

# ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

---

## NETWORK LAYER PRINCIPLES

---

TR/13

September 1982

Free copies of this document are available from ECMA,  
European Computer Manufacturers Association  
114 Rue du Rhône - CH-1204 Geneva (Switzerland)

Phone: +41 22 735 36 34 Fax: +41 22 786 52 31

# ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

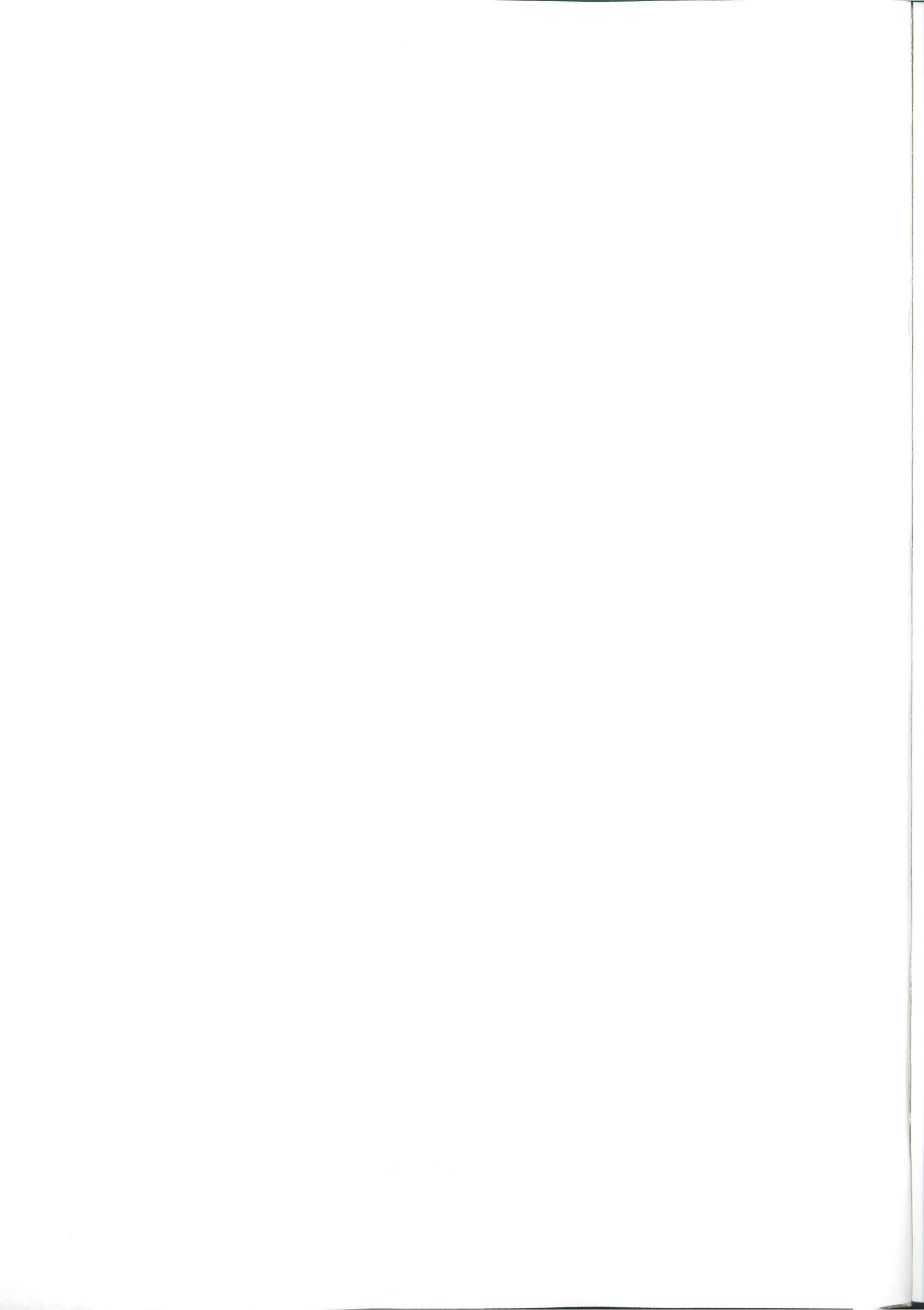
---

## NETWORK LAYER PRINCIPLES

---

TR/13

September 1982





## TABLE OF CONTENTS

|   | <u>Page</u> |
|---|-------------|
| 1. INTRODUCTION   | 1           |
| 2. GENERAL STATEMENTS   | 1           |
| 3. ARCHITECTURE   | 2           |
| 3.1 General   | 2           |
| 3.2 Note about ESGs   | 3           |
| 3.3 Recursive extension   | 4           |
| 3.4 Some implementation aspects of gateways                                     | 4           |
| 3.5 The architecture of a gateway   | 4           |
| 4. GLOBAL NETWORK SERVICES  | 5           |
| 4.1 Non-connection-oriented services  | 5           |
| 4.2 Connection-oriented services  | 6           |
| 5. SUBNETWORK SERVICES (LAYER 3a AND LOWER LAYERS)                              | 10          |
| 5.1 Non-connection-oriented subnetworks   | 10          |
| 5.2 Connection-oriented subnetworks   | 11          |
| 6. SUBNETWORK-ENHANCEMENT LAYER (LAYER 3b)                                      | 12          |
| 7. THE SUBNETWORK INTERCONNECTION LAYER (LAYER 3c)                              | 13          |
| 7.1 General   | 13          |
| 7.2 Routing and addressing  | 14          |
| 7.3 The interconnection rules   | 15          |
| APPENDIX A - LANs IN THE OSI REFERENCE MODEL                                    | 17          |
| A.1 General   | 17          |
| A.2 Some possibilities of Incorporating LANs in the Reference Model             | 18          |
| A.3 Hybrid Applications   | 20          |
| APPENDIX B - ENHANCEMENT REQUIREMENTS FOR CONNECTIONLESS (DATAGRAM) SUBNETWORKS | 25          |
| APPENDIX C - NETWORK LAYER ADDRESSING   | 27          |
| C.1 Introduction  | 27          |
| C.2 What is a Global Network Address?   | 27          |
| C.3 Internal Structure of the Network Layer                                     | 28          |
| C.4 General Structure   | 30          |
| C.5 The relation between SNAPAs and NSAPAs                                      | 30          |
| C.6 The relation between routing and addressing                                 | 31          |
| C.7 Other sublayer considerations   | 31          |
| C.8 Issues  | 32          |
| APPENDIX D - THE ROAD CONCEPT   | 33          |



## 1. INTRODUCTION

This Technical Report reflects the current understanding of the architectural aspects of the Network Layer, as defined in the Reference Model for Open Systems Interconnection.

It is felt that the principles to be used for interconnecting a number of (heterogeneous) networks are of prime importance for the Network Layer structure and therefore it is this aspect that dominates this document.

## 2. GENERAL STATEMENTS

- 2.1 Public networks, private networks and local area networks usually impose their own access protocols and address conventions on their users. Therefore, no architectural distinction is made between these networks, and all should be adequately dealt with as sub-nets of the Global network.
- 2.2 According to the Reference Model, a layer may be divided into sublayers. Every sublayer is a grouping of functions that can be bypassed in certain cases. In no way can all functions of all sublayers be bypassed in such a way to achieve a null functionality layer.  

The sub-layering technique will be used for the Network Layer. Sub-layering of the Network Layer should be regarded as being subject to recursive extension downwards, i.e. repeated nesting of networks down to the Link Layer.
- 2.3 The service provided by a sublayer to its adjacent higher (sub) layer may be subject to formal definition. This does not hold for the specification of inter-sublayer interfaces.
- 2.4 Interconnection of subnetworks is only possible if the services provided by both subnetworks are equivalent. If this is not the case, either a common subset of the services has to be chosen (subnetwork de-enhancement) or a new (subnet-enhancing) sublayer has to be added on top of a "poor" subnetwork to achieve equivalent subnet services.
- 2.5 This interconnection of subnetworks providing equivalent services implies a well defined cross-mapping of subnet service primitives.
- 2.6 Interconnection of subnetworks can be done either on a connectionless basis or on a connection basis. In the first case the subnets to be interconnected do not necessarily need to provide connection-oriented services. In this case the Global Network service will be connectionless.  

In the second case the subnets to be interconnected, possibly enhanced, as in 2.4 above, need to provide connection-oriented services. In this case the Global Network service will be connection-oriented.
- 2.7 Attention will be initially focussed on the provision of a connection-oriented network service, i.e. the second case of 2.6.



- 2.8 The network service comprises a standard connection-oriented service and a standard connectionless service. No optional services are provided.

### 3. ARCHITECTURE

#### 3.1 General

The architecture of the OSI Network Layer is based on the following concepts:

- the Global OSI network service concept
- the Subnetwork concept
- the Gateway concept.

#### The Global OSI network service concept

The Global OSI network service is defined as the abstract machine to which the transport entities of all OSI end-systems are attached, and which provides the means for data transfer between all these OSI transport entities.

#### The Subnetwork concept

A Subnetwork is defined as any collection of equipment and physical media which forms an autonomous whole and which can be used for interconnecting a number of end-systems. Examples of such subnetworks include:

- commonly recognized, common carrier supplied public networks,
- privately supplied and utilized networks,
- local area networks.

