IEC 61158-5-7

Edition 1.0 2007-12

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications – Part 5-7: Application layer service definition – Type 7 elements

IEC 61158-5-7:2007(E)

IEC 61158-5-7

Edition 1.0 2007-12

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications –
Part 5-7: Application layer service definition – Type 7 elements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE XK

ICS 35.100.70; 25.040.40

ISBN 2-8318-9455-7

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-7: Application Layer Service definition – Type 7 elements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in the IEC 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

International Standard IEC 61158-5-7 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition and its companion parts of the IEC 61158-5 subseries cancel and replace IEC 61158-5:2003. This edition of this part constitutes an editorial revision.

This edition of IEC 61158-5 includes the following significant changes from the previous edition:

a) deletion of the former Type 6 fieldbus for lack of market relevance;
b) addition of new types of fieldbuses;
c) partition of part 5 of the third edition into multiple parts numbered -5-2, -5-3, …

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/475/FDIS	65C/486/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under http://webstore.iec.ch in the data related to the specific publication. At this date, the publication will be:

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

The list of all the parts of the IEC 61158 series, under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the “three-layer” fieldbus reference model described in IEC/TR 61158-1.

The application service is provided by the application protocol making use of the services available from the data-link or other immediately lower layer. This standard defines the application service characteristics that fieldbus applications and/or system management may exploit.

Throughout the set of fieldbus standards, the term “service” refers to the abstract capability provided by one layer of the OSI Basic Reference Model to the layer immediately above. Thus, the application layer service defined in this standard is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-7: Application Layer Service definition – Type 7 elements

1 Scope

1.1 Overview

The fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a "window between corresponding application programs."

This standard provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment. The term "time-critical" is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This standard defines in an abstract way the externally visible service provided by the Type 7 fieldbus Application Layer in terms of

a) an abstract model for defining application resources (objects) capable of being manipulated by users via the use of the FAL service,
b) the primitive actions and events of the service;
c) the parameters associated with each primitive action and event, and the form which they take; and
d) the interrelationship between these actions and events, and their valid sequences.

The purpose of this standard is to define the services provided to

1) the FAL user at the boundary between the user and the Application Layer of the Fieldbus Reference Model, and
2) Systems Management at the boundary between the Application Layer and Systems Management of the Fieldbus Reference Model.

This standard specifies the structure and services of the IEC fieldbus Application Layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) and the OSI Application Layer Structure (ISO/IEC 9545).

FAL services and protocols are provided by FAL application-entities (AE) contained within the application processes. The FAL AE is composed of a set of object-oriented Application Service Elements (ASEs) and a Layer Management Entity (LME) that manages the AE. The ASEs provide communication services that operate on a set of related application process object (APO) classes. One of the FAL ASEs is a management ASE that provides a common set of services for the management of the instances of FAL classes.

Although these services specify, from the perspective of applications, how request and responses are issued and delivered, they do not include a specification of what the requesting and responding applications are to do with them. That is, the behavioral aspects of the applications are not specified; only a definition of what requests and responses they can send/receive is specified. This permits greater flexibility to the FAL users in standardizing such object behavior. In addition to these services, some supporting services are also defined in this standard to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this standard is to specify the characteristics of conceptual application layer services suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of application layer protocols for time-critical communications.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of services standardized as the various types of IEC 61158.

This specification may be used as the basis for formal application programming interfaces. Nevertheless, it is not a formal programming interface, and any such interface will need to address implementation issues not covered by this specification, including

a) the sizes and octet ordering of various multi-octet service parameters, and

b) the correlation of paired request and confirm, or indication and response, primitives.

1.3 Conformance

This standard does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems.

There is no conformance of equipment to this application layer service definition standard. Instead, conformance is achieved through implementation of conforming application layer protocols that fulfill the Type 7 application layer services as defined in this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60559, *Binary Floating-point Arithmetic for Microprocessor Systems*

IEC/TR 61158-1 (Ed.2.0), *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-3-7, *Industrial communication networks – Fieldbus specifications – Part 3-7: Data-link layer service definition – Type 7 elements*

IEC 61158-4-7, *Industrial communication networks – Fieldbus specifications – Part 4-7: Data-link layer protocol specification – Type 7 elements*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model — Part 1: The Basic Model*

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Basic Reference Model — Part 3: Naming and addressing*

ISO/IEC 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824, *Information Technology – Abstract Syntax notation One (ASN-1): Specification of basic notation*

ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

3 Terms, definitions, symbols, abbreviations and conventions

For the purposes of this document, the following terms as defined in these publications apply.

3.1 ISO/IEC 7498-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 7498-1 apply:

a) application entity
b) application process
c) application protocol data unit
d) application service element
e) application entity invocation
f) application process invocation
g) application transaction
h) real open system
i) transfer syntax

3.2 ISO/IEC 8822 terms

a) abstract syntax
b) presentation context

3.3 ISO/IEC 9545 terms

a) application-association
b) application-context
c) application context name
d) application-entity-invocation
e) application-entity-type
f) application-process-invocation
g) application-process-type
h) application-service-element
i) application control service element

3.4 ISO/IEC 8824 terms

a) object identifier
b) type

3.5 Fieldbus data-link layer terms

The following terms as defined in IEC 61158-3-7 and IEC 61158-4-7 apply.

a) acknowledgement response DLPDU
b) basic cycle
c) basic transaction

d) bus-arbitrator (BA)
e) control field
f) destination address
e) DL-segment, local link
g) DLCEP-identifier
h) DLCEP-iedentifier DLPDU
i) end of message transaction indication DLPDU
j) identified variable (or simply « variable »)
k) invalid DLCEP-identifier
l) macrocycle
m) message DLPDU identifier
n) message response DLPDU
o) periodic scanning of variables
p) published identified varaible
q) request response DLPDU
r) source address
s) subscribed identified variable
t) triggered message scanning
u) triggered periodic scanning of messages
w) triggered periodic scanning of variables
x) triggered scanning of variables
y) turnaround time
z) variable response DLPDU

The following symbols and abbreviations as defined in IEC 61158-3-7 and IEC 61158-4-7 apply.

a) BA
b) B_Dat_cons
c) B_Dat_Prod
d) B_Req1/2
e) ID_DAT
f) ID_MSG
g) ID_RQ1/2
h) PRT
i) Q_IDMSG
j) Q_IDRQ1/2
k) Q_Msg_Aper
l) Q_Req1/2
m) Q_RPRQ
n) RQ_Inhibit
o) RP_ACK
p) RP_DAT
q) RP_DAT_MSG

r) RP_DAT_RQ1/2
s) RP_DAT_RQ1/2_MSG
t) RP_MSG_ACK
u) RP_MSG_NOACK
v) RP_NAK
w) RP_END
x) STT
y) TI

3.6 Fieldbus application layer specific definitions

For the purposes of this standard, the following terms and definitions apply.

3.6.1
access protection
limitation of the usage of an application object to one client

3.6.2
active connection control object
instance of a certain FAL class that abstracts the interconnection facility (as Consumer and Provider) of an automation device

3.6.3
address assignment table
mapping of the client's internal I/O-Data object storage to the decentralised input and output data objects

3.6.4
allocate
take a resource from a common area and assign that resource for the exclusive use of a specific entity

3.6.5
application
function or data structure for which data is consumed or produced

3.6.6
application layer interoperability
capability of application entities to perform coordinated and cooperative operations using the services of the FAL

3.6.7
application objects
multiple object classes that manage and provide a run time exchange of messages across the network and within the network device

3.6.8
application process
part of a distributed application on a network, which is located on one device and unambiguously addressed

3.6.9
application process identifier
distinguishes multiple application processes used in a device

3.6.10
application process object
component of an application process that is identifiable and accessible through an FAL application relationship

NOTE Application process object definitions are composed of a set of values for the attributes of their class (see the definition for Application Process Object Class Definition). Application process object definitions may be accessed remotely using the services of the FAL Object Management ASE. FAL Object Management services can be used to load or update object definitions, to read object definitions, and to dynamically create and delete application objects and their corresponding definitions.

3.6.11
application process object class
a class of application process objects defined in terms of the set of their network-accessible attributes and services

3.6.12
application relationship
cooperative association between two or more application-entity-invocations for the purpose of exchange of information and coordination of their joint operation

NOTE This relationship is activated either by the exchange of application-protocol-data-units or as a result of preconfiguration activities.

3.6.13
application relationship application service element
application-service-element that provides the exclusive means for establishing and terminating all application relationships

3.6.14
application relationship endpoint
context and behavior of an application relationship as seen and maintained by one of the application processes involved in the application relationship

NOTE Each application process involved in the application relationship maintains its own application relationship endpoint.

3.6.15
attribute
description of an externally visible characteristic or feature of an object

NOTE The attributes of an object contain information about variable portions of an object. Typically, they provide status information or govern the operation of an object. Attributes may also affect the behaviour of an object. Attributes are divided into class attributes and instance attributes.

3.6.16
behaviour
indication of how an object responds to particular eventss

3.6.17
bit-no
designates the number of a bit in a bitstring or an octet

3.6.18
channel
single physical or logical link of an input or output application object of a server to the process

3.6.19
class
a set of objects, all of which represent the same kind of system component

NOTE A class is a generalisation of an object; a template for defining variables and methods. All objects in a class are identical in form and behaviour, but usually contain different data in their attributes.

3.6.20
class attributes
attribute that is shared by all objects within the same class

3.6.21
class code
unique identifier assigned to each object class

3.6.22
class specific service
service defined by a particular object class to perform a required function which is not performed by a common service

NOTE A class specific object is unique to the object class which defines it.

3.6.23
client
a) object which uses the services of another (server) object to perform a task
b) initiator of a message to which a server reacts

3.6.24
communication objects
components that manage and provide a run time exchange of messages across the network

EXAMPLES: Connection Manager object, Unconnected Message Manager (UCMM) object, and Message Router object

3.6.25
configuration identifier
representation of a portion of I/O Data of a single input- and/or output-module of a server

3.6.26
connection
logical binding between application objects that may be within the same or different devices

NOTE 1 Connections may be either point-to-point or multipoint.

NOTE 2 The logical link between sink and source of attributes and services at different custom interfaces of RT-Auto ASEs is referred to as interconnection. There is a distinction between data and event interconnections. The logical link and the data flow between sink and source of automation data items is referred to as data interconnection. The logical link and the data flow between sink (method) and source (event) of operational services is referred to as event interconnection.

3.6.27
connection channel
description of a connection between a sink and a source of data items

3.6.28
connection ID (CID)
identifier assigned to a transmission that is associated with a particular connection between producers and consumers, providing a name for a specific piece of application information

3.6.29
connection path
octet stream that defines the application object to which a connection instance applies

3.6.30
connection point
buffer which is represented as a subinstance of an Assembly object

3.6.31
consume
act of receiving data from a producer

3.6.32
consumer
node or sink that is receiving data from a producer

3.6.33
consuming application
application that consumes data

3.6.34
consumerID
unambiguous identifier within the scope of the ACCO assigned by the consumer to recognize the internal data of a configured interconnection sink

3.6.35
control commands
action invocations transferred from client to server to clear outputs, freeze inputs and/or synchronise outputs

3.6.36
conveyance path
unidirectional flow of APDUs across an application relationship

3.6.37
cyclic
repetitive in a regular manner

3.6.38
data consistency
means for coherent transmission and access of the input- or output-data object between and within client and server

3.6.39
dedicated AR
AR used directly by the FAL User

NOTE On Dedicated ARs, only the FAL Header and the user data are transferred.

3.6.40
device
physical hardware connected to the link

NOTE A device may contain more than one node.

