INTERNATIONAL STANDARD

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Information technology — Telecommunications and information exchange between systems — Definition of the relaying functions of a Network layer intermediate system

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Définition de la fonction de transmission d'un système intermédiaire dans la couche réseau

Reference number
ISO/IEC 10028:1993(E)

Contents

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

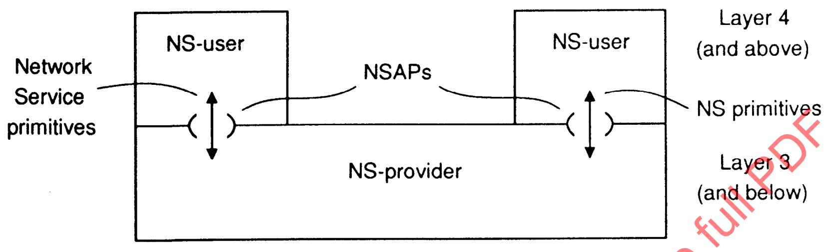
International Standard ISO/IEC 10028 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Sub-Committee SC 6, *Telecommunications and information exchange between systems*.

Annexes A, B and C are for information only.

Introduction

This International Standard is one of the set of standards associated with the Network layer of ISO 7498's Reference Model for Open Systems Interconnection (OSI). It has been developed within the architectural framework defined for the Network layer in ISO 8648.

ISO 8348 defines the OSI Network Service (NS) in terms of the behaviour of a single NS-provider operating as a "black box" between correspondent NS-users, in accordance with ISO TR 8509, as illustrated:



ISO 8648 defines an architectural organization that applies to the internal functioning of the NS-provider within the Network layer. In particular, it provides a common set of concepts and terminology for use in Network layer standards which extends and refines those of ISO 7498.

This International Standard provides a further level of detailed refinement of the description of the NS-provider, by defining the operation of intermediate systems in support of the Network service. This definition remains abstract, in the sense that it is independent of the details of particular subnetworks and protocols.

Other standards specify the use of Network layer protocols by an intermediate system in performing the functions defined in this International Standard.

This International Standard complements those defining the Network service and specifying the use of protocols for NS provision in end systems, in order to provide a complete set of Network layer standards covering each segment of the information flow between correspondent NS users. Other standards deal with associated information flows for routing and management.

Information technology — Telecommunications and information exchange between systems — Definition of the relaying functions of a Network layer intermediate system

1 Scope

This International Standard defines the abstract operation of the relaying functions of a Network entity in an intermediate system, as needed to support the OSI connection-mode Network service.

As the principal means for expressing the definition, the concept of the Network Internal Layer Service is used. This is similar to an OSI layer service, but adapted to expressing the invariants of the information flow within and throughout the layer, rather than just the external functionality of the layer provided between two service access points.

The definition includes the invocation of Network routing functions as a necessary element of the Network relaying functions, but it does not specify how those routing functions are to be realized.

The definition of Network relaying functions applies both to a subnetwork supporting all elements of the Network Service (as defined in ISO 8648), and to a Network relay system interconnecting two subnetworks according to any of the three approaches defined in ISO 8648. In the case of the hop-by-hop harmonization approach to interconnection, the definition of Network relaying functions applies to the result of harmonizing the subnetwork service(s) to the level of the Network Service. The harmonization functions, which require protocol mechanisms to be specified, are outside the scope of this International Standard.

This International Standard is intended for use in guiding the design and application of real interworking units and real subnetworks (eg, local area networks and private packet switched networks) which are to support the OSI NS. It is also intended for use in the development of standards for the Network layer, to ensure that the requirements deriving from the need for Network layer relaying are taken into account.

There are no requirements for conformance to this International Standard.

NOTE — Conformance requirements relating to Network layer relaying are to be found in the specifications for mappings between the Network Internal Layer Service and Network protocols.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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*

NOTE — See also CCITT Recommendation X.200 (1993).

CCITT Recommendation X.213 (1992) | ISO/IEC 8348:1993, *Information technology — Open Systems Interconnection — Network service definition.*

ISO/TR 8509:1987, *Information processing systems — Open Systems Interconnection — Service conventions.*

ISO 8648:1987, *Information processing systems — Open Systems Interconnection — Internal organization of the Network layer.*

3 Definitions

3.1 Reference model definitions

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

a) Network layer
b) Network service
c) Network service access point
d) Network service access point address
e) Network entity
f) Network relay
g) correspondent Network entities
h) Network connection
j) Network connection endpoint
k) Network function

3.2 Network layer architecture definitions

This International Standard makes use of the following terms defined in ISO 8648:

a) real subnetwork
b) subnetwork
c) interworking unit
d) Network relay system
e) intermediate system
f) end system

3.3 Service conventions definitions

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

a) Network service-user
b) Network service-provider
c) primitive
d) request (primitive)
e) indication (primitive)
f) response (primitive)
g) confirm (primitive)

3.4 Network relaying definitions

For the purposes of this International Standard the following definitions also apply:

3.4.1 domain: A subset of those open systems containing Network entities, in which there is a common understanding of values for certain domain-related parameters of NILS primitives.

3.4.2 domain-related parameter: A parameter of NILS primitives that does not have a set of values defined by this International Standard — whether directly, or indirectly by reference to ISO/IEC 8348 — to be applicable throughout the Network layer.

3.4.3 hop: The communication path supporting the transfer of information by NILS primitives, or by NILS primitives and Network service primitives, for an instance of communication between two Network entities that are adjacent in the modelling chosen for the Network layer interconnection.

4 Abbreviations and names of NILS elementary sequences

4.1 General abbreviations

CO	connection-mode
EES	extended end system
ENSDU	expedited Network service data unit
ISB	internal service bearer
N-	Network-
NC	Network connection
NHEP	Network hop endpoint
NILS	Network internal layer service
NISAP	Network internal service access point
NS	Network service
NSAP	Network service access point
NSDU	Network service data unit
OSI	open systems interconnection
QOS	quality of service

4.2 Names of NILS elementary sequences of primitives for N-connections

The following is a summary of the names defined in clause 8 for the elementary sequences of primitives that are used in defining the behaviour of a Network connection according to the Network internal layer service. Each item includes a brief description of the nature of the sequence's function, and a reference to the figure defining the sequence.

ABORT	NC request aborted (figure 4)
DT	Normal data transfer (figure 7)
EC	Expedited data confirmation (figure 7)
ED	Expedited data transfer (figure 7)
ESTAB	NC confirmed (figure 6)
FR	Generated flow control, of received data (figure 7)
FT	External flow control, of transmitted data (figure 7)
RC	Receipt confirmation (figure 7)
RELC	NC release, generated collision (figure 9)
RELF	NC release, forwarded (figure 9)
RELG	NC release, generated (figure 9)
RELX	NC release, external collision (figure 9)
REQ	NC request completed (figure 4)
RESC	Confirmation of forwarded reset (figure 8)
RESF	Forwarded reset (figure 8)
RESG	Generated local reset (figure 8)
RESX	External local reset (figure 8)
RETRY	NC establishment retry (figure 5)
RJ1	NC request rejected (figure 4)
SD	NC status discarded (figure 5)
SF	NC status forwarded (figure 5)
SG	NC status generated (figure 5)

5 The model of relaying by an intermediate system

5.1 Elements of the relaying model

This International Standard uses ISO 8648's structuring for intermediate systems as the basis for defining the operation of such systems in supporting the OSI connection-mode Network service.

Figure 1 illustrates, in a form adapted from ISO 8648, the general model of an intermediate system and the information flow through it. That flow represents, for each instance of Network layer communication handled by the intermediate system, the use made of the Network service by the NS-users in the end systems connected to the two sides of the intermediate system; the end systems may be connected either directly or through other intermediate systems. The sides of the intermediate system are labelled A and B for convenience in referring to them.

ISO/IEC 8348 defines the Network service in terms of primitives that occur in end systems, across the upper boundary of the Network layer. The first task of this International Standard is to provide corresponding definitions to allow discussion and specification of the information flow that represents those primitives in intermediate systems, and entirely within the Network layer. This is done by defining the Network internal layer service (NILS), including the correspondence between elements of the NILS and those of the Network service. The NILS is defined in terms of primitives with associated parameters, of the four types defined (but for OSI layer services) in ISO TR 8509.

The NILS is an abstraction of the interface in an intermediate system between the protocol support for the Network service and the N-relaying and N-routing functions. It is defined at a level corresponding to ISO 8648's subnetwork independent convergence protocol

(SNICP) role. Like the OSI Network service, therefore, it is independent of the details of particular protocols and subnetworks. The definition of the NILS, however, involves less abstraction from the level of detail that is typical of protocols than does the Network service: this reflects the role of the NILS as an expression of general Network layer internal mechanisms, as opposed to just the Network layer functionality that needs to be made visible to an NS user. In figure 1, the items 1A and 1B represent instances of the NILS. Clauses 7 to 9 contain the definition of the NILS.

Item 2 in figure 1 represents the N-relaying function, which relates the elements of the two instances of the NILS. The N-relaying function is defined in clauses 8 and 9.

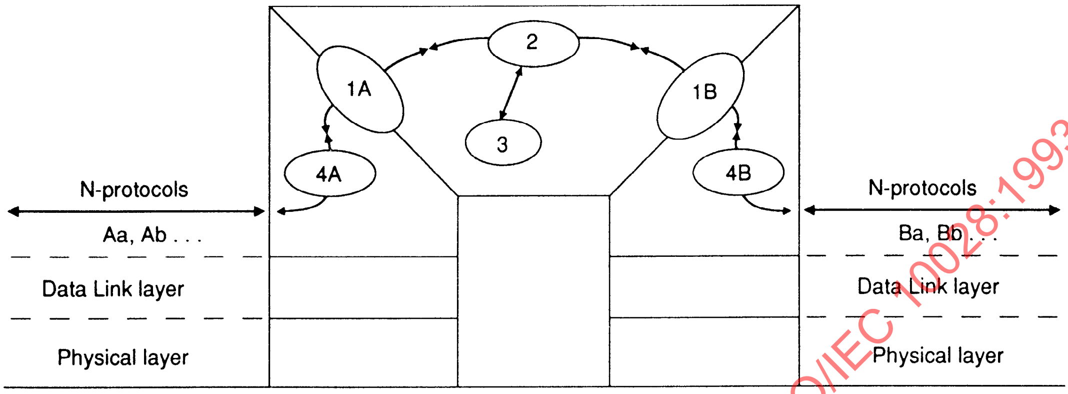


Figure 1 — Intermediate-system model

Item 3 represents the N-routing function needed to perform the relaying. The N-relaying function's interface to this is defined in clause 9.

Items 4A and 4B in figure 1 represent the mappings of the NILS to the protocol combinations used on the two sides of the intermediate system. These mappings for OSI standard Network protocols are specified in other standards.

NOTES

1 The protocol combinations on the two sides of an intermediate system may be different. If there are K such combinations, the relaying model implies that only the K protocol mappings for the NILS need to be specified in order to cover the full set of K-squared interworking possibilities.

2 The protocols used on a given side of an intermediate system may be combined "vertically", as occurs when separate protocols are used in two or more of the roles defined in ISO 8648; or they may be combined "horizontally", as for instance when an N-routing-protocol exchange is invoked in support of a particular attempt at NC establishment.

3 The OSI abstract modelling technique means that the NILS primitives at a given side of an intermediate system are to be considered as a direct abstraction from the NPDUs transmitted and received by the system. Thus items 4A and 4B in figure 1 truly represent mappings between those NPDUS and NILS primitives: they do not represent, for example, Network protocol implementations, with the implied possibility that these can intervene, below the NILS interface, in the flow of Network-service-level information represented by the NILS. To the extent that such interventions are observable outside the intermediate system, the model ascribes them all — apart perhaps from those resulting from protocol violations — to the relaying function shown as item 2.