Subnetworks are usually characterized by the fact that they impose their own interfacing requirements (access protocols) on their users.

The term "subnetwork" may also be applied to collections of subnetworks interconnected such that, to their users, they can be treated as a single subnetwork.

#### Gateways

Not all subnetworks provide addressability of, and accessibility to, all existing OSI end-systems. Therefore, the OSI Global network service will in practice comprise a (large) number of individually designed and administered public, private wide area, and private local area subnetworks offering different services and imposing different interfacing requirements (access protocols). Such subnetworks cannot be interconnected directly. Gateways are needed to perform the necessary adaptations (see Fig. 1).

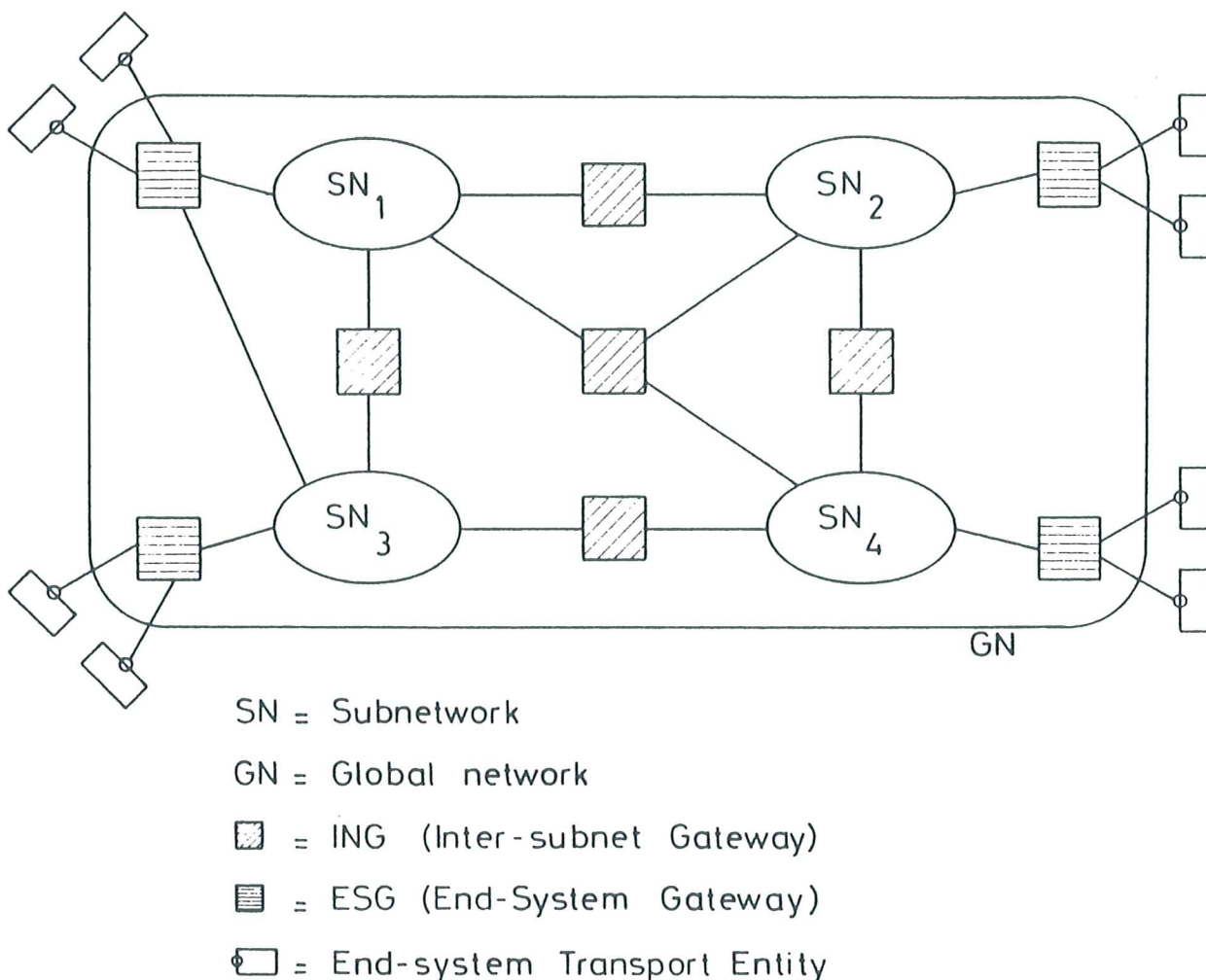


Fig. 1. Subnetwork Interconnection by Gateways

Two types of gateways are distinguished:

- Gateways which are placed between subnetworks. These gateways are called Inter Subnet Gateways (INGs).
- Gateways which are placed between End-System Transport Entities and Subnetwork(s). These are called End-System Gateways (ESGs).

### 3.2 More about ESGs

The existence of ESGs is usually ignored. They are, however, of prime importance because they contain all functions needed to provide the Transport Entities in End Systems with the illusion that they are attached to one single Global network. Indeed, all functions and protocols needed to combine the subnetworks into one Global network are placed in the complete set of gateways, and it is the specific task of the ESG to mask for the Transport entities in End Systems the existence of the individual subnets and the individual gateways.

3.3 Recursive extension

In many cases, subnetworks may be constructed as a combination of lesser (lower levels) subnetworks. The same architectural principles then apply recursively. Ultimately any Link Layer can in fact be considered as a (simple) subnetwork, usually providing a number of fixed link-connections, and interconnected by "gateways" according to the same architectural principles. Any level 2 protocol may therefore conveniently be regarded as a level 3 subnet protocol.

3.4 Some implementation aspects of gateways

The gateways described above are functions that may be implemented in a variety of ways:

- An ING function may be implemented in separate equipment, or in one or several pieces as additional (software) modules in existing subnetwork equipment.
- An ESG function may be implemented in separate equipment, or in existing subnetwork equipment. In these cases the Global network interface corresponds to the Global network access protocol across the physical boundary between the End System and the Global network.
- An ESG function may also be implemented in the existing End System. In that case the Global network interface corresponds to the (conceptual) interface between layer 3 and layer 4 in the End System, and that the End System is involved in all internetting activities of the ESG.

3.5 The architecture of a gateway

The architecture of a gateway is based on splitting the network layer into three sublayers 3a, 3b and 3c (see Fig. 2). Layers 1, 2 and 3a are subnet specific and exist to implement the different subnet access protocols.

To the transport entity in an End System (only applicable for ESG)

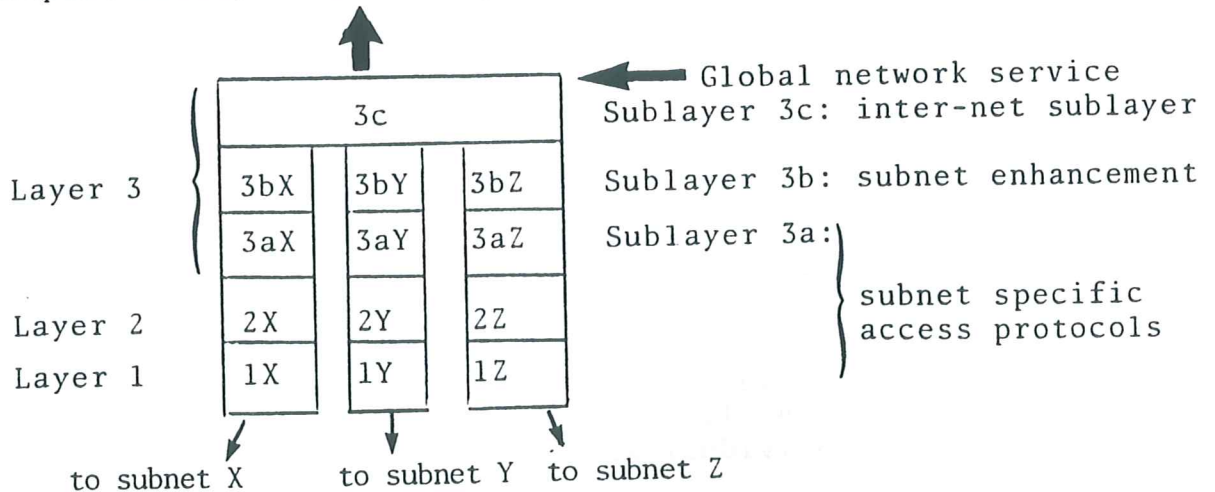


Fig. 2 - General Architecture of a Gateway



Sublayer 3b provides any subnet specific enhancement protocols needed to achieve a subnet-service level, required by layer 3c.

Sublayer 3c performs all service primitive cross-mapping and routing functions.

A transport entity in an End System is attached to the "top-side" of sublayer 3c of an ESG. Hence the only essential difference between an ESG and an ING is the possibility of attaching a transport entity to the gateway in case of an ESG, and to concatenate two subnetworks in case of an ING. In all other aspects both gateway-types are equivalent. Some gateways can have both functionalities.