3.6.41
device profile
collection of device dependent information and functionality providing consistency between similar devices of the same device type

3.6.42
end node
producing or consuming node

3.6.43
endpoint
one of the communicating entities involved in a connection

3.6.44
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.6.45
error class
general grouping for related error definitions and corresponding error codes

3.6.46
error code
identification of a specific type of error within an error class

3.6.47
event
instance of a change of conditions

3.6.48
FIFO variable
a Variable Object class, composed of a set of homogeneously typed elements, where the first written element is the first element that can be read

NOTE On the fieldbus only one, complete element can be transferred as a result of one service invocation.

3.6.49
frame
denigrated synonym for DLPDU

3.6.50
group
a) <general> a general term for a collection of objects.
b) <addressing> when describing an address, an address that identifies more than one entity

3.6.51
interface
a) shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate
b) collection of FAL class attributes and services that represents a specific view on the FAL class

3.6.52
interface definition language
syntax and semantics of describing service parameters in a formal way

NOTE This description is the input for the ORPC model, especially for the ORPC wire protocol.

3.6.53
interface pointer
key attribute that unambiguously addresses an object interface instance

3.6.54
invocation
act of using a service or other resource of an application process

NOTE Each invocation represents a separate thread of control that may be described by its context. Once the service completes, or use of the resource is released, the invocation ceases to exist. For service invocations, a service that has been initiated but not yet completed is referred to as an outstanding service invocation. Also for service invocations, an Invoke ID may be used to unambiguously identify the service invocation and differentiate it from other outstanding service invocations.

3.6.55
index
address of an object within an application process

3.6.56
instance
actual physical occurrence of an object within a class that identifies one of many objects within the same object class

EXAMPLE California is an instance of the object class state.

NOTE The terms object, instance, and object instance are used to refer to a specific instance.

3.6.57
instance attributes
attribute that is unique to an object instance and not shared by the object class

3.6.58
instantiated
object that has been created in a device

3.6.59
logical device
certain FAL class that abstracts a software component or a firmware component as an autonomous self-contained facility of an automation device

3.6.60
manufacturer ID
identification of each product manufacturer by a unique number

3.6.61
management information
network-accessible information that supports managing the operation of the fieldbus system, including the application layer

NOTE Managing includes functions such as controlling, monitoring, and diagnosing.

3.6.62
member
piece of an attribute that is structured as an element of an array

3.6.63
method
synonym for an operational service which is provided by the server ASE and invoked by a client

3.6.64
module
hardware or logical component of a physical device

3.6.65
multipoint connection
connection from one node to many

NOTE Multipoint connections allow messages from a single producer to be received by many consumer nodes.

3.6.66
network
a set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.6.67
object
abstract representation of a particular component within a device, usually a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have clearly defined interface and behaviour

3.6.68
object remote procedure call
model for object oriented or component based remote method invocation

3.6.69
object specific service
service unique to the object class which defines it

3.6.70
originator
client responsible for establishing a connection path to the target

3.6.71
peer
role of an AR endpoint in which it is capable of acting as both client and server

3.6.72
physical device
an automation or other network device

3.6.73
point-to-point connection
connection that exists between exactly two application objects

3.6.74
pre-defined AR endpoint
AR endpoint that is defined locally within a device without use of the create service

NOTE Pre-defined ARs that are not pre-established are established before being used

3.6.75
pre-established AR endpoint
AR endpoint that is placed in an established state during configuration of the AEs that control its endpoints

3.6.76
process data
object(s) which are already pre-processed and transferred acyclically for the purpose of information or further processing

3.6.77
produce
act of sending data to be received by a consumer

3.6.78
producer
node that is responsible for sending data

3.6.79
provider
source of a data connection

3.6.80
publisher
role of an AR endpoint that transmits APDUs onto the fieldbus for consumption by one or more subscribers

NOTE A publisher may not be aware of the identity or the number of subscribers and it may publish its APDUs using a dedicated AR.

3.6.81
resource
processing or information capability of a subsystem

3.6.82
server
a) role of an AREP in which it returns a confirmed service response APDU to the client that initiated the request
b) object which provides services to another (client) object

3.6.83
service
operation or function than an object and/or object class performs upon request from another object and/or object class

3.6.84
subscriber
role of an AREP in which it receives APDUs produced by a publisher

3.7 Abbreviations and symbols

AE	Application Entity
AL	Application Layer
ALME	Application Layer Management Entity
ALP	Application Layer Protocol
APO	Application Object
AP	Application Process
APDU	Application Protocol Data Unit
API	Application Process Identifier
AR	Application Relationship
AREP	Application Relationship End Point
ASCII	American Standard Code for Information Interchange
ASE	Application Service Element
CID	Connection ID
CIM	Computer Integrated Manufacturing
CIP	Control and Information Protocol
Cnf	Confirmation
COR	Connection originator
CR	Communication Relationship
CREP	Communication Relationship End Point
DL-	(as a prefix) Data Link-
DLC	Data Link Connection
DLCEP	Data Link Connection End Point

DLL	Data Link Layer
DLM	Data Link-management
DLSAP	Data Link Service Access Point
DLSDU	DL-service-data-unit
DNS	Domain Name Service
DP	Decentralised Peripherals
FAL	Fieldbus Application Layer
FIFO	First In First Out
HMI	Human-Machine Interface
ID	Identifier
IDL	Interface Definition Language
IEC	International Electrotechnical Commission
Ind	Indication
IP	Internet Protocol
ISO	International Organization for Standardization
LDev	Logical Device
LME	Layer Management Entity
ORPC	Object Remote Procedure Call
OSI	Open Systems Interconnect
PDev	Physical Device
PDU	Protocol Data Unit
PL	Physical Layer
QoS	Quality of Service
Req	Request
Rsp	Response
RT	Runtime
SAP	Service Access Point
SCL	Security Level
SDU	Service Data Unit
SMIB	System Management Information Base
SMK	System Management Kernel
STD	State transition diagram, used to describe object behaviour
S-VFD	Simple Virtual Field Device
VAO	Variable Object

3.8 Conventions

3.8.1 Overview

The FAL is defined as a set of object-oriented ASEs. Each ASE is specified in a separate subclause. Each ASE specification is composed of two parts, its class specification, and its service specification.

The class specification defines the attributes of the class. The attributes are accessible from instances of the class using the Object Management ASE services specified in Clause 5 of this standard. The service specification defines the services that are provided by the ASE.

3.8.2 Conventions for class definitions

Class definitions are described using templates. Each template consists of a list of attributes for the class. The general form of the template is shown below:

FAL ASE:			**ASE Name**
CLASS:		**Class Name**	
CLASS ID:			#
PARENT CLASS:			Parent Class Name
ATTRIBUTES:			
1	(o)	Key Attribute:	numeric identifier
2	(o)	Key Attribute:	name
3	(m)	Attribute:	attribute name(values)
4	(m)	Attribute:	attribute name(values)
4.1	(s)	Attribute:	attribute name(values)
4.2	(s)	Attribute:	attribute name(values)
4.3	(s)	Attribute:	attribute name(values)
5.	(c)	Constraint:	constraint expression
5.1	(m)	Attribute:	attribute name(values)
5.2	(o)	Attribute:	attribute name(values)
6	(m)	Attribute:	attribute name(values)
6.1	(s)	Attribute:	attribute name(values)
6.2	(s)	Attribute:	attribute name(values)
SERVICES:			
1	(o)	OpsService:	service name
2.	(c)	Constraint:	constraint expression
2.1	(o)	OpsService:	service name
3	(m)	MgtService:	service name

(1) The "FAL ASE:" entry is the name of the FAL ASE that provides the services for the class being specified.

(2) The "CLASS:" entry is the name of the class being specified. All objects defined using this template will be an instance of this class. The class may be specified by this standard, or by a user of this standard.

(3) The "CLASS ID:" entry is a number that identifies the class being specified. This number is unique within the FAL ASE that will provide the services for this class. When qualified by the identity of its FAL ASE, it unambiguously identifies the class within the scope of the FAL. The value "NULL" indicates that the class cannot be instantiated. Class IDs between 1 and 255 are reserved by this standard to identify standardized classes. They have been assigned to maintain compatibility with existing national standards. CLASS IDs between 256 and 2048 are allocated for identifying user defined classes.

(4) The "PARENT CLASS:" entry is the name of the parent class for the class being specified. All attributes defined for the parent class and inherited by it are inherited for the class being defined, and therefore do not have to be redefined in the template for this class.

NOTE The parent-class "TOP" indicates that the class being defined is an initial class definition. The parent class TOP is used as a starting point from which all other classes are defined. The use of TOP is reserved for classes defined by this standard.

(5) The "ATTRIBUTES" label indicate that the following entries are attributes defined for the class.

a) Each of the attribute entries contains a line number in column 1, a mandatory (m) / optional (o) / conditional (c) / selector (s) indicator in column 2, an attribute type label in column 3, a name or a conditional expression in column 4, and optionally a list of enumerated values in column 5. In the column following the list of values, the default value for the attribute may be specified.

b) Objects are normally identified by a numeric identifier or by an object name, or by both. In the class templates, these key attributes are defined under the key attribute.

c) The line number defines the sequence and the level of nesting of the line. Each nesting level is identified by period. Nesting is used to specify

   i) fields of a structured attribute (4.1, 4.2, 4.3),

   ii) attributes conditional on a constraint statement (5). Attributes may be mandatory (5.1) or optional (5.2) if the constraint is true. Not all optional attributes require constraint statements as does the attribute defined in (5.2).

   iii) the selection fields of a choice type attribute (6.1 and 6.2).

(6) The "SERVICES" label indicates that the following entries are services defined for the class.

a) An (m) in column 2 indicates that the service is mandatory for the class, while an (o) indicates that it is optional. A (c) in this column indicates that the service is conditional. When all services defined for a class are defined as optional, at least one has to be selected when an instance of the class is defined.

b) The label "OpsService" designates an operational service (1).

c) The label "MgtService" designates an management service (2).

d) The line number defines the sequence and the level of nesting of the line. Each nesting level is identified by period. Nesting within the list of services is used to specify services conditional on a constraint statement.

3.8.3 Conventions for service definitions

3.8.3.1 General

This standard uses the descriptive conventions given in ISO/IEC 10731.

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

3.8.3.2 Service parameters

Service primitives are used to represent service user/service provider interactions (ISO/IEC 10731). They convey parameters which indicate information available in the user/provider interaction.

NOTE 1 See the note under 3.8.3.3 relative to the non-inclusion of service parameters that are appropriate to a protocol specification or programming interface specification or implementation specification, but not to an abstract service definition.

This standard uses a tabular format to describe the component parameters of the service primitives. The parameters that apply to each group of service primitives are set out in tables throughout the remainder of this standard. Each table consists of up to six columns: a column for the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the service. The possible six columns are:

1) the parameter name;
2) the request primitive's input parameters;

3) the request primitive's output parameters;

NOTE 2 This is a seldom-used capability. Unless otherwise specified, request primitive parameters are input parameters.

4) the indication primitive's output parameters;

5) the response primitive's input parameters; and

6) the confirm primitive's output parameters.

NOTE 3 The request, indication, response and confirm primitives are also known as requestor.submit, acceptor.deliver, acceptor.submit, and requestor.deliver primitives, respectively (see ISO/IEC 10731).

One parameter (or component of it) is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive specified in the column:

M	parameter is mandatory for the primitive
U	parameter is a User option, and may or may not be provided depending on dynamic usage of the service user. When not provided, a default value for the parameter is assumed.
C	parameter is conditional upon other parameters or upon the environment of the service user.
—	(blank) parameter is never present.
S	parameter is a selected item.

Some entries are further qualified by items in brackets. These may be

a) a parameter-specific constraint:
"(=)" indicates that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table.

b) an indication that some note applies to the entry:
"(n)" indicates that the following note "n" contains additional information pertaining to the parameter and its use.

3.8.3.3 Service procedures

The procedures are defined in terms of

- the interactions between application entities through the exchange of fieldbus Application Protocol Data Units, and
- the interactions between an application layer service provider and an application layer service user in the same system through the invocation of application layer service primitives.

