global routeing problem in the OSI environment will require a combination of techniques, involving both Network layer management protocols and System management protocols.

6 Environment for OSI routeing

OSI Routeing shall be capable of operating effectively in a variety of environments, which when considered together result in a number of difficult goals for any Routeing scheme to sat-

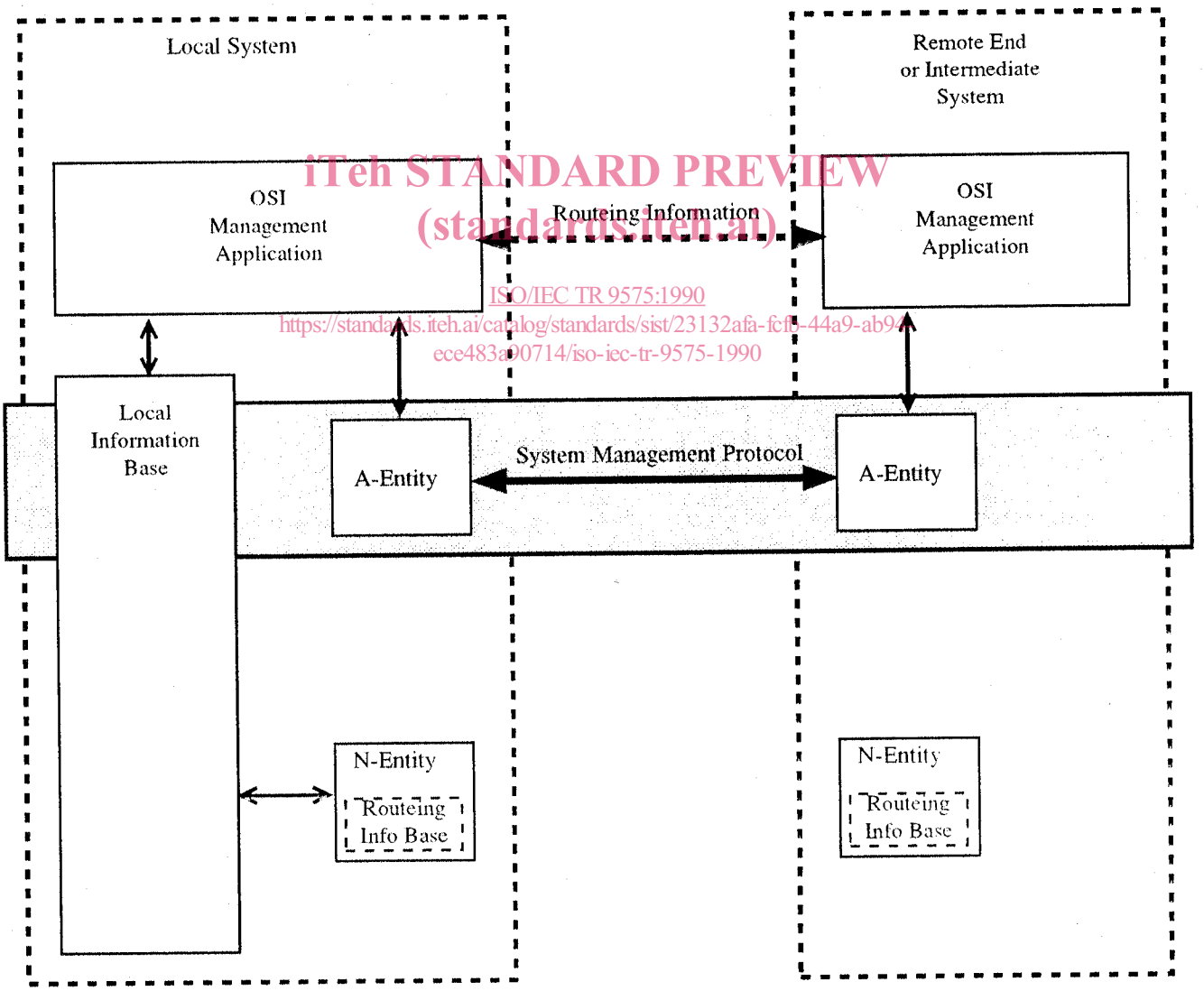

Figure 1 - Routeing exchange using system management