NOTE 1

*Layer 3c expects from layer 3b that equivalent services are offered. Only in that case is interconnection possible (see section 7 hereafter).*

NOTE 2

*Layer 3b has a null functionality if the service provided by the corresponding subnet is sufficient to facilitate proper functioning of layer 3c.*

NOTE 3

*Layer 3a has a null functionality if the access protocol of the corresponding subnet does not contain a layer higher than layer 2.*

NOTE 4

*In any case, not all the sublayers may have null functionality.*

NOTE 5

*Further details of sublayers 3a, 3b and 3c are given in the subsequent sections.*

#### 4. GLOBAL NETWORK SERVICES

A Global network can be connection-oriented or non-connection-oriented. There are different services corresponding to these two categories of Global network.

In both cases the Global network provides for an exchange of user data called network service data units (NSDUs) in both directions simultaneously.

In addition, in the case of a connection-oriented Global network, the Global network provides services to establish a network connection between two end users.

All services provided by the Global network services are standard. No options are defined, for the simple reason that network service options always complicate the transport protocol.

##### 4.1 Non-connection-oriented services

In this category, Global network services are related to data transfer only.

The network data units are restricted to a defined maximum length. NSDUs can be lost or possibly duplicated by the network without notification and are not always delivered in sequence. It is felt that possible duplication of NSDUs causes greater complexity for transport protocol than loss of NSDUs and that loss should be preferred to duplication if this alternative exists. There is no flow control provided by the Global network.

The following primitives are provided to transfer NSDUs:

- N-DATA Request (remote global address of destination, user data)
- N-DATA Indication (remote global address of source, user data).

Usually the quality of service will be pre-known by the transport entities. The quality of service is expressed, for example, in terms of:

- maximum probability of garbling of a delivered NSDU,
- maximum NSDU lifetime within the network.

Complete definition of quality of service for the non connection oriented global network services is for further study.

NOTE 6

*The local global address is assumed to be always available.*

## 4.2 Connection-oriented services

The global network services provide for the establishment and termination of network connections, and for transfer of network service data units across an established network connection. Network connections are always point-to-point connections.

### 4.2.1 Model of a network connection

A property of a network connection is that it exerts back pressure flow control over the rate at which a Network Service User Source entity can issue Network Service Primitives.

To understand the concept of back pressure a connection may be modelled as a queue. For these purposes a queue relates an ordered set of NSDUs such that:

- a) NSDUs are removed from the queue only in response to requests from the Network Service User sink entity.
- b) NSDUs are removed in the same order that they were added.
- c) The number of NSDUs which may be present in the queue is finite but the maximum number is not necessarily either fixed by the NS provider or determinable by the NS user.



- d) NSDUs can only be added if the queue is not full, as determined by the NS provider.
- e) Queues are empty when created by the service provider and can be returned to this state, with loss of their contents, by the Network service provider.

A queue expresses a flow control function; the ability of a user to issue primitives adding NSDUs to the queue will be determined by the behaviour of the user removing NSDUs from the queue and the state of the queue.

NOTE 7

*Although the queueing model is adequate to explain the concept of back pressure flow control, it is a matter of continuing study as to whether this simple model is adequate as a model describing all the externally visible attributes of a connection that must be known to both the source and sink users of the connection.*

*Of particular concern are the relationships, if any, existing to be defined between throughput, transit delay and length of queue, all of which are stochastically variable.*

*Given that relationships do exist to be defined, then like throughput and transit delay, the queue length must also be visible to a user. Such knowledge is seen as being a pre-requisite both of efficient use of User Resources and efficient use of the connection as a resource.*

*The model of a connection not as a queue but as a delay line (or combination of queue and delay line) is seen as a model potentially able to resolve this difficulty of user visibility of queue length. Both models are the subject of continuing study.*

#### 4.2.2 Classification of Network service failures

For the purposes of specifying the basic Network services required to support OSI end systems the following classification of Network service failures are defined:

1. Failures involving the termination of a connection (see 4.2.3.1).
2. Failures involving loss of User Data without loss of the connection (see 4.2.5).
3. Failures involving a loss of ability to provide the negotiated quality of service but without loss of either User Data or the connection (see 4.2.6).

Of these classes of failure 1 and 2 are dealt with as issues of concern to the Network Layer protocol, and hence as issues requiring the definition of appropriate Network Service Primitives and/or parameters of primitives.

Failures in class 3 are seen as issues potentially of concern to Network Management Functions. The subject of how distributed Management Functions intercommunicate and how for both OSI end systems and inter subnetwork gateways,

they are distributed between "in-Layer" and "Application Layer" Network Management Functions is a subject of study within the context of the overall Reference Model.

To avoid any pre-empting of the results of these studies no provision is made in the Network service description at this time for primitives and/or parameters relating to class 3 failures.

#### 4.2.3 Connection establishment and termination services

These services provide one or more connections between two communicating transport entities. The transport entities represent the end system, i.e. the system containing the communication application entities. Transport entities are uniquely identified to other transport entities and the Global network service by the Global network address. More than one Global network connection may exist between the same pair of Global network addresses.

The quality of service related to a network connection will be negotiated during the establishment phase, and maintained by the Global network service for the duration of the connection.

##### 4.2.3.1 Service primitives

The following service primitives are provided to establish a global network connection:

|                         |   |
|-------------------------|---|
| GN-CONNECT Request      | (remote global address of destination, quality of service)                      |
| GN-CONNECT Indication   | (GNC end point identifier, remote global address of source, quality of service) |
| GN-CONNECT Response     | (GNC end point identifier, quality of service)                                  |
| GN-CONNECT Confirmation | (GNC end point identifier, quality of service)                                  |

##### NOTE 8

*The local global network address is assumed to be always implicitly available.*

The following service primitives are provided to terminate or refuse a network connection (see 4.2.2):

|                          |                            |
|--------------------------|----------------------------|
| GN-DISCONNECT Request    | (GNC end point identifier) |
| GN-DISCONNECT Indication | (GNC end point identifier) |

The use of network connection termination is permitted at any time regardless of the current network connection phase. This allows refusal of an N-connect indication by means of an N-disconnect request.



The network service does not guarantee delivery of any data once the termination phase is entered.

#### 4.2.3.2 Quality of Service parameters

Quality of service is expressed in terms of the following characteristics:

- minimum throughput
- maximum transit delay
- maximum error rate
- maximum set up delay
- maximum acceptable duration cost
- maximum acceptable traffic cost

#### 4.2.4 Data Transfer services

The global network data transfer service provides for the transparent exchange of network service data units between transport entities over network connections. The internal structure and meaning of NSDUs is exclusively determined by the submitting transport entities and is not known to network service provider.

The flow of NSDUs across the network connections is controlled by the receiving transport entity, through back pressure at the network service access point (see 4.2.1).

NSDUs are always delivered in sequence and cannot be duplicated by the global network service within the range of the agreed quality of service. NSDUs cannot be lost by the Global network except if indicated by a network originated reset indication. The Global network must guarantee throughput, transmission delay, and residual error rate (non detected errors) asked for by the Global network user at connection time.

NSDUs have a distinct beginning and end and their integrity is maintained by the network service. The maximum NSDU size is not restricted by the network service, that means that the Global network must be able to segment an NSDU into several NPDUs, if needed.

The following service primitives are provided to transfer NSDUs:

|                    |                                       |
|--------------------|---------------------------------------|
| GN-DATA Request    | (GNC end point identifier, user data) |
| GN-DATA Indication | (GNC end point identifier, user data) |

Both primitives may be subject to back pressure flow control.

#### 4.2.5 Reset services

Invocation of the reset services causes the Global network to discard all NSDUs associated with the GNC and to notify the remote NS user that a reset has occurred. In

addition, reset is used by the Global network to indicate both ends of the network connection that an error has occurred with possible loss of data (see 4.2.2).

The reset services may be used by the network service user to resynchronize the use of the network connection and will unblock the flow of NSDUs. Invocation of reset may result in loss of NSDUs and consequently may require recovery mechanism to be effected at transport level.

No NSDU submitted prior to the invocation of the reset will be delivered after notification that the reset has occurred.

The following reset primitives are provided:

|                       |  |
|-----------------------|--|
| GN-RESET Request.     | (GNC end point identifier, user reason)            |
| GN-RESET Indication   | (GNC end point identifier, user or network reason) |
| GN-RESET Response     | (GNC end point identifier)                         |
| GN-RESET Confirmation | (GNC end point identifier)                         |

#### 4.2.6 Notice primitive

The Notice primitive is the subject of further study. Such a primitive is seen as being required to support the classification of network failures specified in section 4.2.2 with respect to loss of network service provider ability to maintain a negotiated quality of service. Such loss of ability is seen as having management implications which are the subject of study within the context of the OSI model as a whole. A Notice primitive may or may not be defined as an element of the network service dependent on the outcome of these studies.

### 5. SUBNETWORK SERVICES (LAYER 3a AND LOWER LAYERS)

There are two categories of subnetworks: non-connection-oriented subnetworks (datagram subnetworks, local area subnetworks, etc.) and connection-oriented networks (circuit-switched subnetworks, packet-switched subnetworks providing the virtual-circuit service).

#### 5.1 Non-connection-oriented subnetworks

##### 5.1.1 Datagram subnetworks

The services provided by datagram subnetworks are identical to non-connection-oriented global network services.

##### 5.1.2 Local area subnetworks

To be supplied later.



## 5.2 Connection-oriented subnetworks

Three kinds of subnetworks are considered: leased, circuit-switched and packet-switched.