These procedures are applicable to instances of communication between systems which support time-constrained communications services within the fieldbus Application Layer.

NOTE The IEC 61158-5 series of standards define sets of abstract services. They are neither protocol specifications nor implementation specifications nor concrete programming interface specifications. Therefore there are restrictions on the extent to which service procedures can be mandated in the parts of IEC 61158-5. Protocol aspects that can vary among different protocol specifications or different implementations that instantiate the same abstract services are unsuitable for inclusion in these service definitions, except at the level of abstraction that is necessarily common to all such expressions.

For example, the means by which service providers pair request and reply PDUs is appropriate for specification in an IEC 61158-6 protocol specification standard but not in an IEC 61158-5 abstract service definition standard. Similarly, local implementation methods by which a service provider or service user pairs request and confirm(ation) primitives, or indication and response primitives, is appropriate for an implementation specification or for a programming interface specification, but not for an abstract service standard or for a protocol standard, except at a level of abstraction that is necessarily common to all embodiments of the specifying standard. In all cases, the abstract definition is not permitted to over-specify the more concrete instantiating realization.

Further information on the conceptual service procedures of an implementation of a protocol that realizes the services of one of the IEC 61158-5 abstract service definitions can be found in IEC/TR 61158-1, 9.6.

4 Concepts

The common concepts and templates used to describe the application layer service in this fieldbus are detailed in IEC/TR 61158-1, Clause 9.

5 Data type ASE

5.1 Overview

An overview of the data type ASE and the relationships between data types is provided in IEC/TR 61158-1, 10.1

5.2 Formal definition of data type objects

The template used to describe the data type class is detailed in IEC/TR 61158-1, 10.2. This includes the specific ASE structure and the definition of its attributes.

5.3 FAL defined data types

5.3.1 Fixed length types

Primitive types that are selected and their characteristics are mostly specified in the ISO 8824 standard.

The Used Data types and the discrepancies between the 8824 and this standard are listed hereafter.

5.3.1.1 BOOLEAN

Conform to the 8824 Standard.

5.3.1.2 FLOATING POINT

CLASS:			**Data type**
ATTRIBUTES:			
1	Data type Numeric Identifier	=	Not used
2	Data type Name	=	FloatingPoint
3	Format	=	FIXED LENGTH
5.1	Octet Length	=	Boolean

This primitive type defines value representation for positive and negative real numbers, including, zero, negative infinite and positive infinite.

The values at the limits (0, +• -•), as well as the various representation formats are defined in IEC 60559.

For this type, the attribut Octet length, of boolean type, indicates whether the representation format is simple precision “4 octets” (FALSE) or double precision “8 octets” (TRUE).

5.3.1.3 BCD

Conform to the ISO/IEC 8824.

5.3.1.4 INTEGER

CLASS:	**Data type**
ATTRIBUTES:	

1	Data type Numeric Identifier	=	Not used
2	Data type Name	=	Integer
3	Format	=	FIXED LENGTH
5.1	Octet Length	=	n

The definition of this primitive type is the same as the integer type definition in ISO 8824 standard. For this type, the Octete lentgh attribute defines the number of bits that are necessary to have a twos complement representation of all possible values.

Ex : Octet lentgh = 1 if -128 ≤ n ≤ 127 ; 2 if -32768 ≤ n ≤ 32767; …..

5.3.1.5 UNSIGNED

CLASS: **Data type**

ATTRIBUTES:

1	Data type Numeric Identifier	=	Not used
2	Data type Name	=	Unsigned
3	Format	=	FIXED LENGTH
5.1	Octet Length	=	n

The definition of this primitive type is the same as the integer type definition in ISO 8824 with the exclusion of negative numbers. For this type, the Octet Length attribute defines the number of bits that are necessary to have a twos complement representation of all possible values.

Ex : 1 : for unsigned8 ; 2 : for unsigned16 ; 4 : for unsigend32 ; 8 for unsigned64

5.3.1.6 GENERALISED TIME

Conform to the ISO/IEC 8824.

5.3.1.7 BINARY TIME

CLASS: **Data type**

ATTRIBUTES:

1	Data type Numeric Identifier	=	Not used
2	Data type Name	=	BinaryTime
3	Format	=	FIXED LENGTH
5.1	Octet Length	=	n

This primitive type is defined as the unsigned type of the present standard, the value of which corresponds to a number of elementary times.

For this type, each value of the *Octet Lentgh* attribute defines the value of an elementary time as well as a number of bits used to represent any possible binary time value, as show in the Table 1.

Table 1 – Binary time coding

Size	**10 ms**	**0,1 ms**	**1 ms**	**10 ms**
16 Bits	0	1	2	3
32 Bits	4	5	6	7
48 Bits	8	9	—	—

5.3.2 String types

5.3.2.1 BIT STRING

Conform to the ISO/IEC 8824.

5.3.2.2 OCTET STRING

Conform to the ISO/IEC 8824.

5.3.2.3 VISIBLE STRING

Conform to the ISO/IEC 8824.

5.3.3 Array types

There are defined as user defined data types for the specific application. User data types are supported by this standard as instances of the data types classes.

User defined types are specified in the same manner that all FAL objects are specified. They are defined by providing values for the attributes specified for their class.

5.3.4 Structures types

There are defined as user defined data types for the specific application. User data types are supported by this standard as instances of the data types classes.

User defined types are specified in the same manner that all FAL objects are specified. They are defined by providing values for the attributes specified for their class.

6 Communication model specification

6.1 Concepts

6.1.1 AL environment

This general model presents the relationship between the AL environment and the application layer services which is the purpose of this standard.

The AL environment is both process control and discrete parts manufacturing. In those systems, manufacturing devices are controlled by a system that performs the automation functions.

6.1.2 Application services

Application services can be divided into two sets. See Figure 1.

The standard specifies the MPS (Manufacturing Periodic/aperiodic Services) application service set. The other service set corresponds to a subset (subMMS) of that specified in the MMS standard.

MPS services are particularly well suited to the real time requirements of a distributed application in the fact that they support:

- The periodic broadcast update of a distributed database in the various control system devices.
- The elaboration of temporal qualifiers associated with the data base.
- The elaboration of consistency qualifiers associated with sets of data within this database.

SubMMS and MCS are essentially considered to fulfil the requirements for configuration and operating mode management within the distributed application.

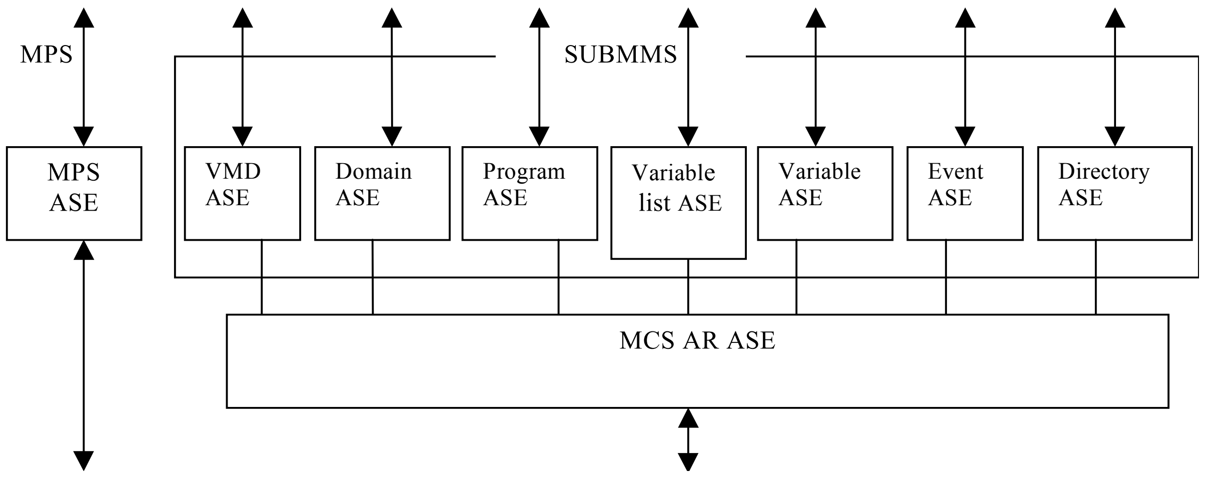


Figure 1 – Organisation of the ASEs and ARs

A distributed application is characterized by various information processing tasks on various devices of a communication system for the requirements of check a production system control application.

Cooperation between the tasks belonging to different devices is modelled in the form of interactions between application processes (APs).

A distributed application is composed of two or more APs, each of the devices of the communication system which can have zero, one or several of them.

As provided for by this standard, the communication between two APs passes via the network.

NOTE The breaking down of a distributed application in several AP's at the level of a device is decided by the user according to his own criteria (Methodology, Functional structuring of the application, Setting into service facilities, etc.)

6.1.3 Application process

6.1.3.1 Application process overview

An AP is modelled by one or several information processing tasks in a device for the requirements of a particular function of the distributed application.

The aspects of an AP, taken into account by the AL, only concern its communication capacities which are modelled by Application Entities (AEs). Each AP can have at the most one AE of a given type.

On the other hand, the cooperation between APs in the framework of a distributed application are performed via the setting up of the relations between AP invocations (APIs) which represent its activities. An AP can, at a given instant, zero, one or several APIs. Besides, each API has one particular utilization of the AE (AEI) which satisfies the communication requirements.

6.1.3.2 AP model

6.1.3.2.1 AP model description

The purpose of the AP model is to show all the aspects of an AP which are taken into account by the AL communication.

NOTE The other aspects concerning the type of information, processing and execution of the latter are not modeled, since they are not involved at the communication level.

***Class*: APPLICATION PROCESS (AP)**

Key Attribute: AP title

Attribute: AP type

Attribute: List of Inherit from Application Entity

Attribute: List of Reference API

6.1.3.2.2 Attributes:

AP title:

A title is attributed to an AP to identify it, among all the other APs, in a non-ambiguous manner in a multisegment AL network. For the requirements of the universal identification of an AP in the AL environment, this AP tile is involved as a constituent of the ISO name proper to AL user site.

This identification can be structured from the name of the device to which it belongs.

NOTE To structure this identification, this AP should remain permanently in the equipment.

AP type:

The type of an AP helps to designate a set of APs to which it belongs.

NOTE This type is not covered by a title which can be handled in the AL environment.

List of Inherit from Application Entity

The Application Process class inherits an Application Entity class list which gives it the capacity to communicate in the AL environment.

Thus an AP has one or several application entities, which are necessarily of different types.

List of Reference API:

Designates the lists of APIs which model the AP activities. This list can vary dynamically but at a given instant zero, can designate one or several APIs.

6.1.3.3 API model

6.1.3.3.1 API model description

An API model describes the activities of an AP.

***Class*: APPLICATION PROCESS INVOCATION (API)**

Key Attribute: API identification

Attribute: Reference Application Process

Attribute: *List of Reference* AEI

6.1.3.3.2 Attributes:

API identification:

Identifies an Application Process Invocation in a non-ambiguous manner in the given AP field. It is underlined that the scope of this identification is global for the AP and independent of the rules for naming the AP title.

***Reference* Application process**

The purpose of this attribute is to show that this API belongs to a given AP.

The lifetime of an API is necessarily less than or equal to that of the AP to which it belongs.

List of Reference AEI:

This list designates AE uses which are reserved for the API requirements.

An API can use zero, one or several AEIs for each AE of the AP to which it belongs.

The number of referenced AEIs can vary dynamically in time. Consequently, an API, at a given moment, can have one or several AEIs (Complete definition of an AEI in the following paragraph).

6.1.4 Application entity

An AE represents a set of communication capacities for the requirements of an AP. These communication capacities are defined by a set of Application Service Elements (ASEs). The particular uses of the communication capacities of an AE are represented by AE invocations (AEIs).