5.2 Interconnection of intermediate systems

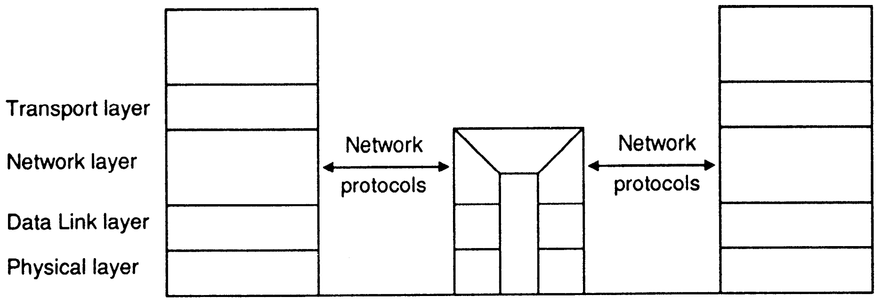
This subclause considers how the model of a single intermediate system, introduced in 5.1, is used where multiple Network entities are interconnected in supporting an instance of Network layer communication. The concern throughout is with Network layer operation considered at the level of the NILS or the OSI Network service. In particular, this subclause provides the framework for defining the correspondence between the OSI Network service, at end systems, and the operation of the NILS at intermediate systems involved in supporting the Network service.

The simplest interconnection scenario involving relaying is that shown in figure 2A, where two end systems communicate via a single intermediate system (representing, for example, a real subnetwork).

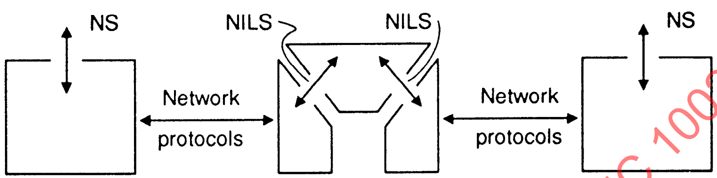
The concern with the Network layer only, and with the NS and NILS level of abstraction within that layer, is expressed in a diagrammatic representation that is simplified and abstracted from that used in figures 1 and 2A. Figure 2C is the representation corresponding to figure 2A, when the relaying function of the intermediate system is isolated for separate consideration.

NOTE 1 — Figure 2B is provided purely to clarify the derivation of figure 2C from figure 2A, by illustrating an intermediate step.

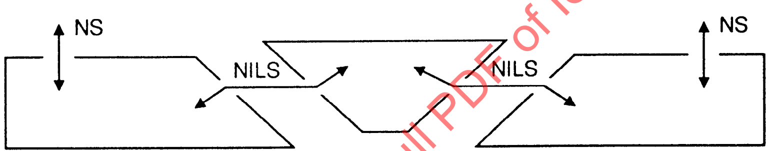
Figures 3A and 3B show a more complex interconnection scenario and its representation. The new feature here is the communication between two intermediate systems, considered as Network relay systems, via a third intermediate system considered as a subnetwork.



A. ISO 8648 representation, with relay model

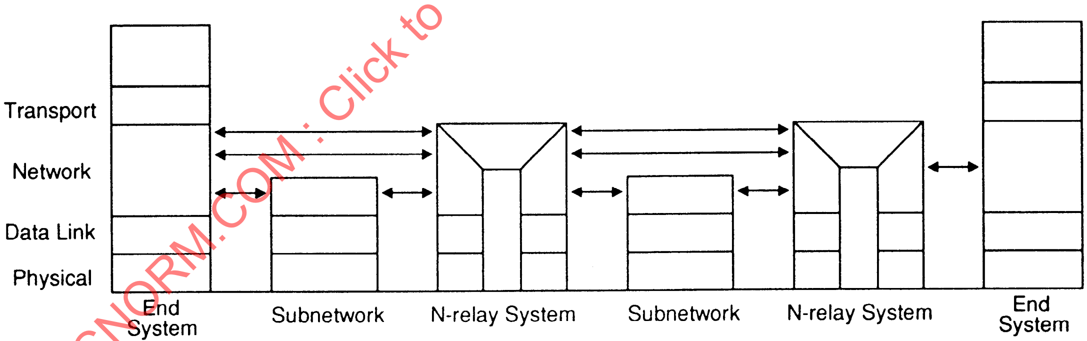


B. Network layer elements only, with relaying component separated

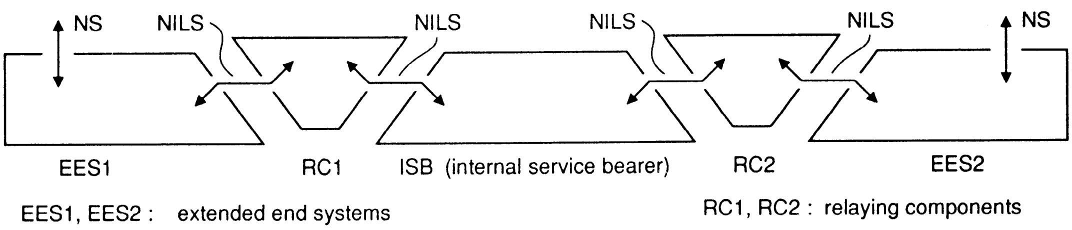


C. Service-level representation: protocol details abstracted

Figure 2 — End system / intermediate system / end system interconnection



A. Full architectural model (ISO 8648)



B. Network layer service-level representation

Figure 3 — Interconnected intermediate systems (Network relay systems and subnetworks)

Figure 3B contains three different kinds of element, which participate in conveying the information flow through the Network layer and interface to each other by means of the NILS. These three kinds of element are enough to express any interconnection scenario; they are described by the following terminology.

a) A relaying component (of an intermediate system) performs the mapping between corresponding NILS primitives at the interfaces on its two sides.

b) An extended end system (EES) provides the Network service to an NS user; it maps between Network service primitives at an NSAP and corresponding NILS primitives at its other interface, which is always to a relaying component.

c) An internal service bearer (ISB) maps between corresponding NILS primitives at its two interfaces (which are always with relaying components).

NOTE 2 — A relaying component represents part of the functionality of real equipment that is represented as a single Network entity in the modelling chosen for the Network-layer interconnection. An ISB or an EES represents parts of the functionality of at least two distinct Network entities, together with the Network protocol or protocols that convey the N-layer information flow between them.

Additional related terms for use in defining and discussing the NILS are as follows.

d) The communication path represented by an EES or ISB for a single instance of Network layer communication is termed a hop.

e) The point at which NILS primitives are exchanged between a relaying component and an EES or ISB is termed a Network internal service access point (NISAP).

f) NILS primitives occurring at a given NISAP and belonging to a single NC are considered to occur at a Network hop end point (NHEP); this is distinct from the NHEP of any other NC, and from the NHEP of any other hop of the same NC, at the given NISAP. For a hop of an NC passing through an EES, the Network connection end point at the NSAP is also termed a Network hop end point, in order to provide a uniform terminology for use in defining the NILS.

NOTE 3 — The role of an NHEP in relation to the NILS is analogous to that of a Network connection end point in relation to the Network service.

The role of a NISAP in relation to the NILS is analogous to that of an NSAP in relation to the OSI Network service. However, unlike an NSAP, an NISAP needs no global identification mechanism such as is provided for NSAPs by Network addresses: NISAPs are purely a modelling abstraction. Because of this, each Subnetwork Point of Attachment (SNPA) of a Network relay system is defined to be associated with exactly one NISAP; more than one SNPA can be associated with one given NISAP. Many-to-one or many-to-many mappings of NISAPs to SNPAs do not occur, by definition.

When only the NILS is considered, the difference between a relaying component and an ISB is simply a reversal of the sense of the basic primitive types. That is, request and response primitives are inputs to an ISB but outputs from a relaying component, and conversely for indication and confirm primitives. When the roles of the various elements are considered in detail, however, different elements of the relaying model are seen to apply to relaying components and to ISBs, and the distinction is seen to relate closely to the choices made in modelling intermediate systems as Network relay systems or as subnetworks.

6 Features of the Network internal layer service

This clause outlines the features provided by the NILS. Clause 7 defines the primitives and parameters of the NILS and relates them to the corresponding elements of the OSI Network service. Clauses 8 and 9 define how the NILS primitives are used in supporting the features of the connection-mode Network service.

The NILS includes all the features of the OSI connection-mode Network service as defined in ISO/IEC 8348, in order to support the provision of the CO NS between NS-users in end systems. In addition, the NILS offers a number of features related to the operation of the CO NS and the needs of management.

NILS features that correspond directly to the features of the connection mode Network service are as follows.

a) NC establishment: the means to establish a Network connection through an intermediate system, for the purpose of transferring NS-user-data between NS-users in end systems interconnected via the intermediate system.

b) QOS negotiation: the establishment of an agreement associated with an NC, between the NS-users and the various N-entities making up the NS-provider for the NC, for a certain quality of service.

c) Normal data transfer: the means of transferring NSDUs in sequence and transparently on an NC.

d) Flow control: the means by which a receiving N-entity, in an end system or intermediate system, can control the rate at which a peer N-entity may send NS-user-data. (Such flow control between N-entities can result from flow control exerted, by local mechanisms, by a receiving NS-user in an end system; or can cause flow control to be exerted, again by local mechanisms, on a transmitting NS-user in an end system.)

e) Expedited data transfer: as a selectable option of the NS-provider, the means of transferring separate expedited NSDUs in sequence on an NC.

f) Receipt confirmation: as a selectable option of the NS-provider, the means to convey confirmation that an NS-user has received certain NSDUs.

g) NC reset: the means by which an NC can be returned to a defined state with the activities of the two NS-users synchronized, invoked by either NS-user or by a Network-entity forming part of the NS-provider for the NC.

h) NC release: the unconditional and therefore possibly destructive release of an NC by either NS-user or by a Network-entity forming part of the NS-provider for the NC.

Additional features relating to the internal operation of the Network layer are as follows.

j) Connection control: the means of exchanging information between intermediate systems in relation to their co-operation in establishing an NC.

k) Error diagnostics: the means of transferring diagnostic information associated with NC resets and NC release.

l) Accounting information: the means of transferring information related to the costs of an NC, at NC release.

The quality of service (QOS) for a Network connection is as defined in ISO/IEC 8348.

Expedited data transfer and receipt confirmation are provider options of the NILS in the same sense as in the CO NS, ISO/IEC 8348.

The operation of an NC is considered as being divided into three phases: NC establishment phase, items (a), (b) and (j) above; data transfer phase, items (c) - (g) and (k) above; and NC release phase, items (h), (k) and (l) above.

7 Primitives and parameters of the Network internal layer service

7.1 Definitions of NILS primitives

The first and third columns of table 1 define, respectively, the NILS primitives, and the parameters associated with each primitive; the fourth column provides references to the definitions of the parameters.

The second and fifth columns of table 1, together with 7.1.1 and 7.1.2, define the basic correspondence between the NILS primitives and parameters and those of the OSI Network service. This correspondence relates one NS primitive and its parameters to one NILS primitive and its parameters, except in the case of N-DATA where the correspondence is as defined in 7.1.3.

7.1.1 Correspondence between NS and NILS primitives

The "request or indication" parts of the entries in table 1 are to be read as meaning that an NILS primitive of type request may correspond to an NS primitive either of type request or of type indication, and an NILS primitive of type indication may also correspond to either type of NS primitive; and similarly for the "response or confirm" entries.

The correspondence defined here is between primitives considered as classes of possible instances. An instance of an NS primitive at an NSAP may correspond to zero, one, or several instances of the corresponding NILS primitives at different NISAPs; that level of correspondence is a consequence of the definitions in clause 8.

NOTES

1 All primitives of the OSI CO NS are present in table 1, with corresponding NILS primitives defined.

2 Three request / indication pairs of NILS primitives are defined that have no corresponding NS primitives: these are NI-CONNECT-PROCEEDING, NI-PAUSE and NI-CONTINUE. The NILS also has NI-EXPEDITED-DATA response and confirm primitives that have no corresponding NS primitives.