### 5.2.1 Leased circuit subnetworks

A leased circuit subnetwork is a subnetwork that coincides with a link service provided by a link protocol placed on top of a given leased circuit (point-to-point or multi-point).

The services provided by a leased circuit subnetwork have indeed the same characteristics as connection-oriented global network services except that the length of NSDUs is restricted to a specific maximum and with quality of service specific to this kind of subnetwork (for example, there is only a duration cost and no traffic cost).

A leased circuit subnetwork has no layer 3a functionality. The connection establishment and termination service primitives are the following:

|                          |   |
|--------------------------|---|
| SN-CONNECT Request       | (local link address, remote link address, quality of service)       |
| SN-CONNECT Indication    | (SNC end point identifier, remote link address, quality of service) |
| SN-CONNECT Response      | (SNC end point identifier)  |
| SN-CONNECT Confirmation  | (SNC end point identifier)  |
| SN-DISCONNECT Request    | (SNC end point identifier)  |
| SN-DISCONNECT Indication | (SNC end point identifier)  |

In this case link addresses are used as subnetwork addresses.

The data transfer primitives are exactly the same as connection-oriented global network data transfer service primitives.

The reset primitives are also the same with one exception. The user or network reason parameter will not usually be provided in the reset request and reset indication primitives.

### 5.2.2 Circuit switched subnetworks

This covers both public circuit-switched data and telephone subnetworks used with a level 2 protocol for data transfer. Sublevel 3a only covers the call control procedures needed to access these networks.

The services have the same characteristics as connection-oriented global network services except that the length of NSDUs is restricted and with quality of service specific to this kind of subnetwork.

The connection establishment and termination service primitives are the following:

|                          |   |
|--------------------------|---|
| SN-CONNECT Request       | (remote subnetwork address, quality of service)                           |
| SN-CONNECT Indication    | (SNC end point identifier, remote subnetwork address, quality of service) |
| SN-CONNECT Response      | (SNC end point identifier, quality of service)                            |
| SN-CONNECT Confirmation  | (SNC end point identifier, quality of service)                            |
| SN-DISCONNECT Request    | (SNC end point identifier)  |
| SN-DISCONNECT Indication | (SNC end point identifier).   |

The data transfer primitives are exactly the same as those offered by connection-oriented Global network.

The reset primitives are also the same with one exception. The user or network reason parameter will not usually be provided in the reset request and reset indication primitives.

### 5.2.3 X.25 subnetworks

The services are exactly the same as those offered by connection-oriented global network basic services (with subnetwork address instead of global address in connect primitives).

It is known that X.25 subnetworks provide more services than those needed to support the standard global network service. These services will not be made available to the global network service users in order not to complicate the transport protocol (as indicated in section 4), and in order to avoid the need for enhancement of each subnetwork that does not provide these services.

This only holds for OSI systems and OSI protocols. It does not impose any constraint on non-OSI systems and non-OSI protocols.

## 6. SUBNETWORK-ENHANCEMENT LAYER (LAYER 3b)

Enhancement is only done in order to upgrade each subnetwork service to the level of the global network services.

In case of a non connection-oriented global network no enhancement is necessary on any subnetwork because all subnetworks offer at least connectionless global network basic services.

In case of connection-oriented global network, enhancement is necessary in the following cases:

- a) Datagram subnetwork: enhancement is necessary to provide connections and flow control on these connections. Enhancement may also be necessary for recovery of lost (or duplicated) datagrams. A protocol as defined for Class 4 in ECMA-72 can be used in order to provide the corresponding services.



- b) Local area subnetwork: enhancement may be necessary to provide at least flow control. This needs further study.
- c) Leased and switched circuit subnetwork: enhancement may be necessary to provide segmenting and reassembling. In this case the approach chosen by teletex may be a possible solution. Enhancement may also be needed with respect to the provision of the user or network reason parameter in the reset request and reset indication primitives.

One of the principle functions of the enhancement sublayer is to provide for the transfer of source and destination global network addresses across subnetworks, in the connection establishment phase, for those subnetworks making no provision for global addressing. For this reason the connection service primitives of the enhancement sub-layer will make provision for both subnetwork and global network address parameter fields, the second being handled by the subnetwork as data (see Appendix C, section 7).

The size of the global network address parameter field is the subject of further study. It is recognized that if CCITT Recommendation X.121-type global addressing is defined then the parameter fields must be at least 14 digits, or 14 octets overall.

## 7. THE SUBNETWORK INTERCONNECTION LAYER (LAYER 3c)

### 7.1 General

This layer is responsible for providing the global network service, as described in section 4, to the Transport Layer.

In section 4 two global network service categories were identified: connection-oriented and non-connection-oriented services.

The service primitives for both categories are given in Table 1 and 2.

The identification of these services is of prime importance for the interconnection task of layer 3c, because these services will always be required from the underlying layer 3b. These services are exactly the equivalent services that are needed to be able to interconnect subnetworks anyhow (see 3.5, Note 1).

|                          |
|--------------------------|
| GN-CONNECT Request       |
| GN-CONNECT Indication    |
| GN-CONNECT Response      |
| GN-CONNECT Confirmation  |
| GN-DISCONNECT Request    |
| GN-DISCONNECT Indication |
| GN-DATA Request          |
| GN-DATA Indication       |
| GN-RESET Request         |
| GN-RESET Indication      |
| GN-RESET Response        |
| GN-RESET Confirmation    |

Table 1

Service Primitives Offered by the Global  
Connection-Oriented Network Service

|                   |
|-------------------|
| N-DATA Request    |
| N-DATA Indication |

Table 2

Service Primitives Offered by the Global  
Non-Connection-Oriented Network Service

## 7.2 Routing and addressing

The following is the subject of continuing study. See Appendices C and D.

### 7.2.1 Addressing

Addressing constitutes an integral part of the network service definition. Two aspects should be distinguished.

- 1) Agreement on the acceptance of a global address space seems not to be sufficient. It is needed in addition that some authority claims (and gets) the responsibility for the allocation of addresses, so that duplicate (and other chaotic) use of these addresses is prevented. It is far from clear how this problem will be solved. Therefore, for the time being, the fact must be accepted that the use of addresses in an OSI environment will be a matter of co-operation and negotiation between all participants that want to communicate across a certain OSI based network.
- 2) Assuming that in practical situations agreement can be achieved on some ad hoc basis, it is of value to investigate the consequences of this acceptance for all OSI protocols that are needed. A first attempt is given in Appendix C.



### 7.2.2 Routing

The complete set of gateways has to be able to execute the routing function by interpreting global addresses offered by the transport entities in End Systems.

This does, however, not mean that each individual gateway should be able to manipulate global addresses. The use of "unintelligent" gateways is not excluded, provided that sufficient support is given by other more intelligent gateways to execute their task.

The most simplest and ideal situation is, however, achieved when all gateways have a complete knowledge of the global addressing conventions, and are able to base their routing decisions on the analysis of global network addresses.

### 7.3 The interconnection rules

The subnetwork Interconnection Layer (3c) performs its task as follows:

- It executes all routing functions, based on analysis of global network addresses (see 7.2 above).
- If a connection-oriented global network service has to be offered, it requires from the underlying layer 3b exactly the same primitives as listed in Table 1 of section 7.1. Each Inter-Subnetwork Gateway will then cascade a certain subnetwork connection with a subnetwork connection constituting the subsequent hop, by cross-mapping of the mentioned service primitives in a straightforward way.

#### NOTE 9

*The specification of collision resolutions is a non-trivial, but integral part of this cross-mapping.*

- If a non-connection-oriented global network service has to be offered, it requires from the underlying layer 3b exactly the same primitives as listed in Table 2 of section 7.1. Each Inter-Subnetwork Gateway will then route individual internet-protocol data units on basis of the analysis of their global network address.

... situations  
... it is  
... of this ac...  
... needed. A fir...  
C... ..

## APPENDIX A

### LANs IN THE OSI REFERENCE MODEL

#### A.1 General

This Appendix discusses methods of incorporating LANs in the OSI Reference Model. The material of this Appendix is the subject of continuing study in Technical Committee ECMA TC24.

Having regard to the definition of "System" as given in ISO DP 7498, section 4.2, and subnetwork as defined in ISO/97/6 N2228 there are two extreme cases of LAN applications to be considered within the framework of OSI:

##### Case 1

The ALN exists as the information transfer means between the various elements comprising an End System or a number of End Systems.

##### Case 2

The LAN exists as a subnet of the OSI Global network for the purposes of interconnecting complete End Systems.

Between these extremes exist the hybrid applications where the LAN is used both to interconnect the elements comprising an End System (or a number of End Systems) and to interconnect complete End Systems; only complete End Systems being addressable at the Network Layer from outside the LAN.

For Case 1 the Reference Model does not impose, nor can it impose, any constraints on the way in which an End System is implemented with respect to its internal architecture or the internal protocols used to support its architecture. Indeed, conformance to the Reference Model within an End System is entirely a matter of free choice within the context of OSI standardization. Other architectures and protocols are not only possible and permitted within the framework of OSI, they can confidently be anticipated.

This is not to say that, within the context of LAN standardization, an OSI-like architecture may not be adopted and imposed to meet the objectives of LAN standardization. This again is an eventuality that may also be anticipated.

For Case 2, the Reference Model imposes conformance on all LAN terminals, because these terminals now coincide with End Systems in the full OSI sense of the word.