An AEI consequently models the communication functions and their state for the particular activities of an API. Communications between APIs take place via AEIs which, as required, may or may not be related by Application Associations (AAs) or Application Relationship (AR) in the AL context.

An AEI in the AL environment gives an API the exclusive possibility of communicating with or without association. An AEI can only participate in one and in only one association application.

The communications without association allow an AEI to exchange information with one or several other AEIs.

An association application allows an AEI to communicate with one or several other AEIs in the framework of a common Context Application (CA).

This context can be negotiated or predefined by configuration for each AEI, for a point to point association which makes use of a pair of AEIs. The context is necessarily prenegotiated for each AEI.

The state of an AEI is thus directly linked to the fact that the latter participates or not in an association and to the state of the association if it participates in a negotiated association.

Generally it can be said that the lifetime of an AEI is equivalent to that of the service exchanged for the communications without association and equivalent to that of the association for communications with associations. However, for a negotiated association, the lifetime of the pair of AEIs is lengthened by their opening and closing transients.

The lifetime of an AEI is controlled by the API which it represents in the AL environment. An API, on the other hand, can have a much longer lifetime than that of its AEIs, equal to that of the AP to which it belongs.

Particular AR are predefined by configuration, these AR are only used by the MPS ASE to exchange plain data (variable). All the parameters relative to the variable are pre-established at the configuration, these parameters never change. Only a new configuration can cancel or modify these particular AR. The identification of this peculiar AR is made by a number unique on the network, this number refer to the whole set of parameters of the AR and the DLL resources implied for the communication. This number similar to a DLCEP Id is called Identifier.

6.1.5 AE model

6.1.5.1 AE model desription

Description of the communication capacities offered by an AE.

***Class*: APPLICATION ENTITY (AE)**
Attribute: AE type
Key Attribute: Qualifier
Attribute: List of Inherit from ASE
Attribute: List of Reference AEI

6.1.5.2 Attributes:

Qualifier:

An AE qualifier identifies an AE non-ambiguously in the field of an application process. The combination of this AE qualifier with the AP title forms an AE title which identifies this AE non-ambiguously in the AL environment.

This AE title allows recovery from the directory of the addressing information, the link addresses.

An AE title can have "Synonyms of the AE title" to be distinguished from one or several other AEs by different titles.

An AE can be globally identified with other AEs with the help of an "AE group designation".

AE type:

The AE type designates a set of AEs sharing the same communication characteristics. Various AEs of the same type inherit the same list of application service elements.

List of Inherit from ASE

The Application Entity (AE) class inherits an ASE class list which gives it the specificity of its communication functions. An AE can support one or several ASEs, the latter being necessarily of different types.

List of Reference AEI

Designates the list of AEIs which model the AE uses. This list, which can vary dynamically , can designate at a given moment, zero, one or several AEIs.

6.1.6 AEI model

6.1.6.1 AEI model description

An AEI model is used to describe a particular use of the AE.

***Class*: APPLICATION ENTITY INVOCATION (AEI)**
Key attribute: AEI identification
Attribute: Reference AE
Attribute: *Reference* API
Attribute: Local AE address
Attribute: Remote AE address
Attribute: Communication mode
[ASSOCIATED; NON-ASSOCIATED]
Constraint: Communication mode = ASSOCIATED
Attribute: Association state
    [OPENING;
    ESTABLISHED;
    CLOSED]
Attribute: Association type
    [NEGOTIATED; PRENEGOTIATED]
Attribute: Association type
    [NEGOTIATED; PRENEGOTIATED]
Attribute: Local AEI access point
Attribute: Remote AEI access point
Attribute: *Inherit from* Application context

6.1.6.2 Attributes:

AEI identification:

Allows non-ambiguous identification of an application entity invocation in the sub-field of an AE reserved for an API of a given AP.

The Non-ambiguous designation of an AEI in the environment requires indicating: AP title / API identification / AE qualifier /AEI identification.

Reference AE:

This reference is used to designate the AE object to which this AEI belongs,

The lifetime of an AEI is necessarily less than or equal to that of the AE to which it belongs.

Reference API:

This reference helps to designate the API object which is represented in the AL environment by this

AEI. An AEI can represent one and only one API in the AL environment.

Local AE address:

Corresponds to the link address which allows locating the AE to which this AEI belongs.

This address is completed with the help of directory functions during the creation of this AEI and remains static for its lifetime.

Remote AE address:

Corresponds, either to a link address which allows locating the AE with which this AEI is corresponding, for point to point exchanges, or with a link address which helps to locate an AE group with which this AEI is corresponding for multipoint exchanges.

This address is filled at the AEI level during the opening of an association with one other AEI or when exchanging data in a non-associated mode.

Communication mode [ASSOCIATED; NON-ASSOCIATED]

(The communication mode in the ASSOCIATED state indicated that this AEI allows an API to communicate in a application context which was previously defined or negotiated. The type of exchanges between AEIs, possible in such a communication mode, is point to point or multipoint.

When the communication mode is NON-ASSOCIATED, this AEI allows an API to communicate outside all pre-established context. The nature of the possible exchanges in a non-associated communication mode is point to point or multipoint.

Association state

[OPENING;

ESTABLISHED;

CLOSING]:

In the associated mode, the possibilities of communication of an AEI with another AEI depends on the state of the association. The various states correspond to the phases in the life of an association application:

OPENING:

Corresponds to an AEI which, at the request of the API which it represents, is negotiating an application context with another AEI, for the requirements of an association. In this state, no exchanges can take place outside those reserved for negotiation of the context.

ESTABLISHED:

Corresponds to an AEI which offers the API which it represents, the possibility of communicating with another API via one of its determined AEIs, within the framework of an application context. This application context has been obtained either by negotiation between the AEI pair or by local predefinition at the AEIs.

CLOSING:

Corresponds to an AEI which, at the request of the API which it represents, or with which it had been associated, is being freed from its application context.

Association type

[NEGOTIATED;

PRENEGOTIATED]

This type indicates if the association has been negotiated or not. This attribute, if it takes the PRENEGOTIATED value, imposes on the association to remain exclusively in the ESTABLISHED state.

Local AEI access point:

Each AEI, in the ASSOCIATED mode, can be directly localized by its AEI access point. This addressing information is filled with the help of the directory functions during the creation of an AEI instance and remains static for its full lifetime.

AEI remote access point:

Each AEI, which is in the ASSOCIATED mode, has this addressing information which localizes the AEI with which it is in correspondence for point to point exchanges. This information is filled in for an AEI at the opening of an association.

This information locates the AEIs with which it is in correspondence for multipoint exchanges.

Inherit from Context Application

This inheritance allows designating the object of the application context which conditions communications with this AEI.

The attributes of this application context are valued during installation of an AEI on the basis of the values proposed by the user in the negotiated associated mode and the non associated mode, whereas they are filled by configuration in the prenegotiated associated mode.

6.1.7 Application context

6.1.7.1 Application context overview

A pair of AEIs require common knowledge of the rules which govern their communications. This set of rules is called Context Application. The application context which can be supported by an AEI is necessarily derived from the possibilities offered by the various ASEs possessed by the AE to which it belongs.

6.1.7.2 Application service elements

6.1.7.2.1 ASE description

The possibilities offered by the various ASEs of an AE are defined by the specification (in ASN1) of one or more set of Application Protocol Data Units (APDU) which form abstract syntaxes. Besides, the use of an abstract syntax to dialogue between two AEs requires the implementation of a transfer syntax which defines the rules for encoding of the APDUs on the bus.

NOTE Among the abstract syntaxes associated with the ASE MMS, the general abstract syntax ISO-9506-MMS-1 can be noted as well as other abstract syntaxes such as those meant for digital controls ISO-9506-NCCS-1 and process control ISO-9506-PROCESS-1.

Class: ELEMENT SERVICE APPLICATION

Attribute: ASE type

Attribute: List of Abstract syntax

Attribute: List of Transfer syntax

6.1.7.2.2 Attributes:

ASE type:

Several ASE types can be met with in the AL environment. This standard is covered by the SubMMSE definition derived from the ASE MMS defined by the ISO.

The MCSE (Messaging Common Service Element) service corresponds to the control ASE which should necessarily be used to project another ASE application on the link layer messaging. This service element has unique encoding rules which are universally known in the AL messaging environment.

NOTE The MCS encoding rules are not given in ASN1. They are directly given in the representation used for the transfer.

List of Abstract Syntax:

An application service element can have one or several abstract syntaxes. Each of them correspond to a set of APDUs described in an ASN1 module universally identified in the AL environment.

NOTE For example, an abstract syntax defined in ASN1 has the following appearance:

```
<module name> <module universal identifier>
Definitions::= BEGIN{
IMPORTS <..>, <..>, ….FROM <external module>
EXPORTS <..>, <..>, …
     PDU module ::= CHOICE {
     {<production name> [N°] <production>} +
     }}
END
```

This standard keeps AL SUBMMS-1, derived from the reference core, as one of its abstract syntaxes for the MMS service element.

List of Transfer syntax:

A transfer syntax defines the abstract syntax encoding rules used. An ASE could support several transfer syntaxes within the framework of an AE, which could be used according to the requirements depending on the possibilities of their correspondents.

One of the transfer syntaxes taken into account by this AL environment standard for the implementation of the AL abstract syntax, AL SUBMMS-1, is proposed by the ISO basic encoding rules (BER).

Like the abstract syntaxes, the transfer syntaxes are universally identified in the AL environment.

6.1.7.3 Type of application context

6.1.7.3.1 Application context description

The application context belonging to an AEI conditions the possible communications with it. In the information contained in the application context, some is specific to the AE architecture, i.e. with the type of ASE resting on MCS as well as with the abstract transfer syntax selected. Other information is specific to the choice performed on the API level and corresponding to the restrictions to the negotiated abstract syntax and to the quantity of communication resources used.

***Class*: APPLICATION CONTEXT**
Attribute: Context name
Key Attribute: Context identification
Attribute: Reference ASE
    Attribute: Abstract syntax
    Attribute: Transfer syntax
    Constraint: Com. mode = ASSOCIATED
    Attribute: Application reductions
Attribute: Service quality

6.1.7.3.2 Attributes:

Identification of the context:

Allows identifying an application context in the field of an AE. It thus has an exclusive local role.

Context name:

Used to identify, in the AL environment, the bases of a context consisting of the selected ASE, an abstract syntax and a transfer syntax. This name is used during the association negotiation or during a transfer of data in the non-associated mode.

Reference ASE:

One of the AE application service elements which is selected by this application context.

Abstract syntax:

An abstract syntax among those of the ASE within the framework of the AE, which is selected by this context.

Transfer syntax:

The transfer syntax selected for encoding the ASE PDUs, implemented within the framework of this AE, which is selected by this context.

Application reductions:

The abstract syntax selected at the level of an AEI application context for a given service element can be used in a reduced manner. This possibility is used only for transmission in the associated mode.

Service quality:

The selected service quality.

6.1.7.4 Directory

6.1.7.4.1 Directory overview

In order to communicate mutually, the AEIs make use of directory functions which given them the addressing information which they require. These directory functions are necessary exclusively during the opening of association or during a transmission in the mode without association.

6.1.7.4.2 Addressing model

The link layer offers data transfer services in the non-connected mode and an addressing space allowing location of the application entities. This addressing space allows locating the entities Individually and/or by groups, and on the other hand to locate them with the help of physical or logic addresses. These two types of addresses respectively allow taking into account or not of the network topology in the location of application entities.

The application layer has a double location requirement, that of the AEs during negotiation of the associations or transmission of data without association, and that of the AEIs during transmission of data within the framework of an association.

Consequently, the AE addresses and the AEI access points which need to be located are addressed with the link addresses from the single link addressing space.

In the case of point to point exchanges, the AE addresses and the AEI access points are designated with the help of individual link addresses. In the case of multipoint exchanges, the AE address and the AEI access point locating the transmitter are designated by individual link addresses whereas the AE address and the AEI access point locating the receivers are designated by group link addresses.