7.1.2 Correspondence between parameters of NS and NILS primitives

For those parameters marked "(=)" in table 1, the value of such a parameter in an instance of an NILS primitive other than NI-DATA is equal to the value of the parameter of the same name in any corresponding instance of an NS primitive; the NS-provider has a passive role with respect to these parameters, conveying them unchanged.

For those parameters marked "(*)", the value of such a parameter in an instance of an NILS primitive can be different from the value of the parameter of the same name in a corresponding instance of an NS primitive; the NS-provider can have an active part in negotiating or generating these parameters — see clause 9.

NOTE — The parameters of all OSI CO NS primitives except N-DATA are present in table 1, marked "(*)" or "(=)" to define their correspondence with

NILS parameters; the missing parameters of N-DATA correspond to parameters of NI-DATA as defined in 7.1.3.

7.1.3 Correspondence between N-DATA and NI-DATA primitives

An N-DATA primitive with an NS-User-Data parameter of length *L* octets corresponds to a sequence of *L* NI-DATA primitives, as follows:

a) the value of the NS-User-Data-Octet parameter in the *n*th NI-DATA primitive of the sequence, $0 < n < L+1$, is the value of the *n*th octet of the NS-User-Data parameter;

b) the value of the NSDU Qualifier parameter in the *n*th NI-DATA primitive of the sequence, $0 < n < L$, is "Normal";

c) the value of the NSDU Qualifier parameter in the *L*th NI-DATA primitive of the sequence is "Last" if the N-DATA primitive does not contain the Confirmation Request parameter, and otherwise is "Last with Confirmation Request".

NOTE — The qualifying symbol "(=)" is used against the parameters of NI-DATA in table 1, since the above correspondence conveys the content of a corresponding N-DATA primitive's parameters without change.

Table 1 — Primitives and parameters of the NILS, and correspondence with OSI connection-mode Network service

NILS primitive	NS primitive	NILS Parameters	Reference	Note
NC establishment				
NI-CONNECT request or indication	N-CONNECT request or indication	Called Address	7.2.2	(=)
		Calling Address	7.2.2	(=)
		Receipt Confirmation Selection	7.2.3	(*)
		Expedited Data Selection	7.2.4	(*)
		QOS-Parameter Set	7.2.5	(*)
		NS-User-Data	7.2.8	(=)
		NI Connection Control	7.2.11	3
NI-CONNECT response or confirm	N-CONNECT response or confirm	Responding Address	7.2.2	(=)
		Receipt Confirmation Selection	7.2.3	(=)
		Expedited Data Selection	7.2.4	(=)
		QOS-Parameter Set	7.2.5	(=)
		NS-User-Data	7.2.8	(=)
		NI Connection Control	7.2.11	3
NI-CONNECT-PROCEEDING request or indication	none	none		2
NC release				
NI-DISCONNECT request or indication	N-DISCONNECT request or indication	Originator	7.2.6	(*)
		Reason	7.2.7	(*)
		NS-User-Data	7.2.8	(=), 1
		Responding Address	7.2.2	(=), 1
		NI Diagnostic	7.2.12	1, 3
		NI Location	7.2.13	1, 3
		NI Accounting	7.2.14	1, 3

Table 1 (concluded)

NILS primitive	NS primitive	NILS Parameters	Reference	Note
Normal data transfer and receipt confirmation				
NI-DATA request or indication	N-DATA request or indication	NS-User-Data-Octet NSDU Qualifier	7.2.9 7.2.10	(=), 4 (=), 4
NI-DATA-ACKNOWLEDGE request or indication	N-DATA-ACKNOWLEDGE request or indication	none		5
Flow control				
NI-PAUSE request or indication	none	none		2
NI-CONTINUE request or indication	none	none		2
Expedited data transfer				
NI-EXPEDITED-DATA request or indication	N-EXPEDITED-DATA request or indication	NS-User-Data	7.2.8	(=)
NI-EXPEDITED-DATA response or confirm	none	none		2
NC reset				
NI-RESET request or indication	N-RESET request or indication	Originator Reason NI Diagnostic NI Location	7.2.6 7.2.7 7.2.12 7.2.13	(*) (*) 1, 3 1, 3
NI-RESET response or confirm	N-RESET response or confirm	none		5

NOTES

(=) See 7.1.2.

(*) See 7.1.2.

1 This parameter is not present in all instances of the primitive: see clause 8 for details.

2 This NILS primitive has no corresponding NS primitive: it is defined as part of the Network layer's internal support for provision of the CO NS: see clause 8 for details.

3 This NILS parameter has no corresponding NS parameter: it is defined as part of the Network layer's internal support for provision of the CO NS.

4 See 7.1.3 for the correspondence between N-DATA and NI-DATA primitives and their parameters.

5 This Network service primitive has no parameters.

7.2 Parameters of NILS primitives

The ranges of parameter values are as defined in 7.2.2 to 7.2.14 below. Parameters with names that are not prefixed with "NI" correspond exactly with parameters of the CO NS as defined in ISO/IEC 8348. Parameters with names prefixed with "NI" are specific to the NILS: 7.2.1 defines some general properties of these (four such parameters are defined, see 7.2.11 to 7.2.14).

7.2.1 NILS-specific parameters

The function of the NILS-specific parameters is to convey information that is not directly reflected in the Network service parameters seen by NS users in end systems, but that relates to support of the Network service by intermediate systems.

Whereas values of Network service parameters have meanings that are globally defined for the OSI environment by ISO/IEC 8348, it is possible that values of some NILS-specific parameters will be defined in more restricted domains. Although such domains could be dependent on particular subnetworks, etc, the need to convey the parameter values across other hops is a subnetwork-independent property of Network layer relaying, hence the inclusion of these parameters in the NILS. To allow correct interpretation, such a parameter value is considered in general to be structured to contain a domain identifier as well as the domain-specific value. (Where a parameter consists of a number of subparameters, this structuring can apply to each subparameter.) Parameters, or subparameters, of this kind are referred to as "domain-related (sub)parameters" in the remainder of this International Standard.

Domain identifiers are Network addresses, as defined in ISO/IEC 8348 (thus including the possibility of Network entity titles).

A null value, defined globally for the Network layer, exists for each NILS-specific parameter.

NOTES

1 The concept of domain that is involved here is not limited to that of addressing domains as in ISO/IEC 8348, nor of routing domains as in ISO 9542 or ISO/IEC TR 9575, although both such domain types could be appropriate in some instances; also likely to be important are protocol domains — e.g. that of ISO/IEC 8208 — and administrative domains of various kinds.

2 Inclusion in the NILS of the subnetwork-independent function of conveying domain-related (sub)parameters is particularly related to the aim (see clause 1) of guiding the design of future subnetworks and protocols, so that they accommodate better the requirements for interworking of heterogeneous subnetworks.

3 Processing of domain-related (sub)parameters is not a subnetwork-independent function, and therefore no details of such processing appear in the NILS definition. The NILS definition is limited to stating that such (sub)parameters can be processed in intermediate systems — for example, at a subnetwork-dependent level — and that such processing can cause forwarded values of the (sub)parameters to differ from received values (see, e.g. P2 in 8.3.1).

4 Null values are necessary to deal with subnetworks which do not support particular NILS-specific parameters.

7.2.2 Addresses

A Called Address, Calling Address, or Responding Address parameter takes a Network address as its value. Such values are conveyed unchanged through a hop or relaying component.

7.2.3 Receipt Confirmation Selection

A Receipt Confirmation Selection parameter has one of two possible values, "use of Receipt Confirmation" or "no use of Receipt Confirmation".

7.2.4 Expedited Data Selection

An Expedited Data Selection parameter has one of two possible values, "use of Expedited Data" or "no use of Expedited Data".

7.2.5 QOS-Parameter Set

In connection-mode operation a QOS-Parameter Set parameter consists of a set of subparameters for each of:

a) throughput (calling to called);
b) throughput (called to calling);
c) transit delay;
d) protection;
e) priority.

Table 2 defines the subparameters that are present for each QOS parameter on each type of NI-CONNECT primitive. The table also defines the correspondence with those ISO/IEC 8348 QOS subparameters for which values are conveyed unchanged through a hop or relaying system: the same "(=)" notation as in table 1 is used, see 7.1.2.

The Current subparameters of NI-CONNECT request and indication primitives correspond both to the Available subparameters of N-CONNECT indication and to the Target subparameters of N-CONNECT request. The "(*)" notation of table 1 is used to indicate, as per 7.1.2, that values of corresponding subparameters in corresponding instances of NILS and NS primitives can be different: the values are related as defined in 8.3.1.

Table 2 — QOS-Parameter Set subparameters

Primitive: / QOS parameters	NI-CONNECT request, NI-CONNECT indication	NI-CONNECT response, NI-CONNECT confirm
Throughput (calling to called), Throughput (called to calling), Protection, Priority	) Current, (*)) Lowest Quality Acceptable (=)))	Selected (=)
Transit Delay	) Target, (=)) Current, (*)) Lowest Quality Acceptable (=)	Selected (=)

(=), (*) — see 7.1.2 and 7.2.5.

7.2.6 Originator

An Originator parameter has one of three possible values, "NS user", "NS provider" or "undefined".

7.2.7 Reason

A Reason parameter has one of the values defined in ISO/IEC 8348, constrained according to the value of the associated Originator parameter as also defined in ISO/IEC 8348.

7.2.8 NS-User-Data

An NS-User-Data parameter has a sequence of octets as its value. In NI-CONNECT and NI-DISCONNECT primitives the length of the sequence is in the range zero to 128 octets inclusive; in NI-EXPEDITED-DATA the length is in the range one to 32 octets inclusive. Such values are conveyed unchanged through a hop or relaying component.

7.2.9 NS-User-Data-Octet

An NS-User-Data-Octet parameter has a single octet as its value. Such values are conveyed unchanged through a hop or relaying component (subject to the correspondences, in an EES, defined in 7.1.3).

7.2.10 NSDU Qualifier

An NSDU Qualifier parameter has one of three possible values, "Normal", "Last" or "Last with confirmation request". Such values are conveyed unchanged through a hop or relaying component (subject, in an EES, to the correspondence between N-DATA and NI-DATA primitives defined in 7.1.3).

7.2.11 NI Connection Control

An NI Connection Control parameter consists of a number of domain-related subparameters (see 7.2.1), as follows (7.2.11.1 to 7.2.11.4).

7.2.11.1 NI Additional QOS is a subparameter which conveys information relating to the NS provider's support for QOS parameters other than those conveyed in the QOS-Parameter Set parameter. Details are domain-dependent.

NOTE — An example might be a value for maximum connection establishment delay.

7.2.11.2 NI Cost Determinants is a subparameter which conveys information relating to the NS user's control of costs incurred by the NC. Details are domain-dependent.

7.2.11.3 NI Authentication is a subparameter which conveys information relating to the authentication of the NS user to intermediate systems through which the NC might pass. Details are domain-dependent.

7.2.11.4 NI Route Control is a subparameter which conveys information about the route to be followed by the NC. The null value indicates that there are no constraints on the route; otherwise, details are domain-dependent.

7.2.12 NI Diagnostic

An NI Diagnostic parameter is a domain-related parameter (see 7.2.1) which conveys more detailed information than do Reason parameters about provider-originated reset or release of an NC. According to the domain identified, this information can be structured as a number of subparameters. The null value indicates that no such information is available.

7.2.13 NI Location

An NI Location parameter is a Network entity title identifying the intermediate system or end system that originated the primitive. The null value indicates that this identification information is not available.

7.2.14 NI Accounting

An NI Accounting parameter is either null, or consists of a number of domain-related subparameters (see 7.2.1) which convey information relating to the cost of an NC. Different subparameters can identify different domains; according to the domains identified, cost information can be expressed in monetary terms or resource-usage measures, or both. The null value indicates that cost information is not available.