It is quite clear that unless an internal architecture compatible with OSI is adopted for Case 1 then the problem of designing dual-purpose systems able to exist either as LAN terminals or as OSI End Systems will be magnified.

The next section is an attempt to classify the different possibilities that may occur.

#### A.2 Some Possibilities of Incorporating LANs in the Reference Model

In accordance with the considerations expressed above, different possibilities can be identified. These possibilities are ordered on the basis of the degree to which conformance with the Reference Model is pursued. Possibilities 1 and 2 are related to Case 1 above, and possibility 3 is related to Case 2.

1) Possibility 1: The LAN architecture is chosen without striving for any conformance with the Reference Model

This is a completely legitimate approach, provided the LAN is considered as existing within an OSI Open System. The internal LAN architecture then may or may not be layered. If a layered structure is chosen, it need not be in accordance with the Reference Model. The only constraint is that the gateway between the End System LAN and the OSI Global network incorporates an Application Layer relay masking (making invisible) all internal protocols below the Application Layer down to and including the Physical Layer (see Fig. 1).

2) Possibility 2: The LAN architecture is chosen, striving for some degree of conformance with the Reference Model but still retaining the LAN as an externally invisible component of an End System

If this approach is chosen, then several possibilities can be identified, the extremes of which are indicated as possibilities 2a and 2b below.

Possibility 2a The gateway between the End System LAN and the Global network incorporates an Application Layer relay masking all internal protocols below the Application Layer down to and including the physical media. However, if maximum conformance with the Reference Model is aimed, a seven-layer architecture can be chosen for the LAN, similar to the OSI layered structure (see Fig. 2).

For this case:

- One (or more) of the protocol classes as defined in ECMA-72 may be used as the "internal layer 4" LAN protocol (in Fig. 2 this is indicated as layer 4'). If so, it will not be externally visible.
- The internal counterpart of the OSI sub-layer 3(c) will be restricted to local addressing in accordance with whatever conventions are adopted within the End System. Such conventions will again have no external visibility.
- Internal LAN protocols (layers 1 and 2) will be technology dependent, unconstrained by the OSI Reference Model and again not externally visible.

Possibility 2b The gateway between the End System LAN and the Global network incorporates a Transport Layer relay masking all internal protocols at and below the Transport Layer.

For this case:

- The Transport Layer relay is not externally visible. It may be regarded, in effect, as an element of a distributed form of End System Transport entity externally visible as any other End System Transport entity.
- The protocols operating above the Transport Layer become externally visible and must conform to OSI Standards.
- The protocols operating below the Transport Layer can be freely chosen (Fig. 3). However, if the aim of maximum conformity with the Reference Model is to be achieved layers 1 up to and including layer 4 can be chosen for the LAN similar to the corresponding OSI layered structure (see Fig. 4).

Possibility 2c Between the extreme cases of possibility 2a possibility 2b all other possible cases of Session, Presentation and mixed Transport/Session/Presentation/Application Layer relaying can be identified.

Above the relay functions of whatever form, the internal architecture conforms to OSI standards and has external visibility. Below the relays all internal protocols are invisible and unconstrained by the Reference Model.



3) Possibility 3: The LAN exists as a subnet of the OSI Global net for the purpose of interconnecting complete End Systems

This case is a simple progression of possibility 2b above in which the gateway between the LAN and the external network becomes a Network Layer relay (see Fig. 5).

At this point the LAN becomes, by definition, a subnetwork of the global network. As for the previous cases the internal architecture above the relay function becomes externally visible and is required to conform to the Reference Model.

All devices attached to the LAN contain independent Transport Layer entities addressable both internally and externally by their Global network addresses.

As for all subnets of the OSI Global Network the internal LAN protocols are technology dependent and unconstrained by the OSI Model.

For this case, LAN terminals are constrained to implement global network addressing at the 3(c) sub-layer. They are also constrained to implement a full Transport layer function as opposed to the relaying function for possibility 2b.

A.3 Hybrid Applications

A hybrid application of a LAN is defined in this context as an application in which the LAN is used to both interconnect the elements comprising an End System (or a number of End Systems) and to support communication between complete End Systems.

For such applications the following considerations apply:

- For coexistence on the same LAN all the End System elements and complete End Systems attached to the LAN must implement the same internal LAN protocols and satisfy local addressing conventions.
- For the complete End Systems attached to the LAN the local addressing conventions will exist as subnetwork addressing conventions (layer 3b or below).
- For the complete End Systems attached to the LAN, global network addressing conventions must be observed and they must incorporate a 3(c) sublayer.

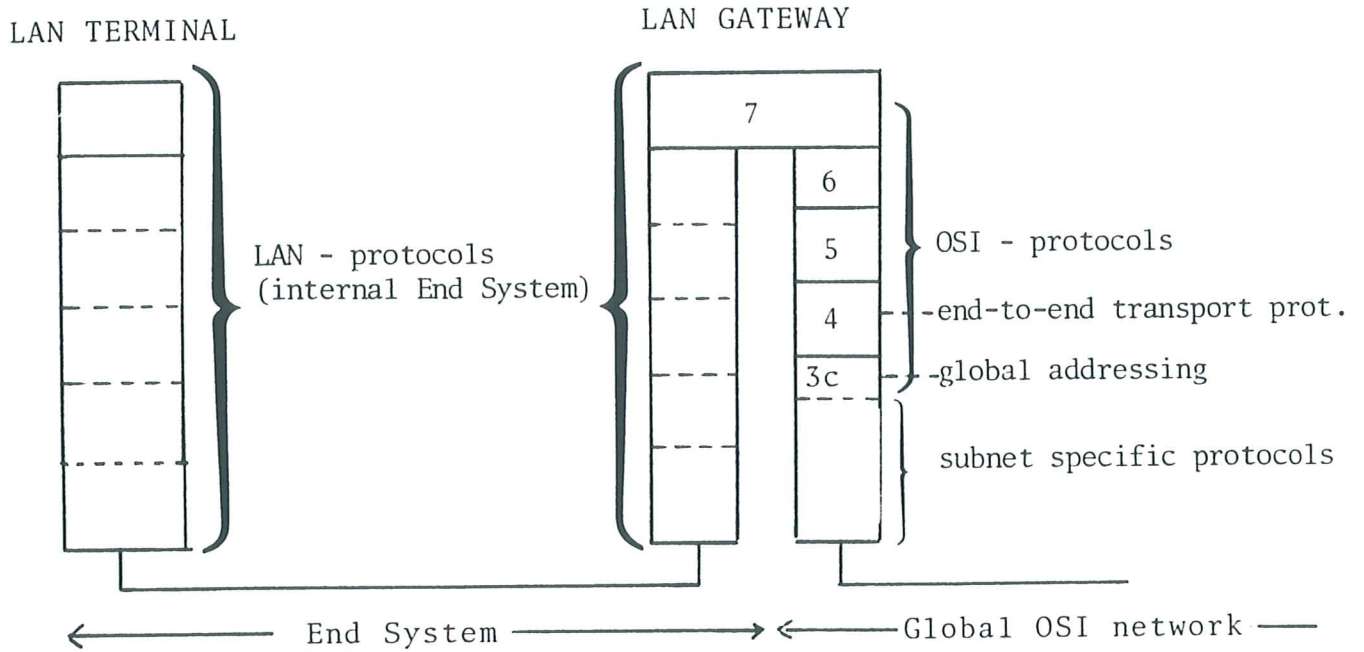


Fig. 1 : Application Layer relay in gateway, facilitating the choice of an "internal" LAN architecture which is not constrained by the Reference Model

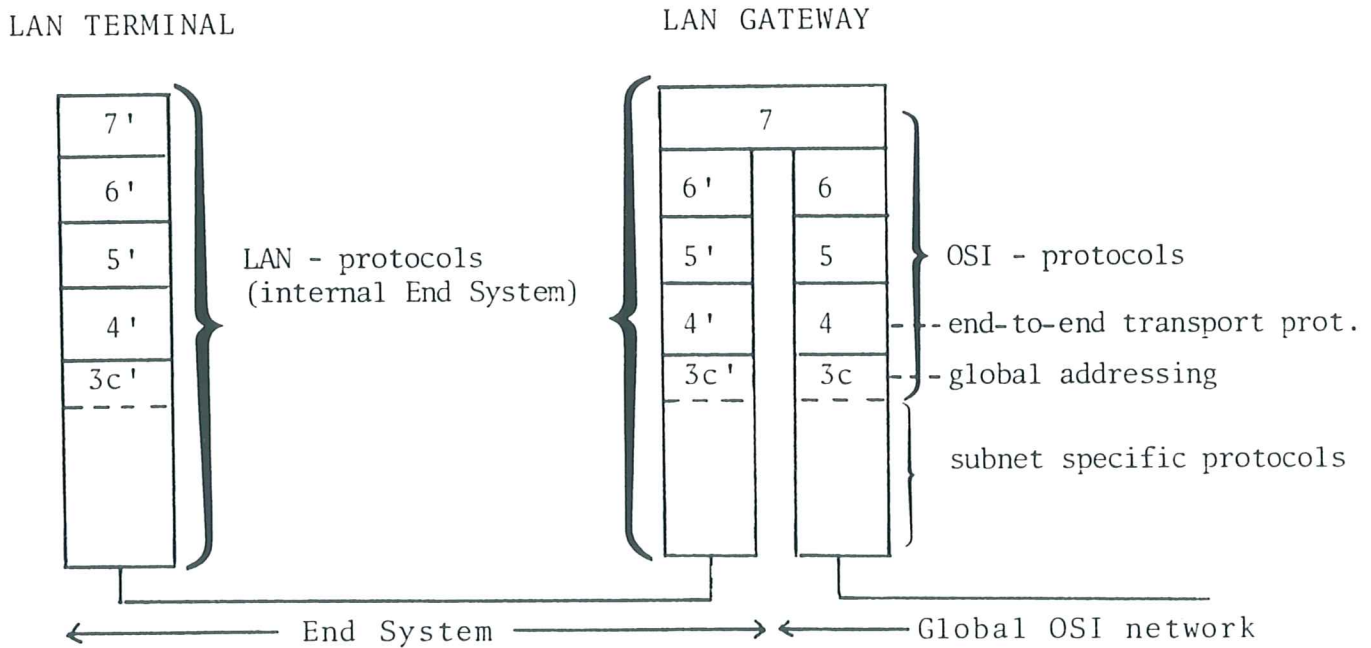


Fig. 2: Application Layer relay in gateway, combined with the choice of an "internal" LAN architecture which maximally conforms to the OSI Reference Model