The rules allocating the liaison addresses used for the AE addresses and the AEI access points are not defined in this standard.

The abbreviations used to speak about these two uses of link addresses are: ADAE for those which are associated with AE addresses and ADAEI for those which are associated with AEI access points.

NOTE The ADAEIs are allocated by the directory functions of a device to the AEIs, in the sub-set which was attributed to an AE.

The address values contained in this sub-set can be, for example selected by dividing up the addressing space according to the network architecture or well chosen according to other criteria better satisfying the communication requirements of the user application.

Addressing rules:

Rule_1: Each AE is identified by one and only one "AE title" which is in a bi-univocal relation with an ADAE, allowing it to be located in the AL environment.

Rule_2: Each AE can be designated by one or several synonyms, each being in relation with one and only one address.

Rule_3: Each AE can be designated in the framework of one or several "AE group designations", each being in relation with one and only one address.

NOTE It is important to note that biunivocity is not a property of rules 2 and 3.

Rule_3: Each AEI which is identified by an AEI identification in the field of an AE, an API, of a given AP, is in biunivocal relation with an ADAEI, allowing it to be located in the AL environment.

6.1.7.4.3 Directory functions

The projection between the names allowing identification of the various objects (AEs and AEIs) in the application, and the link addresses (respectively ADAE and ADAEI) used to locate them in the AL environment, is managed by the directory service.

For any communication initiative at the level of an AEI, the latter calls the directory functions which give it the addresses necessary for the exchanges.

— Initiator Directory Function (IDF):

This function is implemented for an AEI initiating an exchange concerning an association opening or a transmission of data in the non-associated mode.

IDF is used to:

- obtain an ADAE pair allowing location of the local and remote AEs according to their AE titles,
- allocate an ADAEI for the local AEI access point and optionally of another for the remote AEI access point. This allocation only takes place when setting up an association.

<Input parameters> ::=

<Local AE title>

<Remote AE title

| Synonym of the AE title

| Designation of the AE group>

<Transmission mode>

with <Transmission mode>::=<ASSOCIATED ï NON-ASSSOCIATED>;

<Output parameter> ::=

<Local ADAE>

<Remote ADAE>

[<Local ADAEI>] (*)

[<Remove ADAE≥] (**)

(*) This ADAEI is only returned in the case of an ASSOCIATED" transmission mode.

(**) This ADAEI is returned or not according to the remote AE title.

Responder Directory Function (RDF):

This function is implemented at the level of a called AE, for the opening of an association.

RDF:

Used to allocate an ADAE at the level of the called entity during the response phase for an association opening request.

<Input parameters> ::=

<Local ADAE>

<Remote ADAE>

<Output parameters> ::=

<Local ADAEI>

NOTE This function is not used on the level of a responder if the initiator of the communication had already performed the allocation by use of the function.

6.1.8 Coordination of the AEIs

6.1.8.1 AEI communication description

The initiative and the type of communications belong to the APIs. The four types of communication are:

– Information exchanges in the non-associated mode.
– Association opening requests.
– Information exchanges in the associated mode.
– Association closing requests

NOTE For each of these types of communication, the AL environment objects are implemented in a specific manner which is covered by the following paragraphs.

6.1.8.2 Information exchanges in the non-associated mode

When an API wishes to initialize a data transfer in the non-associated mode, it proceeds in the following manner:

Exchange scenario:

• It addresses, as applicable:

  – either the source AE identified by its <AE title>, indicating the addressee (either by its <AE title>, or by an <AE synonym title>, or by an <AE group designation> and the <Application context>,
  – or an AEI whose mode is NON-ASSOCIATED, if the latter has been created to allow a series of exchanges.

• The local procedure which takes place at the AE after this request by the API is as follows:

If the API addresses the AE, the following local procedure is executed:

- Creation of an AEI object in the NON-ASSOCIATED mode,
- Entering of the attributes of this object:
- <Application context> takes the value indicated by the request,
- <Remote AE address> takes the value returned by IDF for the non-associated communication mode,
- <Local AE address>: takes the value returned by ID for the non-associated communication mode.
- Then whatever the addressing which took place, a data transfer service in the MCSE non-associated mode takes place within the framework of this AEI. The user data encapsulated in this data transfer is that of the MCS user application service which was requested.
- The AEI thus used could be maintained or revoked after this exchange. In case of revocation, this will be effective immediately if the service is not confirmed or after reception of the response and passage to API of the data contained in it, if the service is confirmed.

• The following procedure is executed at the addressee AE:

- Depending on whether an AEI does not yet exist or exists already, the following operations are executed or not:
- Creation of an AEI object in the NON-ASSOCIATED mode.

• Filling of the attributes of this object:

- <Application context>: takes the value indicated in the received PDU, if it is supported by the AE.
- <Remote AE address> takes the value contained in the received PDU.
- <Local AE address> takes the value contained in the PDU.
- Identification of an API object designated implicitly or explicitly in the PDU.
- Passage of the <Application service> contained in the PDU received at the API identified for the execution.
- The AEI thus used can be revoked or preserved at the end of this exchange. In case of revocation, this will be effective immediately if the service is not confirmed or after transmission of the response if it is confirmed.

6.1.8.3 Association opening request

If the API wishes to initialize an association opening request, it proceeds in the following manner:

Opening scenario:

• The API locally addresses the calling AE identified by its <AE title>, indicating:

- the called <AE title>,
- the <opening service> (Initiate Rq in MMS) which contains the <Application reductions> of the association, which will be negotiated,
- the <Application context> description other than the application reductions which will be negotiated at the MCS level.

• The local procedure which will be executed at the AE level after this API request, is the following:

- Creation of an AEI object in the ASSOCIATED mode in the OPENING state.
- Entering of the attributes of this object:
- <Remote AE address; local AEI access point>: take the value returned by IDF.
- Consideration of the application context requested by the user, and possible reduction of this, if its local AE cannot offer it.
- A_Associate.Rq service call by MCSE in the framework of this AEI with the application context given by the user as well as the opening request user PDU.
- On reception of the response, the other AEI attributes can be filled:
- <Remote AEI access point>: takes the value contained in the PDU.
- <Application context> tales the value contained in the response which can correspond to a reduction of that requested.
- Passage of the AEI state to ESTABLISHED,

• The procedure which takes place at the responder AE level on reception of an opening request transmitted by the source procedure is the following:

- Creation of an AEI object in the ASSOCIATED mode in the OPENING state.
- Filling of the attributes of this object:
- <Application Context>: takes the value indicated in the PDU, or a reduction, if the AE does not support it.
- <Local AE address> tales the value received in the PDU.
- <Local AEI access point> can take the optional value contained in the PDU or that returned by the RDF (Responder Directory Function).
- <Remote AE address; Remote access point> take the values received in the PDU.
- Addressing of the API from its implicit or explicit identification in the PDU.
- Passing to the user of the opening request PDU.
- When the API gives its response, a call of the A_ASSOCIATE.Rp service of MCSE in the framework of this AEI, with the PDU user, as a response to the opening request and possible updating of the context if this has been reduced by the API.
- Passage of the AEI state to ESTABLISHED.

6.1.8.4 Exchange of information in the associated mode

When an API wishes to initialize an associated mode exchange, it proceeds as follows.

Exchange scenario:

• It addresses the AEI locally in the ESTABLISHED state, identified by its <AEI identifier> relative to its area by indicating:

  - the <application service> which should be executed with the called entity.

• The local procedure which should be performed at the AEI level is as follows:

  - During reception of the response, for a confirmed service, sending of this to the user.
  - Call of the data transfer service in the MCSE associated mode in the AEI framework, with as user data the PDU associated with the service.

• The procedure executed at the responder AEI on reception of the service request is as follows:

- Passing of the <Application service> contained in the API PDU.
- Service call and information transfer in the MCSE associated mode, in the framework of the AEI, with as user data the response PDU associated with this service.

6.1.8.5 Request for termination of an association.

When an API wishes to initialize a request for termination of an association, it proceeds as follows:

Closing scenario:

- It locally addresses the AEI identified by its <AEI identification> in its area, indicating:
  - the <Closing application service>.
- The local procedure which is executed at the AEI initiating this closing is as follows:
  - Setting of the AEI to the CLOSING state (Blocking of the data transfers beyond what has been engaged).
  - MCSE A-RELEASE service call to transmit the closing request service in the framework of this AEI.
  - On reception of the positive response, revocation of the AEI object, return to the ESTABLISHED state in the other cases;
- The remote procedure which is performed at the responder AEI level is as follows:
  - Setting of the AEI to the CLOSING state.
  - (Blocking of the data transfers outside those engaged).
  - Passing of the closing request service to the user.
  - At a positive response from the user, revocation of the AEI object and sending of the response to the initiator using the MCSE.

6.1.9 Concepts for sub_MMS

6.1.9.1 General

Sub-MMS communications can be established through negotiated or predefined association as well as without association.

The assignment of access rights to association as well as the protections of objects, allow and the protection of objects authorizes selective access to the objects.

6.1.9.2 Sub-MMS communication channels

1- A Sub-MMS communication can be achieved without association:

These communication can take place in point to point (confirmed/unconfirmed services), in multipoint or in distribution (unconfirmed services).

In this case a service request (other than Initiate, Conclude and Abort) should be refused if the service is not supported, if the resources are insufficient, if it is not in compliance with the protocol, etc.

The Initiate, Conclude and Abort services have no significance.

This type of communication does not support the access protection mechanism on the objects.

2- A Sub-MMS communication can be performed in a predefined association:

These communication can take place in point to point (confirmed/unconfirmed services), in multipoint or in distribution (unconfirmed services).

In this case a service request (other than Initiate, Conclude and Abort) should be refused if the service is not supported, if it is not in compliance with the protocol or if the resources reserved for the association are insufficient, etc.

The Initiate, Conclude and Abort services have no significance.

This type of communication does/does not support the access protection mechanism on the objects.

3- A Sub-MMS communication can be performed in a negotiated association:

These communication can take place in point to point (services confirmed/unconfirmed),

In this case a service request (other than Initiate, Conclude and Abort) should be refused if the service is not supported, if it is not in compliance with the protocol, or if the resources reserved for the association are insufficient, etc.

This type of communication does/does not support the access protection mechanism on the objects.

6.1.9.3 Access protection mechanism

6.1.9.3.1 Protection level introduction

The access to Sub-MMS object can be refused to some clients. For this we define the protection levels assigned to an object and access right assigned to the association.

6.1.9.3.2 Protection level assigned to an object

The definition of objects other than the VMD object includes an OPTIONAL attribute called "ACCESS PROTECTION" which determines if an object is protected or not.

An object which is not protected has its "ACCESS PROTECTION" attribute forced to the value "FALSE".

An object which is protected has its "ACCESS PROTECTION" attribute forced to the value "TRUE".

1 – Password,
2 – Access Groups,
3 – Access Rights.

Password:

The "Password" attribute allows restricting access only to clients holding the password.

Access Groups:

"Access Groups" attribute allows to restrict the access only to clients who belong to one of the groups defined by the attribute.

Access Rights:

The "Access Rights" attribute indicates the various possibilities to obtain access to the object.

It also indicates for each of these access possibilities, the services which can be executed as well as the conditions to be fulfilled, as shown in Table 2.

Table 2 – Access protection

Object class	**Executable operations**
Domain	Load, Upload, Delete, Connect to a program invocation
Program invocation	Execute, Initialize, Stop, Delete
Variable	Read, Write
Variable-List	Read, Write, Delete
Event	Read, Alter, Acknowledge
Access granted because of password	**Conditions to be fulfilled**
Yes	a) The association password is identical to that of the object.
No	b) The value of the password of the association is ZERO; condition (a) is not fulfilled
Access granted because of group membership	**Conditions to be fulfilled**
Yes	a) The group word for the association and the object have at least one identical group No
No	b) The value of the association group word is ZERO; condition (c) is not fulfilled
Access granted to all	**Condition to be fulfilled**
Yes	e) The "Access Rights" attribute authorizes access to all clients.