NOTE — An NI Accounting parameter does not, in general, convey complete information about the NC's cost; however, knowledge about the domains involved might allow an NI-user to determine whether or not the cost information was complete.

8 Sequences of primitives

8.1 Introduction

The Network service is provided between a given pair of NS-users through a chain of alternating hops and relaying components. The flow of information along this chain is expressed by the sequence of primitives, with their associated parameters, at each NSAP and NISAP. In order to define fully the end-to-end provision of the CO NS, this International Standard defines the possible sequences of primitives:

a) between the NSAP and NISAP of an extended end system (EES);
b) between the two NISAPs of an internal service bearer (ISB); and
c) between the two NISAPs of a relaying component.

This does not require three parallel but separate definitions. The behaviour of each of the three kinds of element is essentially the same, and a common generic definition is used together with simple mappings that generate the three specific definitions needed.

The conventions used in the generic definition, and the mapping rules for generating the specific cases, are defined in 8.2. The generic definitions of the elementary sequences of primitives, relating the two interfaces of an element of the NS-provider, are contained in 8.3.

Elementary sequences are combined together to support Network connections. The terminology and notation used in defining combinations of elementary sequences are defined in 8.4. The generic definitions of the sequences of primitives, as combinations of elementary sequences, are contained in 8.5.

8.2 Conventions for the generic definition

The generic definition of the sequences of NILS primitives is based upon elementary sequences of generic primitives, which are defined in time sequence diagrams in 8.3.

8.2.1 Naming of elementary sequences

Each elementary sequence is named; a name is in upper case letters, and appears before a colon in the top left corner of its defining diagram.

The two sides (NHEPs, or NCEP and NHEP) of the relaying component or hop represented in a time sequence diagram are labelled A and B, where A is the calling side during NC establishment. Many elementary sequences are asymmetrical with respect to the two sides, but apply equally to both directions of information flow between the sides. In such cases, the two sides are doubly labelled on two lines, with A and B interchanged; the sequence is also doubly named, the name for the A-B interchanged version having a prime (´) character appended to the basic name.

8.2.2 Generic primitive names

Arrows in the diagrams represent primitives, with the obvious directional significance. Each arrow is labelled with a generic primitive name of the form GPRIM.s, where GPRIM is the name of an NILS primitive with its NI-prefix removed, and the suffix s is one of (r, t, r´, t´).

8.2.3 Parameter relationships

An arrow may also be marked with [=], or with **[Pn]** for some number n. These relate to the parameters of the primitive. A primitive marked [=] always has suffix t or t´, and always appears as the forwarded result of a similar primitive with suffix r or r´ at the other side; the [=] mark means that all the forwarded parameters have the same values as those received. A **[Pn]** mark refers to a definition, similarly labelled, in the accompanying text. In addition, any parameters marked (=) in table 1 or table 2 are forwarded unchanged as noted in 7.1.2 or 7.1.3.

8.2.4 Mapping of generic primitives to NILS and CO NS primitives

To interpret a sequence of generic primitives for one of the specific contexts, each GPRIM.s name is transformed according to table 3 to the form n-SPRIM TYPE. The prefix n is either N, for an NS primitive at an NSAP of an EES, or NI for an NILS primitive at an NISAP. The name SPRIM is the same as GPRIM, as defined in table 1. The TYPE (request, etc) is as defined in table 3.

At an NSAP, generic primitives that have no corresponding NS primitive map to null; similarly, parameters with no corresponding NS parameter are ignored at the NSAP.

The generic to specific mapping at an NSAP also includes the mapping between N-DATA and NI-DATA primitives, as defined in 7.1.3.

Table 3 — Mapping from generic primitives to NILS and NS

		Relaying component	ISB	Calling EES (NSAP = A)	Called EES (NSAP = B)
n	at A :	NI	NI	N	NI
	at B :	NI	NI	NI	N
type for :	r :	indication	request	request	request
	r´ :	confirm	response	response	response
	t :	request	indication	indication	indication
	t´ :	response	confirm	confirm	confirm

8.3 Elementary sequences of primitives for Network connections

8.3.1 NC establishment

The elementary sequences for NC establishment phase occur in three subphases, as in figures 4 to 6. These subphases occur in succession; the possible combinations of elementary sequences within each subphase are defined in 8.5.

Figure 4 defines the elementary sequences for NC request subphase. This subphase includes the sequences for rejecting and aborting an NC when the original CONNECT.r is not forwarded to the other NISAP or NSAP. (These one-sided sequences are special cases of NC release as well as of NC establishment.) NC request subphase is entered on occurrence of the original CONNECT.r; normal completion is on occurrence of the forwarded CONNECT.t, with immediate entry to NC proceeding subphase; abnormal termination occurs on DISCONNECT.r (ABORT) and may occur on DISCONNECT.t (RJ1, request rejected).

Parameters of the primitives in sequences RJ1 and REQ are related by **P1** and **P2** (see below).

Figure 5 defines the elementary sequences for NC proceeding subphase. This subphase is entered on completion of NC request subphase; normal completion is on entry to NC confirmation subphase; abnormal termination is by entry to NC release phase, following any (or none) of the sequences in figure 5. The subphase need not contain any occurrences of these sequences.

Parameters of the CONNECT.t primitive in the RETRY sequence are related to the original CONNECT.r of the preceding NC request subphase by **P2**.

In the RETRY sequence, the CONNECT.t primitive may occur at a NISAP different from that for previous such primitives of the same NC. This sequence does not occur when B is an NSAP in an EES.

Figure 6 defines the single elementary sequence ESTAB for NC confirmation subphase. This subphase is entered on occurrence of the CONNECT.r´ primitive; normal completion is on occurrence of the forwarded CONNECT.t´ primitive; abnormal termination is by entry to NC release phase without the occurrence of CONNECT.t´.

Parameters of the ESTAB primitives are related to each other, and to those in the CONNECT.t primitive of the preceding REQ or RETRY sequence, by **P3** and **P4**.

Parameter relationships

P1 The parameters of DISCONNECT.t in sequence RJ1 are as follows.

a) Originator is "NS provider".

b) Reason is one of the "connection rejection ..." values defined in ISO/IEC 8348.

c) NS-User-Data and Responding Address are absent.

d) Any or all of NI Diagnostic, NI Location and NI Accounting can be present.

P2 Parameters of CONNECT.t in sequence REQ or RETRY are as follows.

a) Receipt Confirmation Selection is "no use of Receipt Confirmation" if that was the value in the original CONNECT.r, and otherwise can be either defined value.

b) Expedited Data Selection is "no use of Expedited Data" if that was the value in the original CONNECT.r, and otherwise can be either defined value.

c) For each QOS-Parameter Set parameter, the Current or Available subparameter is related to the subparameters in the original CONNECT.r as follows:

1) the value for Transit Delay is increased by an amount that represents the actual delay expected through the hop or relaying component, and is less than the value of the Lowest Quality Acceptable subparameter;

2) the values for Throughput, in either direction, and for Priority are less than or equal to the values of the corresponding original subparameters, and greater than or equal to the values of the corresponding Lowest Quality Acceptable subparameters.

d) NI Connection Control subparameters can be added if they were absent in the original CONNECT.r; if they were present in the CONNECT.r, they can be deleted or changed, to reflect the operation of the hop or relaying component.

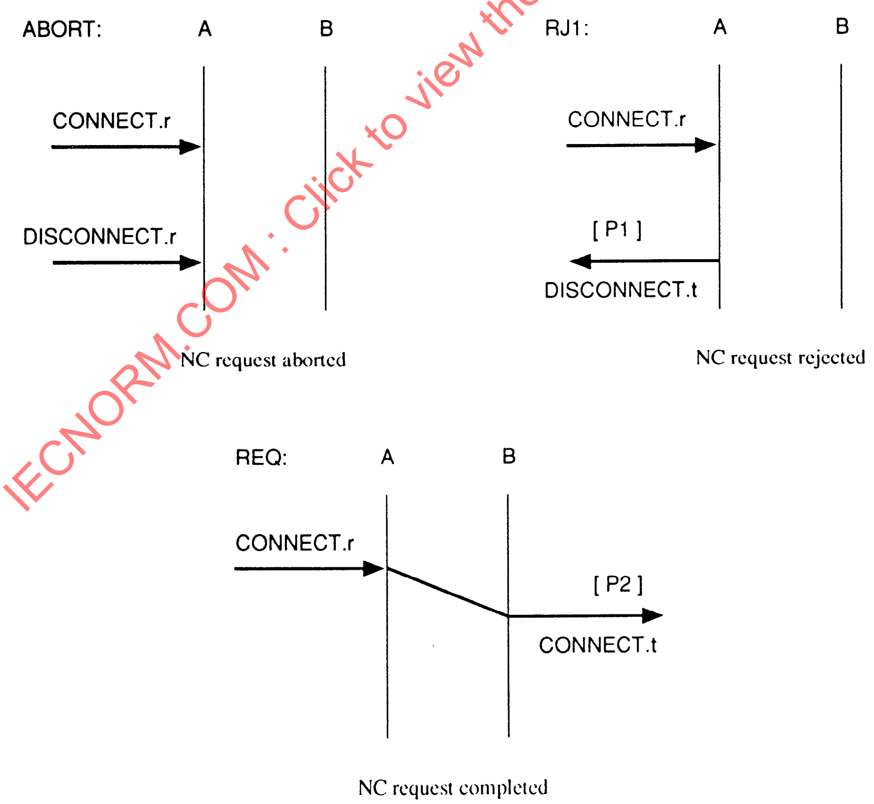


Figure 4 — NC establishment, NC request subphase

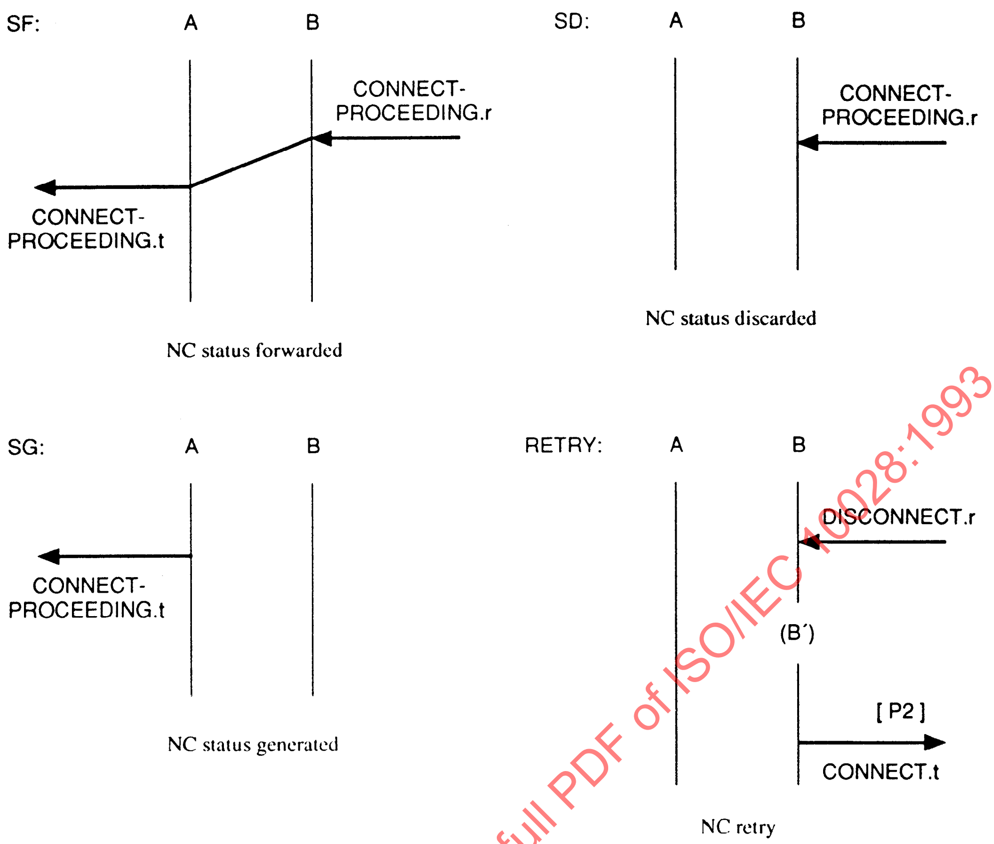


Figure 5 — NC establishment, NC proceeding subphase

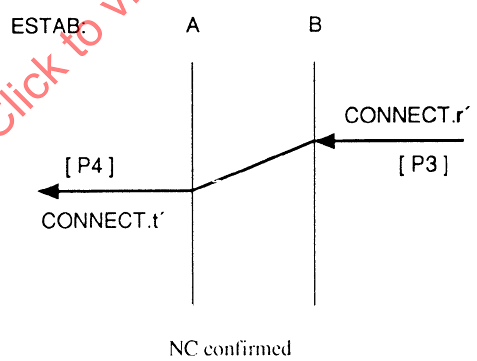


Figure 6 — NC establishment, NC confirmation subphase

P3 Parameters of CONNECT.r´ in sequence ESTAB relate to those of the CONNECT.t of the preceding REQ or RETRY sequence at the same NHEP as follows.