LAN TERMINAL

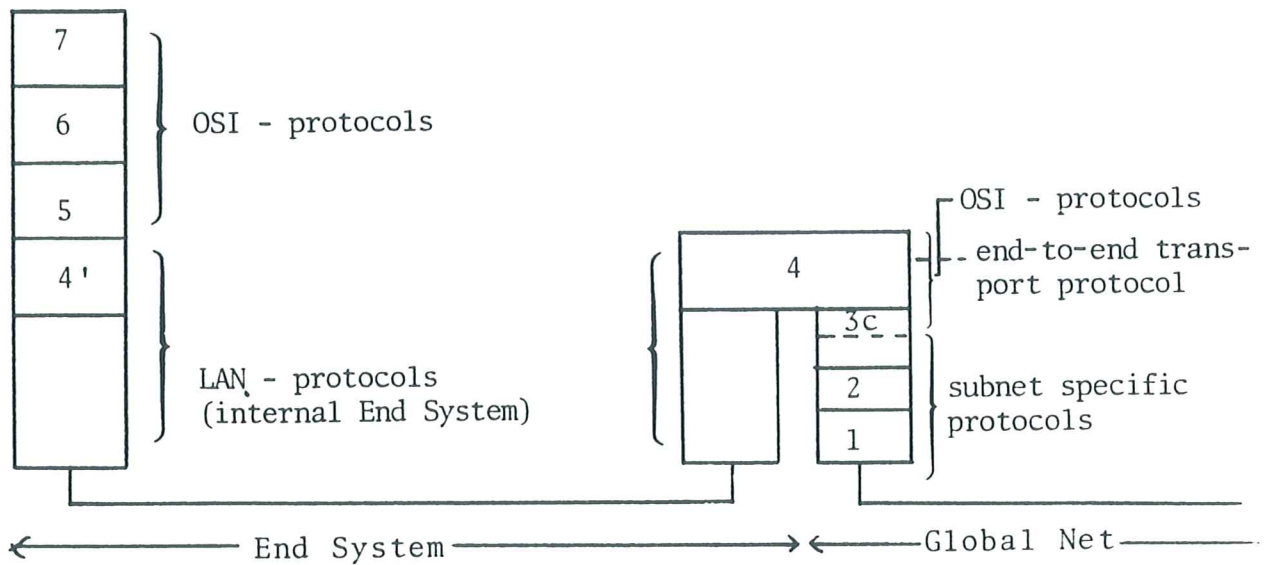


Fig. 3: Transport Layer relay in gateway, imposing OSI-Protocols above layer 4 on all LAN terminals but making no assumption on the LAN specific protocols used

LAN TERMINAL

LAN GATEWAY

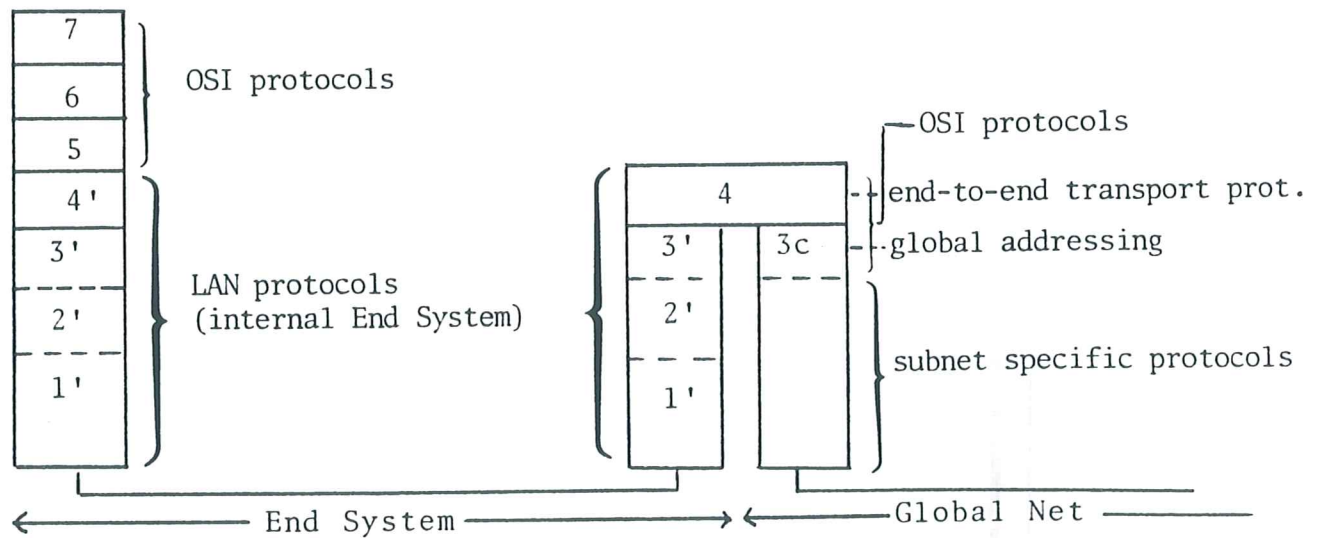


Fig. 4: Transport Layer relay in gateway, imposing OSI propocols above layer 4 on all LAN terminals, combined with the choice of an "internal" LAN architecture at and below layer 4 which maximally conforms to the OSI Reference Model