6.1.9.3.3 Level of the access rights assigned to an association

It is possible to assign access rights to predefined or negotiated associations. In this case these access rights are characterized by the parameters "Password" and "Access Groups".

The "Password" and "Access Group" parameters are granted implicitly to the predefined association.

The "Password" and "Access Group" parameters are granted to the negotiated association by the initiate service.

The "Password" and "Access Group" parameters thus characterize the Client's access rights.

6.1.9.3.4 Access control mechanisms for protected objects

Access to the objects can be granted:

a) either when the "Password" attribute of the object is identical to the association "Password" parameter

b) when the "Access Groups" attribute of the object and the "Access Groups" parameter of the association have at least one group No. in common.

c) or to all the clients when the "Access Rights" attribute permits.

NOTE No access restriction is imposed for the use of the following services:
- Get Name List,
- Get Domain Attributes,
- Get Program Invocation Attributes,
- Get Variable Access Attributes,
- Get Variable List Attributes,
- Get Event Condition Attributes,
- Get OD Header/Data type Attributes.

6.1.9.4 Directory management

6.1.9.4.1 General

All the sub-MMS object describers supported by an application form a directory.

The arrangement of the describers in a directory can be either standardized or free.

The standardization of the directory is performed by an object called "OD" (Object Dictionary).

6.1.9.4.2 Use of the "OD" object

It is not mandatory for a device to support the "OD" object.

6.2 ASEs

6.2.1 MPS ASE (periodic/aPeriodic manufacturing services)

6.2.1.1 Overview

In a MPS environment, a certain number of application objects are implemented. These objects come directly from the instantiation of the different classes previously described.

All these application objects representing the network configuration should be described partially or globally in order to allow:

- the user to have access to the application configuration (e.g.: Access to the variable type),
- the checking of the configuration consistency of the application between several subscribers (e.g.: configuration consistency between the producer and the consumers of a variable).

Moreover, this description is specified in this standard in order to ensure the interoperability in the configuration interchanges between different implementations.

6.2.1.2 Object concepts

6.2.1.2.1 Application objects

The description of periodic/aperiodic MPS services leads to describe all the resources involved in the application layer. This specification defines the static part of the specification.

The specification reactive aspects describe the various service elements actions on the application layer resources:

MPS environment application objects are divided into two sets:

• objects related to variables,

• objects related to variable lists.

Variables are abstract elements that associate a transfer syntax and a semantics to a data.

Variables, and related information, are provided to the user by the communication system, either individually, or by lists.

Other variables are provided with an event characteristic to which the user may associate actions relative to the execution of the distributed application.

6.2.1.2.2 Application objects addressing

The key-attributes (A_Name) used to address the MPS application layer objects all belong_to the same addressing space.

Each of these names in the addressing space is defined within a maximum length of 16 characters.

The characters belong to the set defined for the "visible string" type of the abstract syntax notation ASN1 (ISO 8824).

Within that set, the following characters are to be used:

Upper case letters	(A..Z)
Lower case letters	(a..z)
Digits	(0..9)
Underscore	(_)
Currency symbol	($)

The "space" character is not to be used.

Upper and lower case letters are considered as different characters.

An A_Name should not begin with a digit.

The "underscore" character as a second character defines a standard-reserved name.

6.2.1.3 Variable access sub-ASE

6.2.1.3.1 Concepts

6.2.1.3.1.1 MPS environment variables

An MPS environment variable is an abstraction in the MPS environment, in which it is referenced by a unique name or description. The data associated with this variable corresponds to the representation handled by the data link services, which is exchanged on the network.

6.2.1.3.1.2 Network memory

Control system devices provide an AP with a value of each variable concerned an image of which is stored in local network memory.

6.2.1.3.1.3 Producer/consumer/third party concepts

Application entities that recognise a variable are provided with a local image of it.

Within a distributed application, one unique application entity is declared as the producer of the variable value whereas one or several application entities are declared as consumers of that value.

Moreover, some application entities, while being neither producer, nor consumer of the variable value, may have a knowledge of it in order to invoke the updating of its value. Such application entities are called third party entities.

6.2.1.3.1.4 Periodicity and aperiodicity concepts

The exchange of variable value between the producing entity and the consuming entities can be performed periodically or aperiodically.

A periodic updating is initiated by the network and is defined during the configuration step.

The updating period is determined by

• the user requirements to fulfil the distributed application,

• constraints related to the network.

Aperiodic updating is initiated by a user, such as the producing entity, a consuming entity, or a third party entity.

6.2.1.3.1.5 Synchronous and asynchronous properties

Application entities handling variables elaborated according to production validity, for the produced variables, and transmission validity for the consumed variables.

Definitions:

Production or transmission validity associated with each variable have an asynchronous character as they are elaborated independently from the network activity.

Production or transmission validity associated with each variable have a synchronous character when they involve synchronization orders issued from the network.

A synchronization order corresponds to the event associated with the emission or the reception of a variable of class SYNCHRONIZATION.

6.2.1.3.2 Variable class specification

6.2.1.3.2.1 Variable class modelisation

A variable in the MPS environment is modelled using the following objects (see Figure 2):

- one *Produced Variable Local Image* object that includes all the attributes necessary to a producer user.
- one or several *Consumed Variable Local Image* object that includes all the attributes necessary to one or several Consumer users.

Those two object types are issued from inheritance from several classes:

The *Produced Variable Local Image* objects are instantiated from the *Produced Variable* class.

The *Produced Variable Class* includes all the attributes proper to a producing entity, and inherits from the *Identified Variable* class. That latter class includes all the attributes that are common to every local image associated with that variable.

Moreover, the *Produced Variable* class optionally inherits from two classes *Refreshment* and *Punctual Refreshment* that include all the attributes necessary to the elaboration of informations relative to the production validity associated with that variable, within the producing application entity.

The Consumed Variable Local Image objects are instantiated from the Consumed Variable class.

The *Consumed Variable* class includes all the variable attributes proper to a consuming entity, and inherits from the *Identified Variable* class. That latter class includes all the attributes common to every local image associated with that variable.

Moreover, the *Consumed Variable* class optionally inherits from two classes *Promptness* and *Punctual Promptness* that includes the attributes necessary to the elaboration of the informations relative to the transmission validity associated with the variable within the consuming application entities.

Each of the classes *Produced Variable* and *Consumed Variable* optionally inherits respectively form a class *Production Resynchronization a*nd Consumption Resynchronization that include the attributes relative to the double memorisation of a variable in order to allow the providing of the variable:

- to the network by a producing entity,
- to the consuming entities by the network, upon a synchronization order issued from the network.

All the common attributes of a variable are described in a *Variable* generic class.

The variable type is described in a *Type Constructor* class which is referred by the variable and that allow the elaboration of all the type that may exist in the MPS environment.

Concerning the access to a variable, the *Variable Access* class refers to a variable and indicates the access mode that is used.

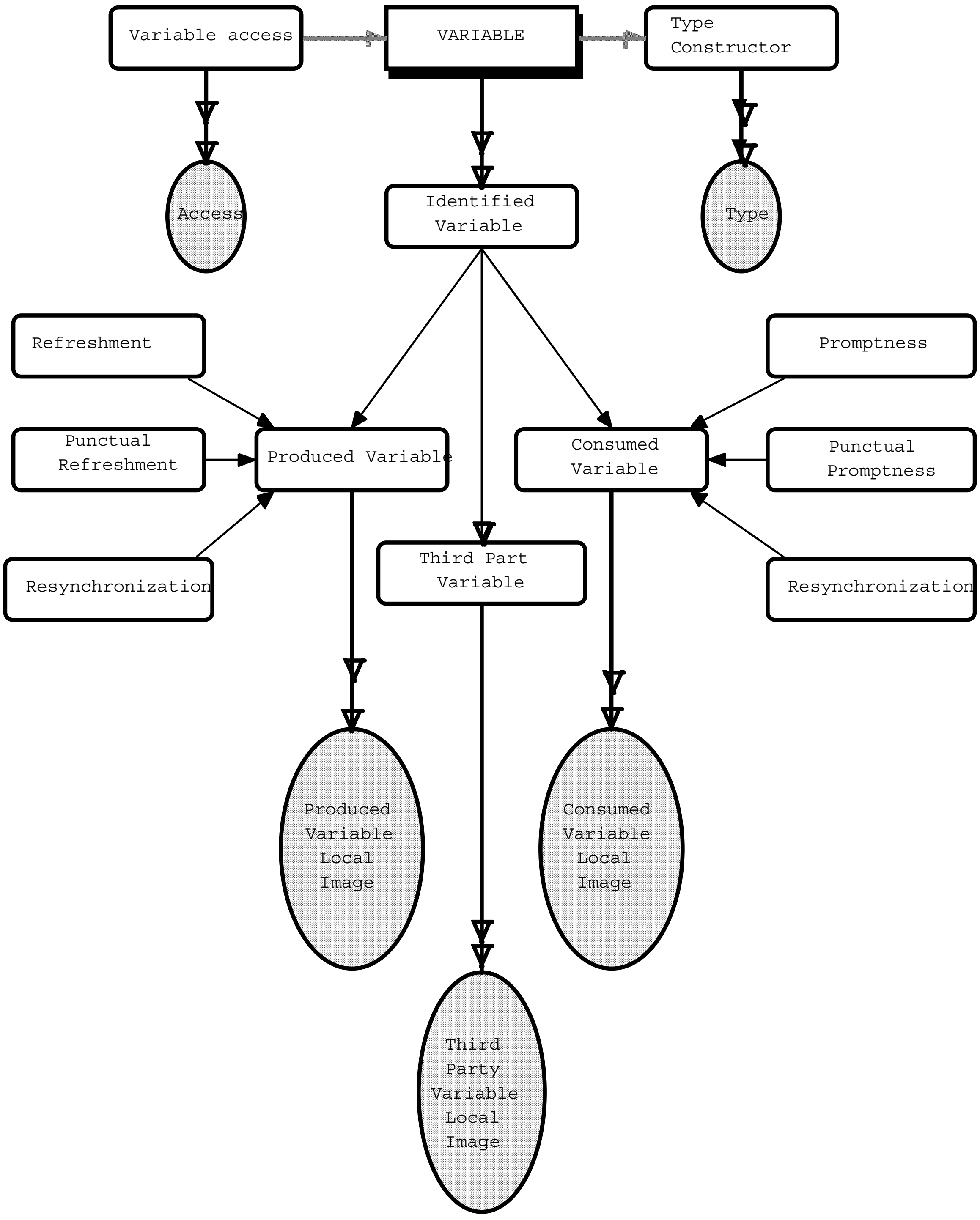


Figure 2 – Object model of the MPS ASE

6.2.1.3.2.2 *Variable* generic class specification

6.2.1.3.2.2.1 Variable generic class model

FAL ASE:	**MPS ASE**
CLASS: Variable	
CLASS ID:	not used
PARENT CLASS:	not used
Generic Class:	VARIABLE
Class Attributes:	

Key-Attribute	:	A_Name
Attribute	:	Reference Type Constructor
Attribute	:	Transmitted status [TRUE, FALSE]
Constraint	:	Transmitted status = TRUE
Attribute	:	Significant Status
Attribute	:	Identifier
Attribute	:	Transmission mode [PERIODIC,APERIODIC]]
Constraint	:	Transmission mode = PERIODIC
Attribute	:	Network period
Attribute	:	Class [NORMAL,SYNCHRONIZATION,DESCRIPTION]
Constraint	:	Class = SYNCHRONIZATION
Attribute	:	Consistency variable [TRUE, FALSE]
Constraint	:	Consistency variable = TRUE
Attribute	:	*Reference* Variable List

Instance Attributes:

Attribute	:	Public value
Constraint	:	Transmitted status = TRUE
Attribute	:	Transmitted status value
Attribute	:	Universal services requested [TRUE, FALSE]
Constraint	:	Universal services requested = TRUE
Attribute	:	Universal services scope [LOCAL,DISTANT]
Constraint	:	Universal services scope = DISTANT
Attribute	:	Priority [NORMAL,URGENT]

6.2.1.3.2.2.2 Attributes

A_Name:

This attribute uniquely identifies, a variable at the interface between the application layer and the user. The A_Name of a variable belongs to the MPS addressing space.