a) Responding Address is as defined in ISO/IEC 8348.

b) Receipt Confirmation Selection is "no use of Receipt Confirmation" if that was the value in the original CONNECT.t of the preceding REQ or RETRY, and otherwise can be either defined value.

c) Expedited Data Selection is "no use of Expedited Data" if that was the value in the original CONNECT.t of the preceding REQ or RETRY, and otherwise can be either defined value.

d) For each QOS-Parameter Set parameter, the value of the Selected subparameter is in the range between the value of the Lowest Quality Acceptable subparameter and the value of the Current subparameter, inclusive, in the original CONNECT.t.

e) NI Connection Control subparameters can be present or absent, according to the operation of any hops and relaying components between the NHEP at which the CONNECT.r´ occurs and the responding NSAP.

NOTE — P3 (b) - (d) are consequences of the CO NS definition in ISO/IEC 8348, either directly (when the CONNECT.r´ is an N-CONNECT response), or indirectly by forwarding of the parameter values unchanged from those in the N-CONNECT response, in accordance with the (=) entries in table 1 and table 2.

P4 NI Connection Control subparameters of the CONNECT.t´ primitive in an ESTAB sequence can be added if they were absent from the CONNECT.r´ primitive; if they were present, they can be deleted or changed, to reflect the operation of the hop or relaying component.

8.3.2 Data transfer phase

The elementary sequences for data transfer phase belong to two subphases, transfer subphase and reset subphase, which occur alternately. The possible combinations of elementary sequence within each subphase are defined in 8.5.3 and 8.5.4.

Figure 7 defines the elementary sequences for transfer subphase. A transfer subphase is terminated by entry to reset subphase or to NC release phase. In either termination case, one or more elementary sequences can remain incomplete; such an incomplete sequence consists of a single DATA.r, EXPEDITED-DATA.r, EXPEDITED-DATA.r´, PAUSE.r, PAUSE.t or DATA-ACKNOWLEDGE.r primitive.

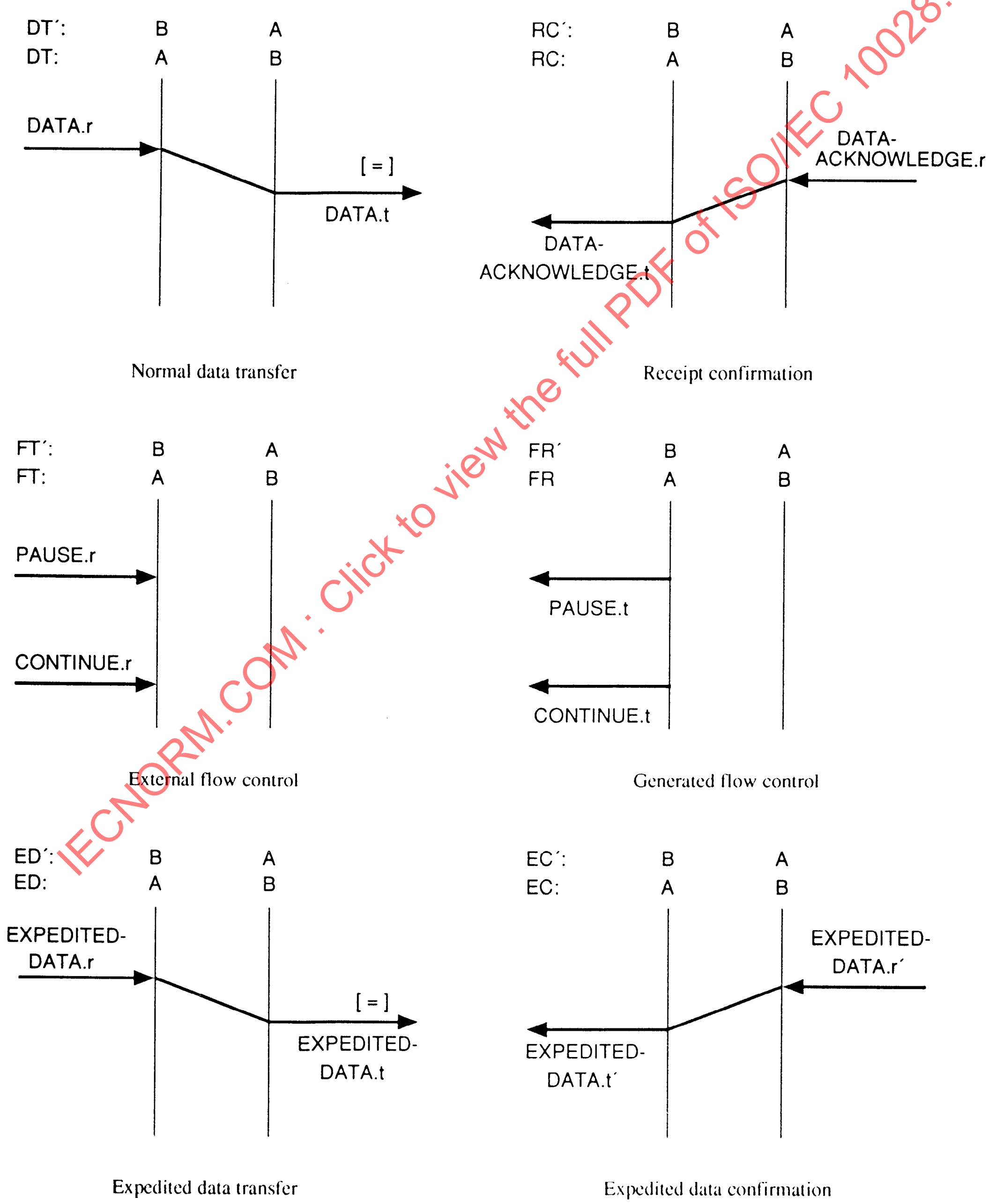


Figure 7 — Data transfer, transfer subphase

Figure 8 defines the elementary sequences involving RESET primitives. A reset subphase can also contain incomplete DT, DT´, ED, or ED´ sequences, and complete or incomplete FT, FR, FT´ or FR´ sequences. A reset subphase is entered from a transfer subphase on occurrence of a RESET primitive at either NHEP; this begins one of the sequences of figure 8. Abnormal termination is by entry to NC release phase, which can leave any elementary sequence incomplete.

P5 Parameters of a generated RESET.t primitive are as follows.

a) Originator is "NS provider" or "undefined"

b) Reason is any value consistent with the Originator value.

c) NI Diagnostic and NI Location can be present or absent (always absent at an NSAP).

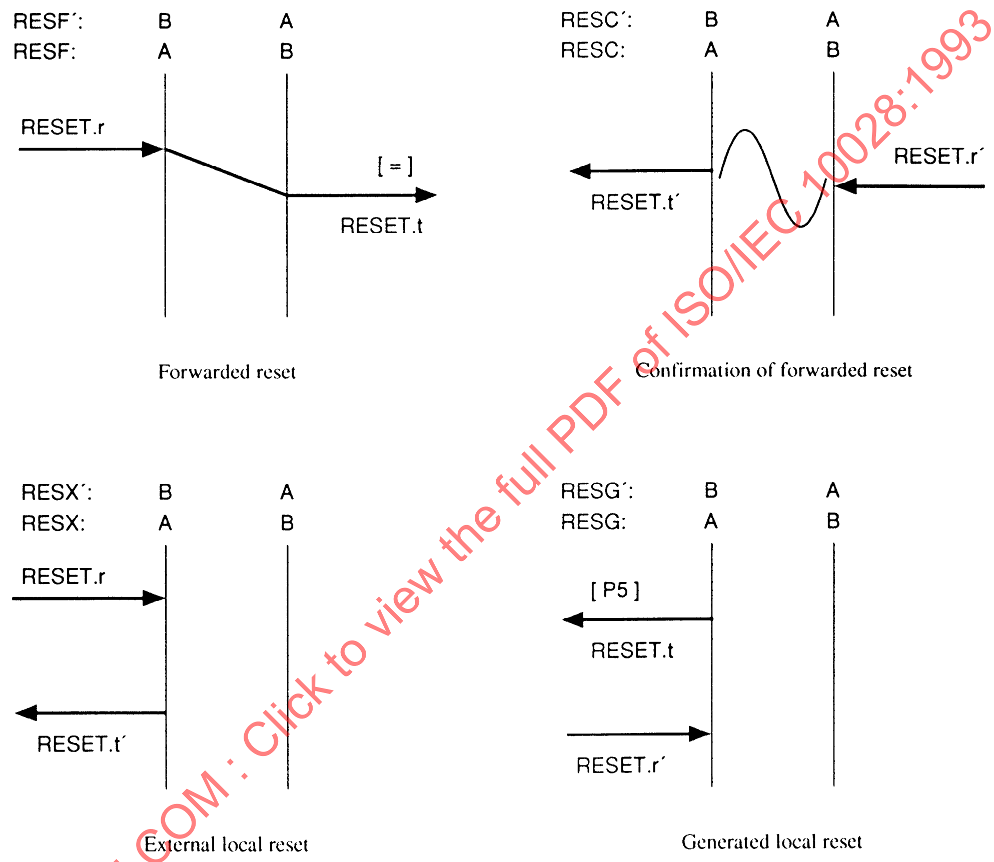


Figure 8 — Data transfer, reset subphase

8.3.3 NC release phase

Figure 9 defines the elementary sequences for NC release phase. NC release phase is entered on the occurrence of any DISCONNECT primitive. Apart from the special cases defined in 8.3.1, NC release phase consists of exactly one of these sequences, and is completed when both primitives of the sequence have occurred.

P6 Parameters of a forwarded DISCONNECT.t primitive are as follows.

a) Originator has the same value as in the original DISCONNECT.r primitive if that is issued at a NISAP, and otherwise (ie, if the DISCONNECT.r is an N-DISCONNECT request) is "NS user".

b) Reason has the same value as in the original DISCONNECT.r primitive.

c) If Originator is "NS user" then NS-User-Data and Responding Address are present and have the same values as in the original DISCONNECT.r primitive; otherwise they are absent.

d) Any or all of NI Diagnostic, NI Location or NI Accounting can be present.

P7 Parameters of a generated DISCONNECT.t primitive are as follows.

a) Originator is "NS provider" or "undefined".

b) Reason is "undefined" if Originator is "undefined" and otherwise is one of the "disconnection ..." values defined in ISO/IEC 8348.

c) NS-User-Data and Responding Address are absent.

d) Any or all of NI Diagnostic, NI Location or NI Accounting can be present.