LAN TERMINAL

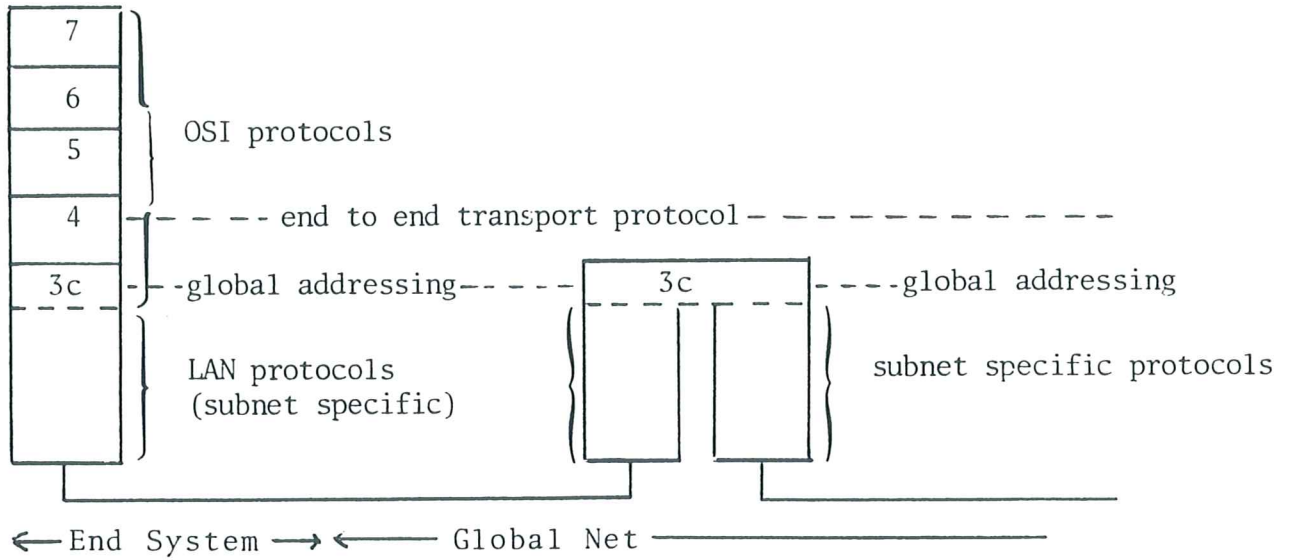


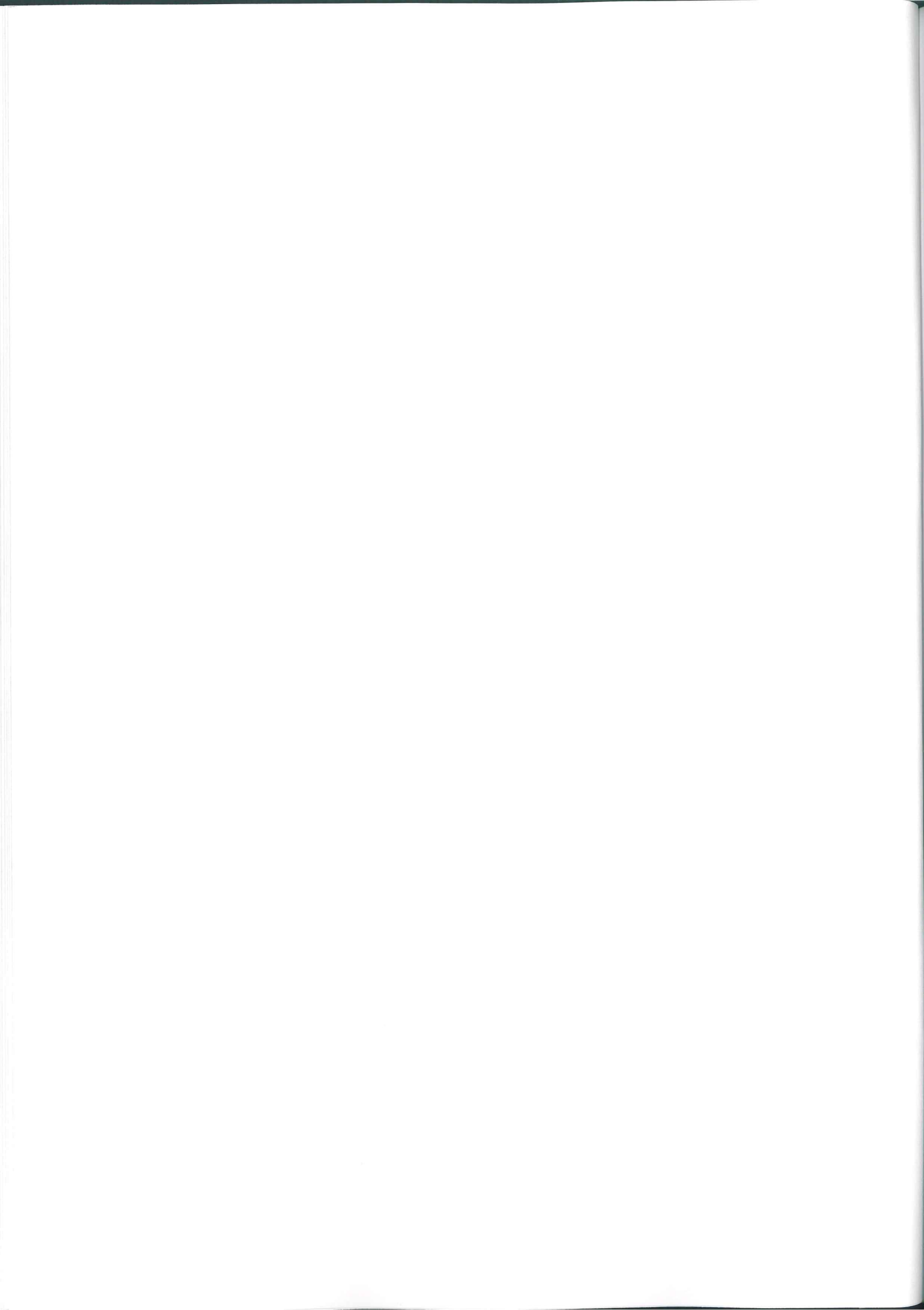
Fig. 5: Standard Global net gateway, imposing LAN-independent OSI protocols at and above layer 3c on all LAN terminals

1951  
1952  
1953  
1954  
1955  
1956  
1957  
1958  
1959  
1960  
1961  
1962  
1963  
1964  
1965  
1966  
1967  
1968  
1969  
1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025

APPENDIX B

ENHANCEMENT REQUIREMENTS FOR CONNECTIONLESS (DATAGRAM)  
SUBNETWORKS

- B.1 According to ISO/TC97/SC16 N 566: "Report of the ad hoc Group on Connectionless Data Transmission", the notion "connection" does not necessarily imply the maintenance of sequence integrity, and the notion "connectionless" does not necessarily imply that sequence integrity will not be maintained.
- As an example, certain Local Area Networks provide an extremely low probability that frames will be lost, duplicated or received out of sequence, although these networks are usually classified as "connectionless".
- B.2 If connectionless subnetworks are used to construct a connection-oriented Global OSI network service, then these subnetworks require the addition of a subnetwork enhancement protocol (layer 3b) to convert them into connection-oriented subnetworks, according to section 6.
- B.3 This enhancement includes as a minimum:
- the provision of connection setup, disconnect, and user generated reset services;
  - the provision of flow control facilities relating to the connection.
- B.4 In accordance with B.1 above, this enhancement does not necessarily imply recovery from lost, duplicated or out of sequence NSDUs. This type of enhancement is only needed if the probability of occurrence of these phenomena is considered as unacceptable.



## APPENDIX C

### NETWORK LAYER ADDRESSING

#### C.1 Introduction

This Appendix gives a preliminary analysis of Network Layer addressing, aiming at establishing some basic principles and identifying key issues.

#### C.2 What is a Global Network Address?

DP 7498 defines an Open System as a collection of "real" resources. These Open Systems are modelled as having a layered structure, facilitating the definition of protocols and services needed to support communication between these Open Systems.

Layer 4 is identified as the "Transport Layer", and contains logical entities, called "transport entities". The OSI network service is defined as an abstract machine, that facilitates the transfer of data between these transport entities. Transport entities are attached to Network Service Access Points, each identified by a "network service access point address" (NSAPA). Hence, the "users" of the OSI network service are: "transport entities". The OSI network service identifies these users by NSAPAs.

Because transport entities as well as NSAPAs are abstract notions, the network service itself is an abstract notion, and should not be confused with the physical network, interconnecting physical open systems (Fig. 1).

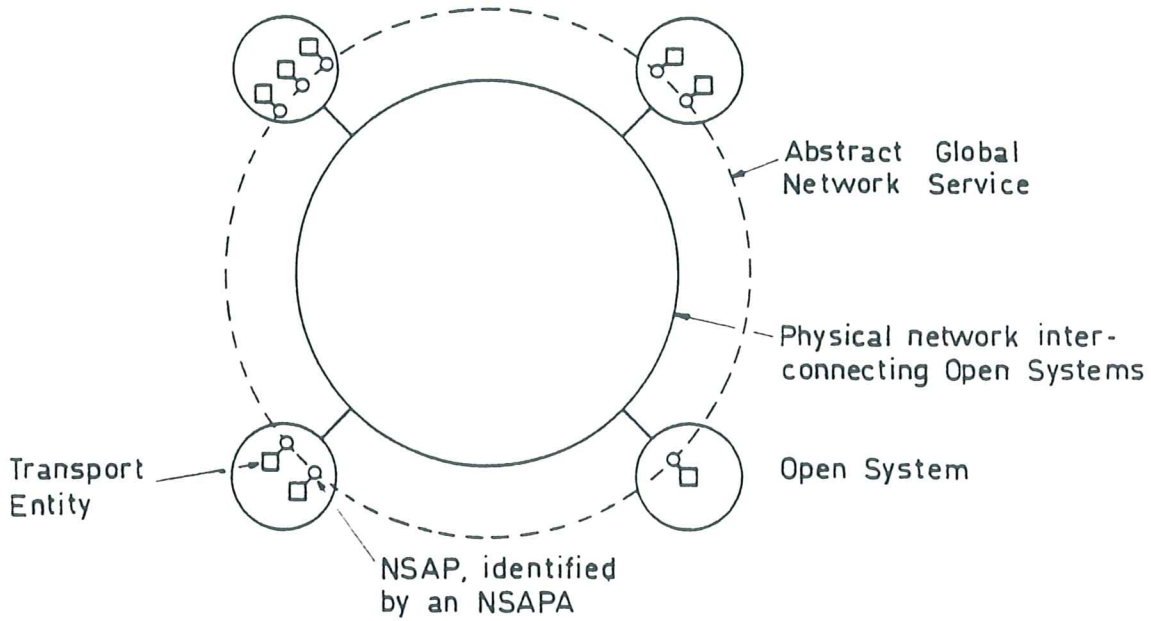


Fig. C.1 The Abstract OSI Global Network Service

In order to distinguish the notion "OSI network service" from the notion "subnetwork service", the OSI network service is denoted as the Global Network Service.

### C.3 Internal structure of the Network Layer

Network Layer addresses identify transport entities between which Network Layer functions support routing. The first step is to determine what are the objects to be identified within the Network Layer to facilitate this routing function.