Moreover, for a variable for which the Class attribute has the value NORMAL, or SYNCHRONIZATION the A_Name length is limited to 14 characters.

***Reference* Type Constructor:**

This reference indicates the A_Name of a global type associated with the variable.

The type is described by a *Type Constructor* object that supports any variable type that may exist in MPS environment.

Transmitted status:

When this boolean attribute has the value TRUE ,status relative to the variable production validity are broadcast to the respective consumers.

Significant status:

For the variables with information relative to their production validity, it is necessary to specify which status are effectively elaborated by the producer.

This attribute is of type Boolean array , each TRUE element indicates, that the production validity status of the associated the variable is significant.

The associated production validity status is defined for the *Transmitted status Value* array element with the same index

The various elements are

S1: Elaboration by the producer of a synchronous or asynchronous refreshment status.

S2: Elaboration by the producer of a punctual refreshment status.

Identifier:

This attribute corresponds to a data link address that refers a data link layer object.

There is a one to one correspondence between a variable A_Name and the associated identifier. Moreover, the relationship between an identifier and a variable A_Name is a local issue committed during the network configuration generation step.

Transmission mode:

This attribute defines the exchanges of the value of the variable it is associated with.

The exchanges may be PERIODIC or APERIODIC, depending on the user requirements, and are defined during the network configuration step.

Network period:

When the transmission mode is PERIODIC, this attribute specifies the updating period of the variable by the network.

This period is expressed in milliseconds.

Class:

This attribute permits to associate a functionality to a variable. It may have one of the following values:

NORMAL: NORMAL class variables indicate process representation information.

SYNCHRONIZATION: SYNCHRONIZATION class variable indicates:

- Synchronization information of the distributed application,
- information necessary to the spatial consistency mechanism for a variable list.

DESCRIPTION: DESCRIPTIONclass variables features the description of all or part of the attributes relative to a variable , to a variable access, to a variable type, or to a variable list.

Consistency variable:

When this attribute has the value TRUE , the described variable corresponds to a consistency variable involved with the spatial consistency mechanism of a variable list.

Reference Variable list:

This reference to the *Variable List* generic class indicates, for a CONSISTENCY class variable, the variables the reception of which, within an application entity, takes part in the elaboration of the consistency variable value when a spatial consistency mechanism is involved

Public value:

This attribute corresponds to the value of the variable provided to the consumers by the producer.

After instantiation, that attributes includes:

- the public value provided to the network,
- the last public value received from the network

regarding that the instance corresponds to a producer's one or a consumer's one.

At a given time, it is to be considered the value available at the consumer, the value transmitted during the last exchange, and the last value received by each consumer.

The last value received by a consumer is not always identical to the last transmitted value because of possible transmission faults.

Transmitted status value:

This attribute corresponds to the array of production validity status , relative to a variable, and transmitted with that variable value. Each status within the array is a boolean.

All the production validity status associated with the variable value are not necessarily significant.

As for the variable public value, that attribute instantiation includes:

- the status values provided to the network,
- the last status values received from the network

regarding that the instance corresponds to a producer's one or a consumer's one.

The handling at a producer and at the consumers of the set consisting of the variable value and its associated status values is atomic.

Status array elements:

S1	Synchronous/asynchronous refreshment status
S2	Punctual refreshment status

NOTE The abstract syntax defines the array of status.

Requested universal services:

When this boolean attribute has the value TRUE , universal services may be invoked for the variable. in consideration.

Universal services scope:

This attribute is used by the variable access extended services, and defines the service category -local or distant- to use for the universal read/write services.

When that attribute has the value LOCAL , universal services that are used correspond to local services; when it has the value DISTANT , they correspond to distant services.

Priority:

This attribute is used by the variable access extended services and defines the priority level used to request variable updating when the universal services correspond to distant services.

When that attribute has the URGENT value, flow control guarantees that an urgent updating request will be processed before a normal request initiated after it.

6.2.1.3.2.3 *Identified Variable* class specification

The *Identified Variable* class is issued from the instantiation of the *Variable* generic class.

6.2.1.3.2.4 *Produced Variable* class specification

6.2.1.3.2.4.1 Produced variable class model

This class gathers all the attributes relative to a variable within a producer application layer.

FAL ASE:	**MPS ASE**
CLASS:	Produced variable
CLASS ID:	not used
PARENT CLASS:	not used

```
Class: PRODUCED VARIABLE
    Attribute          : Inherit from Identified Variable
    Attribute          : Refreshment elaborated [TRUE, FALSE]
    Constraint         : Refreshment elaborated = TRUE
        Attribute      : Inherit from Refreshment
        Attribute      : Punctual refreshment elaborated [TRUE, FALSE]
    Constraint         : Punctual refreshment elaborated = TRUE,
        Attribute      : Inherit from Punctual Refreshment
        Attribute      : Resynchronized Variable [TRUE,FALSE]
    Constraint         : Resynchronized Variable = TRUE
        Attribute      : Inherit from Production Resynchronization
        Attribute      : Emission Indication[TRUE,FALSE]
```

6.2.1.3.2.4.2 Attributes

***Inherit from* Identified Variable:**

Produced Variable class inherits from *Identified Variable* class that provides it with the attributes common to all local copies of the same variable within MPS environment.

Refreshment elaborated:

Refreshment is an information relative to a variable production validity.

This information, which is optionally elaborated, tells the consumer users about the production period of the producer user.

The status associated with this information is elaborated within the producer application layer and provided to the network in the status value associated with the variable value.

When this Boolean attribute has the value TRUE , a refreshment status is elaborated within the producer application entity.

***Inherit from* Refreshment:**

The *Produced Variable* class inherits from the *Refreshment* class.

The *Refreshment* class includes all the attributes relatives to the elaboration of the refreshment information associated with a variable, in order to qualify its production.

Punctual Refreshment elaborated:

Punctual refreshment is an information relative to a variable production validity.

This information, that is optionally elaborated, tells consumer users about the respect by the producer user of a writing operation within a time slot associated with a synchronization order issued from the network.

The status associated with that information is elaborated within the producer application layer and provided to the network in the status value associated with the variable value.

When this boolean attribute has the value TRUE , a punctual refreshment status is elaborated within the producer application entity.

Inherit from Punctual Refreshment:

The Produced Variable class inherits from the Punctual Refreshment class.

The Punctual Refreshment class includes all the attributes relative to the elaboration of the punctual refreshment information associated with the variable, in order to qualify its production.

Resynchronized Variable:

Some users produce variables asynchronously with respect to the network.

These variables can be resynchronized within the application layer by the means of a double buffer.

The private buffer is the one provided to the asynchronous producer user. The public buffer is the one provided to the network.

Resynchronization of such a variable consists of transferring from Private Buffer to Public Buffer upon the reception of a synchronization order from the network.

This attribute supports the chosen option for the variable concerned.

When this boolean attribute has the value TRUE , the concerned variable is resynchronized in production.

***Inherit from* Production Resynchronization:**

The Produced Variable class inherits from the Production Resynchronization class.

The Production Resynchronization class includes all the attributes relative to a variable resynchronization.

Emission Indication:

When it has the value TRUE this boolean attribute indicates that an emission indication (A_SENT.ind) has to be returned to the user once the variable has been sent on the network.

6.2.1.3.2.5 Produced variable local image class specification

Produced Variable Local Image object is issued from the instantiation of the *Produced Variable* Class.

6.2.1.3.2.6 Consumed variable class specification

6.2.1.3.2.6.1 Consumed variable class model

This class gathers all the attributes relative to a variable within a consumer application layer.

FAL ASE:	**MPS ASE**
CLASS:	Consumed variable
CLASS ID:	not used
PARENT CLASS:	not used

Class: CONSUMED VARIABLE

Attribute	: *Inherit from* Identified Variable
Attribute	: Promptness elaborated [TRUE, FALSE]

Constraint	: Promptness elaborated = TRUE
Attribute: *Inherit from* Promptness	
Attribute	: Punctual Promptness elaborated [TRUE, FALSE]
Constraint	: Punctual Promptness elaborated = TRUE
Attribute: *Inherit from* Punctual Promptness	
Attribute	: Resynchronized Variable [TRUE, FALSE]
Constraint	: Resynchronized Variable = TRUE
Attribute: *Inherit from* Consumption resynchronization	
Attribute	: Reception Indication [TRUE, FALSE]

6.2.1.3.2.6.2 Attributes

***Inherit from* Identified Variable:**

Consumed Variable class inherits from *Identified Class* that provides it with all the attributes common to every local copy of the same Identified Variable within MPS environment.

Promptness elaborated:

Promptness is an information relative to a variable transmission validity.

This information, that is optionally elaborated, tells a consumer user about the reception of a variable respecting a consumption period

The status associated with this information is elaborated within the consumer application layer and provided to the consumer user.

When this boolean attribute has the value TRUE , a promptness status is elaborated within the consuming application entity.

***Inherit from* Promptness:**

Consumed Variable class inherits from Promptness class.

Promptness class includes all the attributes relative to the elaboration of a promptness status associated with a consumed variable.

Punctual Promptness elaborated:

Punctual promptness is an information relative to a variable transmission validity.

This information, that is optionally elaborated, tells a consumer user about the reception of a variable within a time slot associated with a synchronization order issued from the network.

The status associated with this information is elaborated in the application layer and provided to the consumer user.

When this boolean attribute has the value TRUE , a punctual promptness status is elaborated within the consuming application entity.

***Inherit from* Punctual Promptness:**

Consumed Variable class inherits from the Punctual Promptness class.

Punctual Promptness class includes all the attributes relative to the elaboration at the consumer level of a punctual promptness status associated with a variable.

Resynchronized Variable:

Some users consume variables asynchronously with respect to the network.

These variables can be resynchronized within the application layer by the means of a double buffer.

The private buffer is the one provided to the asynchronous consuming user. The public buffer is the one receiving the value from the network.

Resynchronization of such a variable consists in transferring the public buffer into the private buffer upon a synchronization order from the network.

This attribute supports the chosen option for the variable concerned in consumption resynchronization.

When this attribute has the value TRUE , the associated variable is resynchronized in consumption.

***Inherit from* Consumption Resynchronization:**

Consumed Variable class inherits from the Consumption resynchronization.

Consumption Resynchronization includes all the attributes relative to a variable resynchronization in consumption.

Reception Indication:

When it has the value TRUE this boolean attribute indicates that a reception_indication (A_RECEIVED.ind) has to be returned to the user once the variable has been received from the network.

6.2.1.3.2.7 Consumed variable local image class specification

Consumed Variable Local Image object is issued from the instantiation of *Consumed Variable* class.

6.2.1.3.2.8 Third party variable class specification

6.2.1.3.2.8.1 Third party varaible class model

FAL ASE:	**MPS ASE**
CLASS:	Third party variable
CLASS ID:	not used
PARENT CLASS:	not used

Class: THIRD PARTY VARIABLE

Attribute : Inherit from IdentifiedVariable

6.2.1.3.2.8.2 Attributes

Inherit from IdentifiedVariable

Third Party Variable class inherits from *Identified Variable* class this provides it with the attributes necessary to know the variable.

Consequently, this variable is only provided with the pair (A_Name, Identifier) of the identified variable it inherits from.

6.2.1.3.2.9 Third party variable local image object class specification

Third Party Variable Local Image object is issued from instantiation of Third Party Variable class.