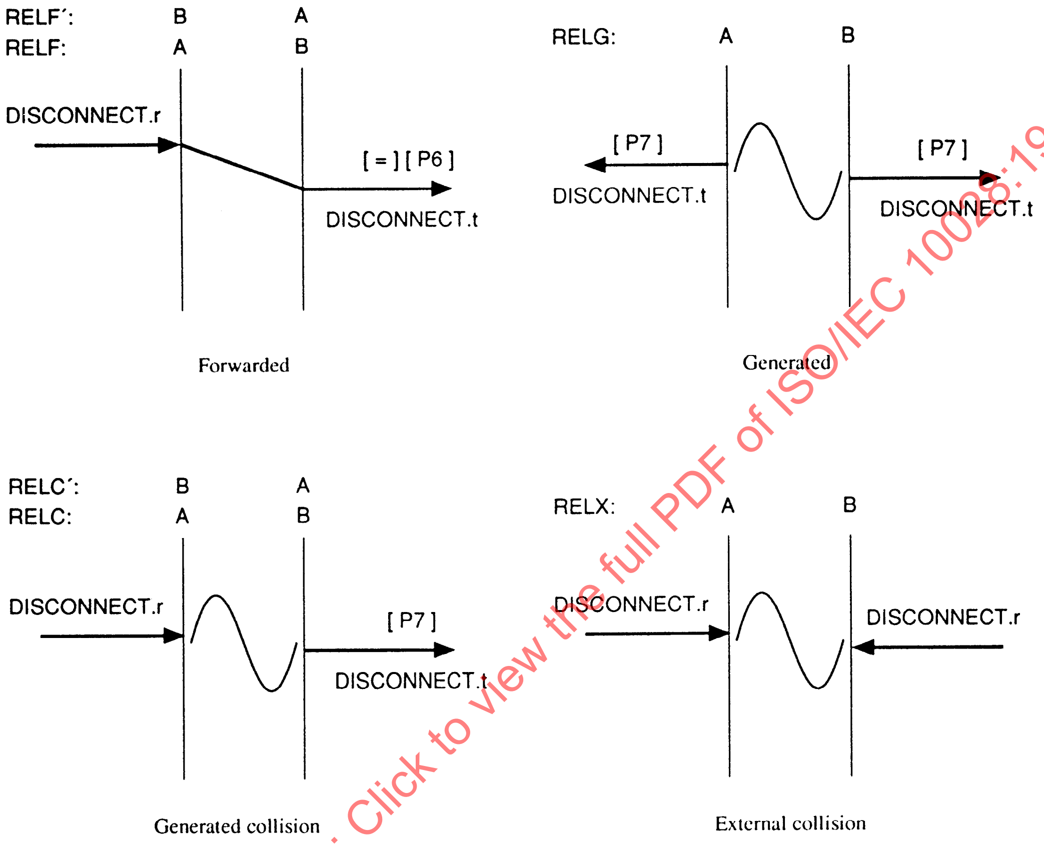
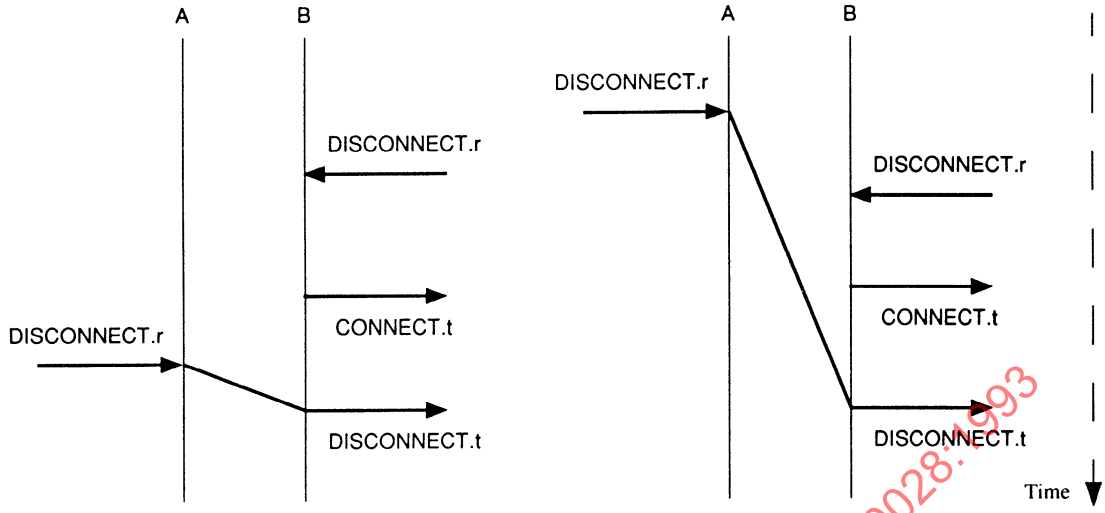


Figure 9 — NC release phase

8.4 Terminology and notation for combinations of elementary sequences

Five methods are defined by which pairs of elementary sequences can be combined in constructing the full behaviour of the NILS at a NISAP.

The simplest method for combining two elementary sequences s1 and s2 is succession, in which the combined sequence of primitives at A consists of s1's sequence of primitives at A followed by s2's sequence of primitives at A, and similarly at B. This method is applicable in all phases of an NC. Note that this does not imply, for example, that s2's primitives at B occur at a later time than s1's primitives at A: the only sequencing relationships between A and B are those associated with elementary sequences that forward primitives (see figure 10).



Logical sequence, RETRY then RELF

Possible temporal sequence

Figure 10 — Example of succession of elementary sequences

The other four combination methods apply only during transfer subphase of the data transfer phase of an NC, for any given NC. These combination methods are crossing, overtaking, interpolation and interleaving; they are illustrated in figure 11, and defined immediately below. A given elementary sequence can combine by these methods with two or more other sequences, producing more elaborate re-orderings; figure 12 is an example with three crossings, one overtaking and two simple successions.

Crossing and overtaking involve only the transfer-subphase elementary sequences that forward primitives between NHEPs: DT, DT´, ED, ED´, EC, EC´, RC and RC´. The two primitives in such a forwarding sequence are referred to as the original primitive and the forwarded primitive.

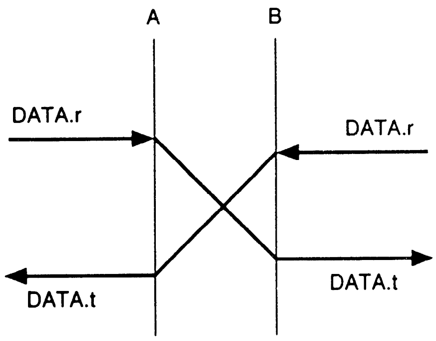
If s1 crosses s2, the original primitive of s1 at A is followed by the forwarded primitive of s2 at A, and the original primitive of s2 at B is followed by the forwarded primitive of s1 at B; or similarly with A and B interchanged.

If s2 overtakes s1, the original primitive of s2 follows the original primitive of s1 at A (or B), and the forwarded primitive of s1 follows the forwarded primitive of s2 at B (or A, respectively).

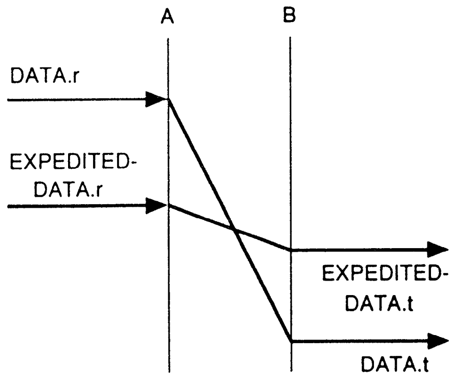
Interpolation involves one of the flow control sequences, and either the other flow control sequence at the same NHEP or any forwarding sequence. If s2 is interpolated in s1 at A, the primitive or primitives of s2 at A follow the PAUSE primitive of s1, and are followed by the CONTINUE primitive of s1; and similarly with B in place of A.

Interleaving involves only the two flow control sequences at a given NHEP: s2 interleaves s1 if the PAUSE primitive of s2 occurs after the PAUSE primitive of s1 and before the CONTINUE primitive of s1, and the CONTINUE primitive of s2 occurs after the CONTINUE primitive of s1.

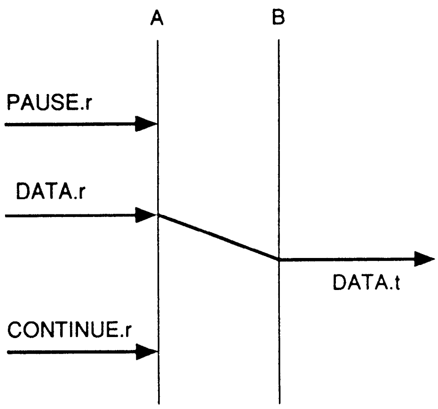
For the NC establishment and NC release phases and the reset subphase of an NC, where elementary sequences are combined only by succession, the set of possible sequences of primitives is defined with the aid of the notation for regular expressions. The transfer subphase of an NC is defined separately, in 8.5.3.



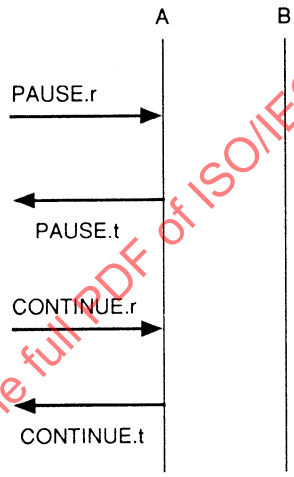
A. Crossing, DT and DT′



B. Overtaking, ED overtakes DT



C. Interpolation, DT in FT



D. interleaving, FR in FT

Figure 11 — Non-successive combinations of elementary sequences

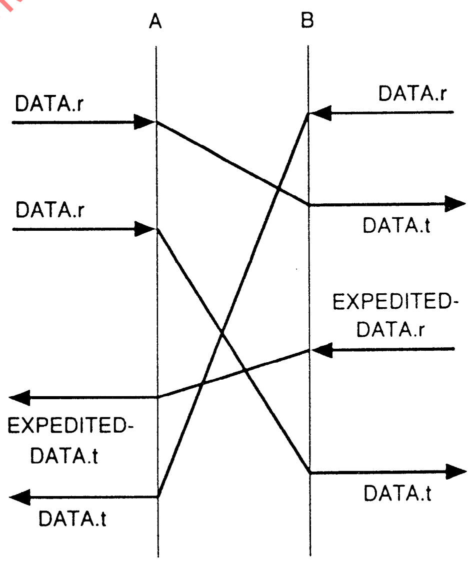


Figure 12 — Example of multiple combination methods

A regular expression generates a set of strings of concatenated symbols. As applied here, each symbol denotes a sequence of primitives, or a set of such sequences; a generated string denotes the sequence of primitives obtained by combining by succession the sequences denoted by the symbols of the string, taken in order. The notation used is as follows.

a) Expressions are constructed from symbols, parentheses and operators.

b) The name of any elementary sequence defined in figures 4 to 9 is a symbol denoting the relevant elementary sequence.

c) A name as in (b) followed by a "\" character is a symbol denoting any incomplete form of the elementary sequence.

d) The characters "<" and ">" delimit certain special symbols. The special symbol <> denotes the null string; other special symbols are described where they appear.

e) Parentheses delimit and group expressions in the usual way.

f) Any symbol is an expression, denoting the string consisting of that symbol.

g) The infix operator "•" expresses concatenation of the expressions which are its operands.

h) The infix operator "|" expresses choice between the expressions which are its operands.

j) The postfix operator "*" expresses repetition: the expression (E)* denotes the set of strings formed by concatenating together zero or more strings each generated by E.