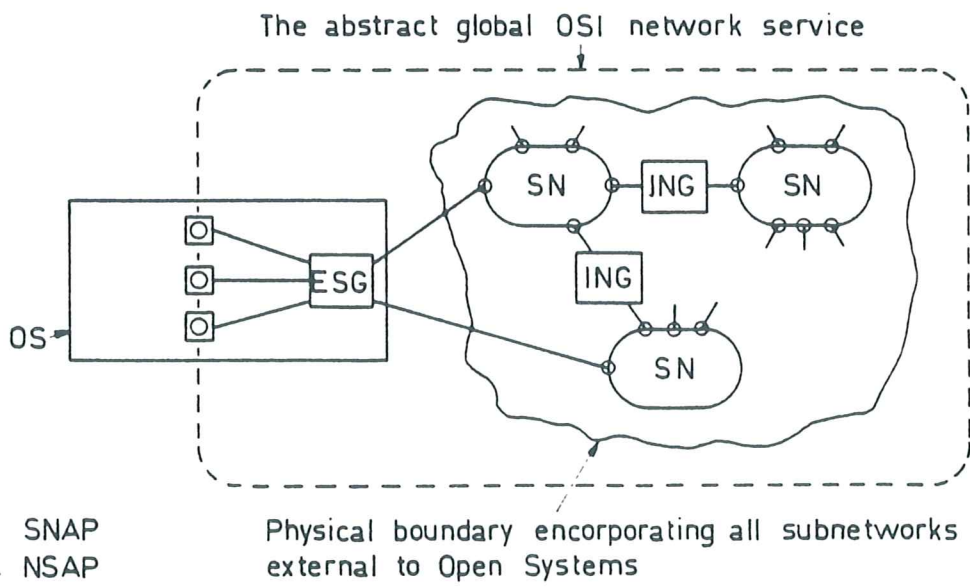


Fig. C.2 Network Layer Objects



OS = Open System  
NSAP = Network Service Access Point  
ESG = End System Gateway  
ING = Inter Subnet Gateway  
SN = Subnetwork  
SNAP = Subnetwork Access Point

A preliminary list of corresponding identifiers is:

OS-ID = Open System Identifier  
NSAPA = Network Service Access Point Address (pointing to one transport entity)  
ESG-ID = End-System-Gateway Identifier  
ING-ID = Inter-Subnetwork-Gateway Identifier  
SN-ID = Subnetwork Identifier  
SNAPA = Subnet-Access-Point Address

Simplification can be achieved (without introducing any constraint) as follows:

#### OS-ID

If there is one ESG per OS, then ESG-ID and OS-ID are equivalent. Therefore the OS-ID can be deleted by the requirement to identify an Open System by its ESG.

No need can be identified to facilitate more ESGs per OS, as the identification of more transport entities within an Open System can conveniently be done by means of NSAPs, and the possible attachment of the Open System to more SNAPs has by definition to be masked at the NSAP level.

#### ING-ID

There is no need to identify an ING, because it contains by definition no sink or source of data. If a system, that contains an ING, needs to be identified (e.g. for management-oriented functions) it should simply incorporate an ESG in addition to the ING.

This reduces the list of objects that need to be identified to:

- NSAPA
- ESG-ID
- SN-ID
- SNAPA

#### NOTE C.1

*The benefits of facilitating multiple NSAPs per single ESG is not quite clear, as long as its relation to transport addressing is not clarified. It may be argued that identification of logical entities within one Open System is already supported by the addressing capability of the Transport (and higher) Layer(s). Therefore, if it can be agreed that multiple NSAPs per ESG and (hence per Open System) are not needed, then a significant further simplification can be introduced by identifying NSAPs by its ESG-ID only. This is for further study.*

#### C.4 General Structure

With regard to the general address structures, the following is proposed:

- Each ESG is known by its unique ESG-ID within the OSI Global network.
- Each NSAP is identified within the Global network by its unique NSAPA, which is the ESG-ID with an additional element (suffix) to distinguish between multiple NSAPs (however, see also the note in section 3 above).
- In order to support the routing task of the Network Layer (sublayer 3c), it is convenient to identify each SN by means of its SN-ID with a value universally unique within the Global network.
- Each subnetwork has its own autonomous addressing scheme by which it identifies its access points. Therefore, an SNAP can be identified by its unique SNAPA consisting of the SN-ID concatenated with an additional element (suffix), being the address corresponding to the own autonomous addressing scheme of that subnetwork.

Hence it is concluded that:

- an SNAPA is constructed as an SN-ID concatenated with a suffix,
- an NSAPA is constructed as an ESG-ID concatenated with a suffix.

#### C.5 The relation between SNAPAs and NSAPAs

Given the three sublayer architecture of the Network Layer, it is obvious that layer 3c has the responsibility of mapping NSAPAs into SNAPAs.

According to section 5.4.2 of DP 7498 this can be done in two ways:

- either as "hierarchical network address mapping", or
- as "network address mapping by tables".

The first method is clearly the simplest. Unfortunately, this method is inappropriate because, according to the same section of DP 7498, this mapping method cannot be chosen "if an (N) address can be mapped into several (N-1) addresses", meaning in the context of sublayer 3c: if an NSAPA can be mapped into several SNAPAs. Considering Fig. 2 above, this is clearly the case, because one gateway can be connected to more than one subnet. This holds by definition for an ING, and it should not be forbidden for an ESG.

The conclusion is therefore, that only "mapping by tables" is possible. Sublayer 3c can therefore be described as being (minimally) responsible for "mapping by tables" of the destination-NSAPA into the SNAPA of the subsequent gateway that has to be passed. In the "destination-ESG" the task is simply reduced to local delivery to the addressed destination NSAP.



NOTE C.2

The fact that the mapping of NSAPAs into SNAPAs has to be done "by tables" does not exclude the possibility of an escaping mechanism being defined in the ESG-ID part of the NSAPA, allowing that an ESG is identified by one of the SNAPAs that provide access to that NSAP.

The escape mechanism allows an End System attached to a number of subnetworks (the "multi-homing" case) to be identified by one only of its subnetwork access points. It may be anticipated, that such an End System will then "normally" be accessed via the indicated subnetwork access point. However, dependent on the complexity of the routing tables, the network remains free to access the End System via any of its access points; this freedom precluding the possibility of the Global Network user being able to use this escaping mechanism to enforce the Global Network service to actually select the indicated subnetwork address to access the End System. In case an End System is attached to only one subnetwork, the escaping mechanism can also be used to address such an End System, in which case a significant simplification of the routing tables can be achieved as well.

C.6 The relation between routing and addressing

An NSAPA identifies global network access points. It does not determine the route as long as more than one route is possible. The routing function itself is closely related to the structure of the routing tables (corresponding to the address mapping discussed in section 5 above).

This does not mean that the Global network user cannot influence the route. It only means that the route can only be influenced by controlling the routing tables rather than providing or structuring the NSAPAs themselves. This subject is also discussed in Appendix D as the "ROAD" concept.

NOTE C.3

Simplification of routing tables may be achieved if addressed End Systems are attached to only one subnetwork, or if addressed End Systems can accept that routing to these End Systems will be done by preference across one of the subnetworks to which the End System is attached.

Additional simplification of routing tables can be achieved if this is combined with the use of escape codes as mentioned in note C.2. Indeed, routing to an addressed NSAP degrades in that case to routing to the (only possible, or the preferred) subnetwork, explicitly identified by the SN-ID of the SNAP. The introduction of more sophisticated and complicated routing tables may then be restricted to those cases, where more than one destination-subnetwork is present, but the "preferred" destination-subnetwork cannot be used for whatever reason.

C.7 Other sublayer considerations

As said above, sublayer 3c is responsible for address mapping (equivalent with the notion: routing). The need for an explicit peer-to-peer protocol in sublayer 3c, executed by means

of constructing and interpreting explicit sublayer 3c protocol headers, is for further study.

Proper functioning of the address mapping task of sublayer 3c requires that the underlying sublayers 3b and 3a are capable of forwarding NSAP addresses transparently between gateways. It is very convenient if this can be done during and not after the subnet-connection-setup phase. Therefore it is suggested as a requirement of the service provided by sublayer 3b that Global address information, as subnet-user-data, be exchanged during the subnet-connection-setup phase. If sublayer 3a does not support this, it should become an enhancement requirement, to be fulfilled by sublayer 3b (see section 6 of the main text).

#### C.8 Issues

- What is the benefit of facilitating the use of more than one NSAP per ESG? Is it more than a duplication of the transport layer addressing capability?
- What is the relation to X.121 and other standardized addressing conventions (telephone, telex)?
- How valid is the proposed address structure in general?
- Which authority should claim and get the responsibility to allocate NSAPAs so that duplicate and other chaotic use of these addresses is prevented?

APPENDIX D

THE ROAD CONCEPT

The Reference Model makes provision for all Global Network Service Access points to be uniquely identified by their Global Network Addresses.

Routing within the Global Network may be done at two levels:

- at the sub-network level as it involves intra-subnetwork switching modes,
- at the Global level as it involves inter-subnetwork gateways.

In practice subnetworks may be geographically overlaid and interconnected by multiple inter-network gateways.

Additionally, multiple routes may exist between two Global Network Service Access Points involving different combinations of sub-networks in tandem, and hence different inter-network gateways.

To meet the requirements for both unique end system addressing and route selection the concept of a ROAD is defined where a ROAD specifies a ROUTE to an ADDRESS.

The ROAD concept is one having significance only in sub-layer 3c, as described in section 3.5.

The structure of a ROAD parameter for inclusion in Network Service primitives incorporating Global network address is the subject of continuing study.

It is appreciated that the ROAD concept is one requiring universal acceptance and the establishment of a global authority for its administration and standardization.

It is also appreciated that without such a global authority the objectives of OSI will never be fully realized.