8.5 Combinations of elementary sequences defining an NC

8.5.1 NC establishment and NC release phases

The combinations of elementary sequences that can occur in NC establishment and NC release phases of the NILS for a given NC are defined by the regular expression:

```
( <RJ3>                                                  {line 1}
| REQ • (SF|SD|SG|RETRY)* • <RJ2>                             {2}
)*                                                            {3}
•    ( ABORT                                                  {4}
     | RJ1                                                    {5}
     | REQ • (SF|SD|SG|RETRY)*                                {6}
          • ( <>                                              {7}
            | ESTAB\ • <ODTB>                                 {8}
            | ESTAB • <DT>                                    {9}
            )                                                {10}
          • (RELF|RELF´|RELG|RELC|RELC´|RELX)                {11}
     )                                                       {12}
```

where

a) the special symbol <RJ3> represents the elementary sequence RJ1 with the constraint that only NILS primitives, not NS primitives, occur (that is, the calling side A is a NISAP);

b) the special symbol <RJ2> represents one of the elementary sequences RELF´, RELC´ or RELG, with the constraints on the parameters of the DISCONNECT primitives that Originator is "NS provider" and "Reason" is one of those for "connection rejection ...", as defined in ISO/IEC 8348;

c) the special symbol <ODTB> is as defined later in this subclause;

d) the special symbol <DT> represents the data transfer phase, as defined in 8.5.2.

The subexpression in lines 1 to 3 represents the possibility of retry by N-entities on the calling side of A, after rejection by this hop or relaying component {1} or by an N-entity on the called side of B {2}. Zero or more such rejections can occur {3} before the final CONNECT.r.

The remaining three-component subexpression {4 to 12} represents the two possibilities for ending the NC without forwarding the final CONNECT to B {4 and 5}, plus the forwarding of the CONNECT {6} and the various ensuing possibilities {6 to 11}.

The repetition subexpression on line 6, like that on line 2, defines the NC proceeding subphase; it states that the elementary sequences for this subphase can occur in succession in any order.

Line 11 defines NC release phase, apart from the special cases occurring earlier in lines 4 and 5: this phase consists of just one of the elementary sequences defined in 8.3.3.

Lines 7 to 9 represent what can occur in an NC between NC proceeding subphase and NC release. Line 7 shows that one possibility is nothing at all: the NC is rejected or disconnected. Line 9 represents successful NC establishment, followed by data transfer phase.

Line 8 represents the case of partial establishment where a confirming CONNECT.r´ occurs at NHEP B, but no forwarded CONNECT.t´ occurs at A because of prior termination of the NC confirmation subphase by NC release. In this case, because the NC is fully established at B's N-entity, primitives belonging to data transfer phase can occur at B before the NC release takes effect. No such primitive can cause forwarded primitives to occur at A; <ODTB>, for "one-sided data transfer phase at B", represents these sequences. <ODTB> is defined in turn by the regular expression

<ODTB> = (<DTS´> • (RESG´|RESX´))* • <DTS´> • (RESG\ | RESX\ | <>)

where <DTS´> is as defined in 8.5.4 below.

8.5.2 Data transfer phase, general structure

The data transfer phase of an NC is built up from alternate transfer subphases and reset subphases. Normal data, expedited data and confirmations of receipt are forwarded only in transfer subphase; reset subphases provide resynchronization of data transfer at the two NHEPs, with possible discarding of data and receipt confirmations.

The structure of the data transfer phase is defined by the expression

<DT> = (<T> | <>) • (<R>.<T>)* • (<R> | <R\> | <>)

where <T> and <R> represent the possible sequences of primitives for transfer and reset subphases respectively; <R\> represents such a sequence for an incomplete reset subphase terminated by the NC release. The possible sequences for <T>, <R> and <R\> are defined in 8.5.3 and 8.5.4.

8.5.3 Data transfer phase, transfer subphase

This subclause defines the sequences of NILS primitives that represent the functions of normal data transfer, flow control, confirmation of receipt, and expedited data transfer. See particularly notes 1 to 9, for explanations of the relationships between these functions that result from the defined sequences of primitives.

Each transfer subphase is constructed from the elementary sequences DT, ED, EC, FT, FR and RC, and their "primed" counterparts DT´, etc.

Both complete and incomplete sequences of these types can occur as defined below. Every complete sequence for normal or expedited data transfer or receipt confirmation belongs to a transfer subphase. Incomplete sequences, and complete flow control sequences, can occur also in reset subphases.

Except for the transfer subphase immediately following NC establishment, every transfer subphase contains at least one complete DT, DT´, ED or ED´ sequence; that is, at least one DATA.t or EXPEDITED-DATA.t primitive is successfully forwarded. The first transfer subphase of an NC can consist only of incomplete DT, DT´, ED and ED´ sequences and complete or incomplete flow control sequences.

The sequences RC and RC´ can occur only if the value of the Receipt Confirmation Selection parameter in the CONNECT.t´ primitive of NC establishment phase was "use of Receipt Confirmation".

The sequences ED, ED´, EC and EC´ can occur only if the value of the Expedited Data Selection parameter in the CONNECT.t´ primitive of NC establishment phase was "use of Expedited Data".

The elementary sequences combine by all the methods of 8.4, according to the following rules.

a) *Succession* Elementary sequences of any type can combine by succession in any order, subject to the constraints that at any time in a given transfer subphase:

   1) the number of EC sequences is equal to or one less than the number of complete ED sequences, and similarly for EC´ and ED´;

   2) the number of RC sequences is less than or equal to the number of complete DT sequences that convey NSDU Qualifier "Last with confirmation request"; and similarly for RC´ and DT´.

b) *Crossing* All possible crossing combinations can occur: that is, any of (DT, ED, EC´, RC´) can cross any of (DT´, ED´, EC, RC), except that rule (a1) excludes crossing of ED and EC, and of ED´ and EC´; and there is no constraint on the occurrence of multiple crossing.

c) *Overtaking* For each direction of transfer independently:

   1) no sequence can overtake another of the same type;

2) a sequence of a given type can overtake one of a different type except that DT cannot overtake ED, and similarly DT´ cannot overtake ED´.

d) *Interpolation* The following interpolation combinations can occur:

1) any, and any number, of (DT, ED, ED´, EC, EC´, RC, RC´) in FT or in FR´;
2) any, and any number, of (DT´, ED, ED´, EC, EC´, RC, RC´) in FR or in FT´;
3) FR in FT, FR´ in FT´;
4) FT in FR, FT´ in FR´;
5) a limited number of DT´ in FT or in FR´;
6) a limited number of DT in FT´ or in FR

where the combinations in (3) and (4) can only occur where they do not result in the interpolated sequence being interpolated in another of its own type; and where the number of interpolated sequences in (5) and (6) is zero when the flow control sequence starts with NI-PAUSE indication, and is of the order O(d * t) when the flow control sequence starts with NI-PAUSE request, where d is the selected transit delay value for the NC and t is the selected throughput for the direction B to A (case 5) or A to B (case 6).

e) *Interleaving* FR and FT may be interleaved in either order, and similarly FR´ and FT´.

NOTES

1 Rule (a1) implies that an ENSDU can be transmitted in a given direction only if any previously transmitted ENSDUs have all been confirmed, and that the confirmations can only be transmitted after receipt of the corresponding ENSDUs. Since there are no CONS primitives corresponding to NI-EXPEDITED-DATA response and confirm, the effect of this is to express flow control of expedited data transfer that is internal to the Network layer.

2 Rule (a2) is the basic consistency rule for receipt confirmation: a confirmation of receipt cannot be transmitted before the corresponding data has actually been received.

3 Rule (c1) implies that normal data is forwarded in sequence, and that expedited NSDUs are forwarded in their own separate sequence; also that the order of confirmations of receipt is preserved, so that they can be correlated with confirmation requests simply by counting.

4 Rule (c2) implies that ENSDUs are expedited with respect to data belonging to normal NSDUs; that is, an ENSDU received after a given octet of normal data may be forwarded before it, but not vice versa.

5 Rule (c2) also implies that there is no inherent mutual ordering between confirmations of receipt and normal data or ENSDUs forwarded in the same direction.

6 Rule (d) expresses the flow control of normal data; with rule (c) it implies the independence of flow control in the two directions. Rule (d) also expresses the fact that the transfer of ENSDUs and confirmations of receipt is unaffected by this flow control.

7 At a relaying component, for example, rules (d1) and (d5) exclude the interpolating of DT´ in FT: in other words, no NI-DATA request can be issued at A after receipt there of NI-PAUSE indication, until the flow control sequence has been completed by receipt of an NI-CONTINUE indication.

8 At a NISAP of an ISB or EES on the other hand, rules (d1) and (d5) allow some NI-DATA indications to occur after an NI-PAUSE request has been issued; however, such data cannot continue to arrive indefinitely after the flow control request.

9 The flow control is therefore of a simple stop-go kind, but taking account of the time taken for a flow control request to propagate through a subnetwork to an entity capable of acting upon it. This is suitable for its intended purpose of expressing the possibility of back pressure flow control propagating through hops and relay systems (see 9.2.1).

Transfer subphase is terminated by entry to reset subphase or to NC release phase. Both of these are destructive transitions, which can cause transfer-subphase sequences to remain incomplete. Occurrence of incomplete sequences is governed by rules (a) to (e) above, subject to the convention that incomplete sequences are considered to be completed in an appropriate order at the points where the new subphase or phase is started. In particular, rule (c1) implies that an incomplete sequence of a given type other than flow control is never followed by a complete sequence of the same type in the same transfer subphase. Conversely, an incomplete sequence at one NHEP can be followed by a complete sequence (of a different type) only if sequences of the second type can overtake those of the first.

8.5.4 Data transfer phase, reset subphase

The essential characteristic of the reset service is its resynchronization of data transfer, including receipt confirmations. This is assured by the division of data transfer phase into alternating transfer and reset subphases, the subphases being synchronized between the two NHEPs. The effect can be stated as follows.

a) Any two primitives of the types DATA.t, EXPEDITED-DATA.t and DATA-ACKNOWLEDGE.t, occurring in the same transfer subphase at one NHEP of a hop or relaying component, derive from corresponding DATA.r, EXPEDITED-DATA.r or DATA-ACKNOWLEDGE.r primitives which belong to the same transfer subphase as each other at the other NHEP.

b) Any two primitives of the types DATA.t, EXPEDITED-DATA.t and DATA-ACKNOWLEDGE.t, occurring in different transfer subphases at one NHEP of a hop or relaying component, derive from corresponding DATA.r, EXPEDITED-DATA.r or DATA-ACKNOWLEDGE.r primitives which belong to different transfer subphases, in the same order, at the other NHEP.

See annex C for explanatory examples.

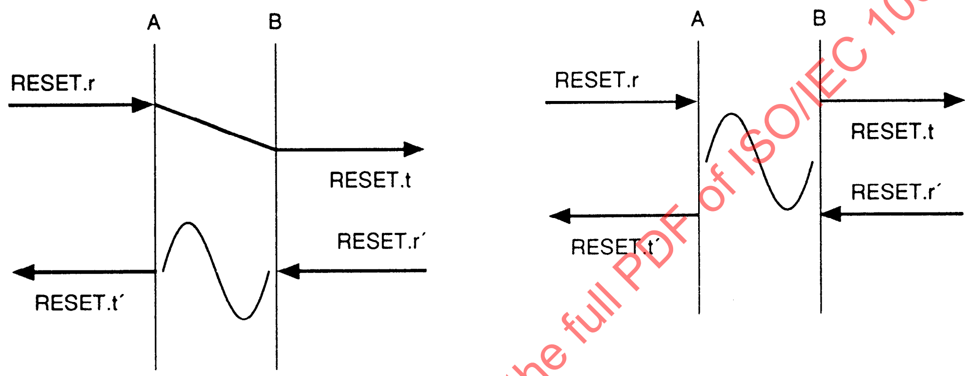
8.5.4.1 Simple resets

The simplest reset subphase consists either of the forwarded reset elementary sequence RESF followed by its confirmation RESC, or of one of the local reset sequences at A combined (by succession) with another such sequence at B. Figure 13 shows the forwarded reset case and one of the other possibilities.

The complete set of these basic reset subphase sequences is:

a) RESF • RESC
b) RESF′ • RESC′
c) RESX • RESX′
d) RESG • RESG′
e) RESX • RESG′
f) RESG • RESX′

Note that the absence of forwarding between the two NHEPs in combinations (c) to (f) means that the order of succession of the two constituent sequences is immaterial: each of (c) to (f) could equally well have been written with the constituents in the opposite order.



A. Forwarded reset and its confirmation B. External reset colliding with generated reset

Figure 13 — Basic reset examples

8.5.4.2 Multiple resets

The possibility of multiple resets in close succession, together with the absence of a sequenced forwarding relationship between confirmation primitives at the two NHEPs, gives rise to an additional set of more complex combinations of elementary sequences for the reset subphase. Each such combination starts with one of the basic combinations. This is followed, at either NHEP or both, by zero or more DATA.r or EXPEDITED.r primitives which are not forwarded at the other NHEP, but are discarded as a result of a following reset sequence; flow control primitives can also occur. This pattern of one-sided transfer subphase activity terminated by reset can be repeated. Figure 14 illustrates such a combination; the final DT′ sequence in the figure indicates the start of the following transfer subphase, which delimits the reset subphase.

The full set of possible sequences for the reset subphase is defined by the following expression, which includes the six basic combinations as its first term.

<R> = (F•C | F′•C′ | (X|G) • (X′|G′)) • (<DTS> • <DTS′> • (F•C | F′•C′)
| <DTS> • (X|G)
| <DTS′> • (X′|G′)
) *

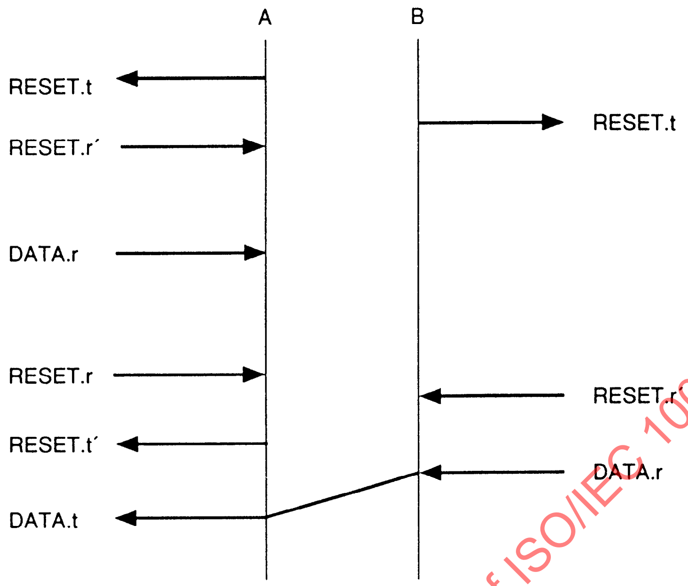
where

a) F, C, X, and G are abbreviations of the names of the elementary sequences RESF, RESC, RESX and RESG respectively.

b) <DTS>, for “discarded transfer subphase”, represents a succession of zero or more incomplete DT and ED sequences and complete FT and FR sequences, with possibly one incomplete FT and / or FR sequence not followed by another FT or FR respectively. The usual succession, interpolation and interleaving rules for transfer subphase apply (crossing and overtaking are not relevant since no sequences involve primitives at the other NHEP).

c) Primed symbols have the usual meaning, interchanging the NHEP labelling in the elementary sequences to represent the opposite direction of flow.

A reset subphase is terminated by entry to NC release phase. In that case, the combination of elementary sequences can be any non-empty truncated combination generated by the above expression.



Sequences RESG • RESG′ • DT\ • RESX • DT′

Figure 14 — Multiple resets in one reset subphase

9 Autonomous behaviour of relaying components

Much of the Network-relaying function of an Intermediate System in support of Network connections is already defined by clause 8's definitions of elementary sequences of primitives and their combinations, including figures 4 to 9, and the parameter mappings **P1** to **P7**: this applies particularly to sequences representing successful forwarding of information. This clause completes the definition; in doing so it deals principally with those sequences in which the relaying component takes an active part, as opposed to passively forwarding received information. Parameters, and QOS-Parameter Set subparameters, that are marked (=) in table 1 or table 2 are forwarded unchanged; forwarding of those parameters is not explicitly described below.

9.1 NC establishment

9.1.1 NC request subphase

A relaying component, on receiving an NI-CONNECT indication, decides whether to forward it as an NI-CONNECT request (REQ elementary sequence) or to reject it by returning an NI-DISCONNECT request (RJ1 elementary sequence). The decision to forward or reject is taken on the basis of :

— routing capabilities
— QOS capabilities in relation to received QOS parameter values
— management (eg, local resource-usage levels)

(The ABORT elementary sequence occurs, instead of REQ or RJ1, when NI-DISCONNECT indication is received before the relaying component has issued the second primitive of REQ or RJ1.)

Considered at the NILS level, the primary purpose of the routing function is to determine which NISAP of the Network relay system is to be used for forwarding the NC request. In addition, the routing function can cause the forwarded values of QOS-Parameter Set and NI Connection Control parameters to differ from the received values.

The routing function takes as input:

— the received Called Address parameter
— the received Calling Address parameter
— the received Expedited Data Selection and Receipt Confirmation Selection parameters
— the received QOS-Parameter Set parameter
— the received NI Connection Control parameter

— local information

and if successful it returns:

— identification of the NISAP on which to forward the NC request
— (possibly) modified Current QOS subparameters
— (possibly) modified NI Connection Control subparameters

NOTES

1 If more than one suitable route exists, decision between them is part of the routing function.

2 A single invocation of the routing function in a real system will normally also return information relevant to the subnetwork protocol(s) used in forwarding the NC request, including information about local and remote SNPAs. However, such information is outside the scope of this International Standard.

3 In the terminology of the OSI Routeing Framework, ISO/IEC TR 9575, the routing function just described as relevant to the NILS is in effect the composition of the two functions F1 and F2 identified in ISO/IEC TR 9575.

4 Details of how routing decisions are made are outside the scope of this International Standard. Such details include (but are not limited to) the nature of routing information accessible to the relaying component, algorithms for route selection, and mechanisms for exchanging routing information between intermediate systems and other systems. Aspects of some of these are covered in other International Standards.

If the routing function fails, so that no NISAP is determined via which the NC request can be forwarded, the NC request is rejected as in 8.3.1 and **P1**. The Reason parameter indicates the reason for failure, as one of:

"connection rejection — NSAP address unknown / permanent condition"
"connection rejection — NSAP unreachable / transient condition"
"connection rejection — NSAP unreachable / permanent condition"
"connection rejection — QOS not available / transient condition"
"connection rejection — QOS not available / permanent condition"
"connection rejection — reason unspecified / transient condition"
"connection rejection — reason unspecified / permanent condition"

When NI-CONNECT request is forwarded, the values of the Current subparameters of its QOS-Parameter Set parameter (see 8.3.1, **P2** (d)) reflect any negotiation by the relaying component.

NOTE — The constraints on QOS subparameter values, 8.3.1 **P2** (d), mean that a relaying component cannot forward NI-CONNECT if it is unable to support some QOS value within the original range. In that case, the NC request will be rejected, as above.

9.1.2 NC proceeding subphase

On receiving an NI-CONNECT-PROCEEDING indication primitive, a relaying component can forward it or discard it (SF, SD elementary sequences respectively: 8.3.1). Which of these occurs is determined in part by the protocol support at NISAP A (some protocols may not support transfer of NI-CONNECT-PROCEEDING primitives) and in part as a local matter. Generation of NI-CONNECT-PROCEEDING request primitives (SG elementary sequence) is similarly determined by a combination of protocol support and local decision.

NOTE — NI-CONNECT-PROCEEDING can be used, eg in conjunction with NI Additional QOS (7.2.11.1), to prevent an intermediate system from prematurely timing out an NC establishment attempt that involves hops with long establishment delays.

The RETRY elementary sequence occurs when, on receiving an NI-DISCONNECT indication primitive at NISAP B, a relaying component determines that another feasible route exists via an NISAP B´. The NISAP, and the route selected, can be the same as or different from those determined for the preceding NI-CONNECT request. This route determination is as in the initial REQ sequence for NC establishment, see 9.1.1 above, but the local information input to the routing function can additionally include information in the parameters of, or derived from, the received NI-DISCONNECT. (If there is no feasible route, the NC request is rejected: RELF´, or possibly RELC´, elementary sequence.)

9.1.3 NC confirmation subphase

The ESTAB elementary sequence is as defined in 8.3.1, **P3** and **P4**. Forwarding of the NI Connection Control parameter can be affected by the relaying component: if originally absent, it can be added to the forwarded NI-CONNECT response; if originally present, it can be deleted, or the subparameters can be changed or added to, to reflect the operation of the relaying component.

9.2 Data transfer phase

9.2.1 Transfer subphase

A relaying component plays no active part in individual DT, DT´, ED, ED´, EC, EC´, FT, FT´, RC AND RC´ elementary sequences (8.3.2).

A relaying component can generate NI-PAUSE request and NI-CONTINUE request primitives, giving rise to FR and FR´ elementary sequences, according to local conditions: these conditions can include increases in buffering usage resulting from FT´ or FT elementary sequences respectively.

NOTE — This flow control is an abstract expression of the means of exerting back-pressure: it implies no commitment to any particular implementation strategy.

The order in which a relaying component generates request primitives — NI-DATA, NI-EXPEDITED-DATA, NI-DATA-ACKNOWLEDGE, NI-PAUSE, and NI-CONTINUE — is a local matter, subject to the rules in 8.5.3 for combination of the transfer subphase elementary sequences.

9.2.2 Reset subphase

A relaying component determines when to issue NI-RESET response primitives according to local criteria (RESC, RESC´, RESX, RESX´ elementary sequences: 8.3.2, 8.5.4).

A relaying component generates NI-RESET request primitives, other than those that result from forwarding received NI-RESET indication primitives, if local conditions cause failures in maintaining the normal features of transfer subphase but do not cause the NC to be released (RESG, RESG´ elementary sequences). The Originator parameter value is "NS provider" and the Reason parameter value is either "congestion" or "reason unspecified". The NI Diagnostic and NI Location parameters can be absent or, otherwise, take values that provide additional information about the generated reset.

9.3 NC release

On receiving an NI-DISCONNECT indication primitive during NC establishment phase or data transfer phase, a relaying component forwards it as an NI-DISCONNECT request primitive (RELF, RELF´ elementary sequences: 8.3.3, **P6**) unless:

a) a colliding NI-DISCONNECT indication is received (RELX sequence); or

b) a local condition causes a generated NI-DISCONNECT request (RELC, RELC´ elementary sequences; see below); or

c) in NC request subphase, the received primitive completes an ABORT elementary sequence; or

d) in NC proceeding subphase, a RETRY elementary sequence is appropriate (9.1.2).

NOTE — An NI-DISCONNECT indication primitive received in NC release phase completes the phase (RELC, RELC´, RELX elementary sequences).

A relaying component generates NI-DISCONNECT request primitives, other than those that result from forwarding received NI-DISCONNECT indication primitives, if local conditions result in inability to establish or maintain the NC (RJ1, RELG, RELC, RELC´ elementary sequences: 8.3.3, **P7**).

Inability to route an NC during NC establishment is dealt with in 9.1.1; for other failures during NC establishment the Reason parameter value in an NI-DISCONNECT request generated at NISAP A is one of:

"connection rejection — permanent condition"
"connection rejection — transient condition"
"connection rejection — QOS not available / permanent condition"
"connection rejection — QOS not available / transient condition".

Apart from these cases of NC rejection, the Reason parameter value is as defined in **P7** (b).

In all generated NI-DISCONNECT request primitives the Originator parameter value is "NS provider", and the NI Diagnostic and NI Location parameters can be absent or, otherwise, take values that provide additional information about the generated release.