6.2.1.3.2.10 *Type Constructor* class specification

6.2.1.3.2.10.1 Type constructor class model

```
FAL ASE:                  MPS ASE
CLASS:     Type constructor
CLASS ID:                 not used
PARENT CLASS:             not used
Class                     :   TYPE CONSTRUCTOR
Key–Attribute             : A_Name
        Attribute         : Construction
                 [SIMPLE, ARRAY, STRUCTURE,PREDEFINED, EXPLICIT]
        Constraint        : Construction = SIMPLE
          Attribute         : Primitive type
          Attribute         : Size
        Constraint        : Construction = ARRAY
          Attribute         : Compressed [TRUE,FALSE]
          Attribute         : Dimension
          Attribute         : Reference Type Constructor
        Constraint        : Construction = STRUCTURE
          Attribute         : List of
            Attribute         : Named field [TRUE,FALSE]
            Constraint        : Named field = TRUE
                Attribute     : field name
            Attribute         : Reference Type Constructor
```

6.2.1.3.2.10.2 Attributes

A-Name:

This attribute uniquely identifies an object within the application layer. An_A_Name belongs to the MPS addressing space Moreover, a Type Constructor A_Name should no be longer than 14 characters.

An A_Name beginning with the characters K_ indicates a type reserved by the standard.

Construction:

The specified type can be of SIMPLE construction, and is then directly derived from the primitive types.

The specified type can be of ARRAY construction, and represents an ordered set of elements of the same type; that latter type can be itself of construction SIMPLE, ARRAY, or STRUCTURE. ARRAY construction type elements are increasingly numbered from zero (0) for the first element.

The specified type can be of STRUCTURE construction, and represents a complex type composed of an ordered set of one or several components. These components may have different types of SIMPLE, ARRAY, or STRUCTURE construction.

The specified type can be of PREDEFINED construction, and is then defined within the standard.

PREDEFINED construction types cannot be used to compose types of ARRAY or STRUCTURE.

The specified type can be of EXPLICIT construction in order to characterise a variable the type of which can change dynamically.

EXPLICIT construction types cannot be used to compose types of ARRAY or STRUCTURE construction.

SIMPLE construction types characteristics
Primitive Type:

Primitive types used.

Size:

This attribute has a value and purpose that depends on the value of the Primitive Type attribute defined above. The size, described for each of the primitive types , for Type Constructor class instances, describes a maximum value to the variable.

ARRAY construction types characteristics
Compressed:

The application layer transfer syntax allows to define, for some ARRAY type variables, compressed encoding rules.

Compressed encoding is specified using a boolean attribute.

When this attribute has the value TRUE , the associated variable value encoding is compressed, each time it is possible depending on the array elements type; when this attribute has the Value FALSE, the associated variable value encoding is not compressed.

Dimension:

This attribute defines the number of elements within the ARRAY construction type.

***Reference* Type Constructor:**

An ARRAY construction type is composed of elements of any one type either of construction SIMPLE, or ARRAY, or STRUCTURE.

This attribute references the "Type" object, instantiated from the *Type Constructor* class associated with the array elements

STRUCTURE construction types characteristics
Named field:

When a type is STRUCTURE , each component composing the type corresponds to the semantic representation of the associated variable. In order to permit a partial access on these components they may be designated with a name. When this attribute has the value TRUE , a name is associated with the corresponding component; when it has the value FALSE, no name is associated with the component.

Field name:

This attribute is a character string that uniquely identifies a structured variable component.

NOTE The scope of component names is local to a structure.

***Reference* Type Constructor:**

A STRUCTURE construction type is composed of components of any type. i.e. SIMPLE, ARRAY, or STRUCTURE.

This attribute denotes that the instance of *Type Constructor* class associated with each component is of type STRUCTURE

PREDEFINED construction types characteristics

PREDEFINED construction types are mostly used for description variables and refer to types that are reserved by the standard.

PREDEFINED construction types cannot be explicitly defined because they need a grammatical extension in order to use optional types, alternative types, or variable length types.

NOTE Grammatical extensions that are involved are specified in ISO 8824 standard.

EXPLICIT construction types characteristics

EXPLICIT construction types allow the associated variables to be provided with an explicit transfer syntax, in order to carry the type semantics with the data.

6.2.1.3.2.10.3 Primitive types

Primitive types that are selected, and their characteristics are mostly specified in the ISO 8824 standard.

NOTE The only access mode available for a primitive type variable is global access.

• BOOLEAN

The definition of this primitive type is the same as the boolean type definition in the ISO 8824 standard. For this type, the *Size* attribute should be omitted.

• BIT STRING

The definition of this primitive type is the same as the bit string definition in ISO 8824. For this type the *Size* attribute defines the number of bits in the bit string.

• INTEGER

The definition of this primitive type is the same as the integer type definition in ISO 8824 standard. For this type, the *Size* attribute defines the number of bits that are necessary to have a twos complement representation of all possible values.

• UNSIGNED

The definition of this primitive type is the same as the integer type definition in ISO 8824 with the exclusion of negative numbers. For this type, the *Size* attribute defines the number of bits that are necessary to have a twos complement representation of all possible values.

• OCTET STRING

The definition of this primitive type is the same as the octet string type definition in ISO 8824 standard. For this type, the *Size* attribute defines the number of octets in the string.

• VISIBLE STRING

The definition of this primitive type is the same as the visible string type definition in ISO 8824 standard. For this type, the *Size* attribute defines the number of characters in the string.

• GENERALISED TIME

This primitive type is defined with a fourteen-digits visible string (YYYYMMDDHHMMSS); it is equivalent to a particular form of the generalised time type in ISO 8824 standard. For this type, the *Size* attribute should be om itted.

• FLOATING POINT

This primitive type defines value representation for positive and negative real numbers, including, zero, negative infinite and positive infinite.

The values at the limits (0, +• -•), as well as the various representation formats are defined in IEC 60559.

For this type, the *Size* attribute, of boolean type, indicates whether the representation format is simple precision (FALSE) or double precision (TRUE).

• BINARY TIME

This primitive type is defined as the unsigned type of the present standard, the value of which corresponds to a number of elementary times.

For this type, each value of the *Size* attribute defines the value of an elementary time as well as a number of bits used to represent any possible binary time value, as shown in Table 3.

Table 3 – Binary time coding

Size	10 ms	0,1 ms	1 ms	10 ms
16 Bits	0	1	2	3
32 Bits	4	5	6	7
48 Bits	8	9	—	—

• BCD

This type is used to represent a set of values corresponding to the numeric representation of digits.

For this type, the *Size attribute* should be omitted.

6.2.1.3.3 Basic mechanisms

6.2.1.3.3.1 Time-out class specification

6.2.1.3.3.1.1 Time-out class model

The elaboration, by producing application entities ,of information relative to production validity involves time-out resources. Likewise for consuming application entities.

The description of this resource can be modelled with an attribute object, whose purpose is to define visible aspects of time-out used by MPS environment services.

FAL ASE:		**MPS ASE**
CLASS:	Time-out	
CLASS ID:		not used
PARENT CLASS:		not used
Class: TIME-OUT		
	Attribute	: Preset
	Attribute	: Current value
	Attribute	: State [RUNNING, IDLE]

6.2.1.3.3.1.2 Attributes

Preset:

Preset corresponds to the duration associated with the time-out when it is armed, whenever the time-out is running or expired.

Current value:

Current value corresponds to the instantaneous value of the time-out.

That value is equal to

- the period remaining before expiration, when the time-out is running
- "0" when the time-out has expired.

State:

The time-out state indicates whether the time-out is active or not.

The two states are as follows:

RUNNING:Corresponds to a running time-out within the time interval between preset value and expiration.

IDLE: Corresponds to an expired time-out.

NOTE As soon as the time-out current value is forced with a non-zero value, the time-out is automatically set to RUNNING state.

6.2.1.3.3.1.3 Time-out mechanism

The dynamic working of a time-out is defined by the evaluation net shown in Figure 3.

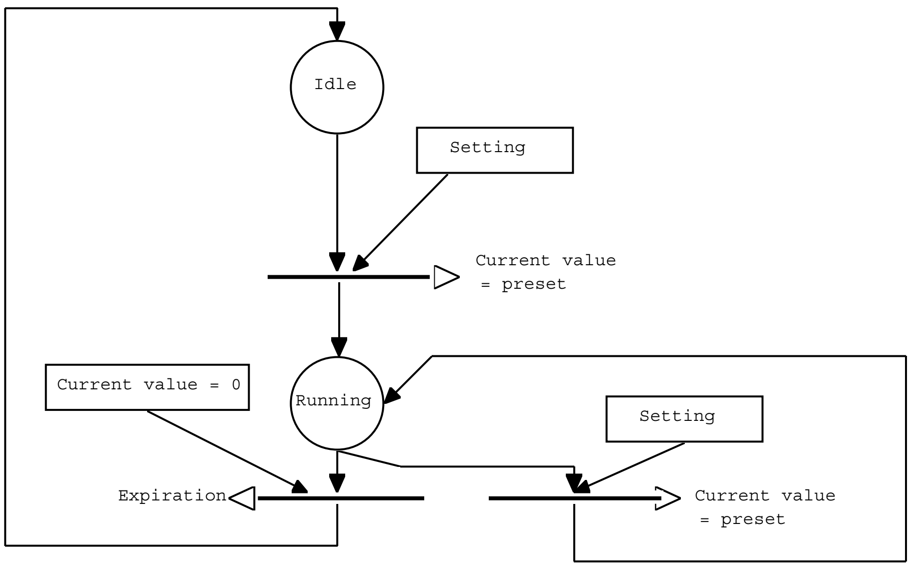


Figure 3 – Time-out evaluation net

6.2.1.3.3.2 Variable addressing

6.2.1.3.3.2.1 Variable addressing description

User access to application variables in MPS environment can be carried out in various ways.

Access to a variable is carried out by means of

- a variable A_Name, in the case of variable global access,
- an access path in the case of explicit partial access to a structured variable named field or to an array element,
- an access A_Name, in the case of renamed partial access to a variable or to one of its components (Structure field, array element…).

Access A_Name belong all to the same MPS addressing space provided to the user at the interface with the application layer.

6.2.1.3.3.2.2 Access modes

6.2.1.3.3.2.2.1 Global access

This access mode allows the user to globally access a variable.

The access to the variable is made with the Application name of the variable that is accessed. In this case, the application name corresponds to the *A_Name* attribute of *Produced Variable Local Image,* or *Consumed Variable Local Image,* or *Third Party Variable Local Image*. It belongs to the MPS addressing space provided to the user at the interface between the application layer and the user.

6.2.1.3.3.2.2.2 Explicit partial access

This access mode allows the user the access to a named field of a structured type variable or to an element of an array type variable.

The explicit partial access is made with an access path corresponding to the enumeration of all successive fields in the structure tree or array elements index; This enumeration should begin from the variable root, to the component that is accessed.

6.2.1.3.3.2.2.3 Renamed access

Renamed access consists in the projection of an A_Name from the MPS addressing space on a variable A_Name, or on a structured type variable access path, or on an array type variable element.

The names that are used in renamed partial access belong to the same addressing space as variable global names; this means they belong to the addressing space provided to the user at the interface with the application layer.

Consequently, renamed access allows the user access to a structure field or to an array element in the same way as for a global variable.

NOTE This access mode is provided to improve transmission efficiency, by grouping several user defined variables in the same structure.

This means that the transmission efficiency improvement can lead to group in a minimum number of DLPDUs variables exchanged between APs in an elementary distributed application. This is done in order to minimise control data in the data link layer.

Optimisation structures created at the application layer are transparent to the user with the renamed access, but they have to be declared in all the application entities that have to access all or part of the user defined variables they represent.

NOTE on optimisation structure elaboration: Only variables which do not need production validity and for which transmission validity is elaborated with the same value of the consumption period can be grouped within the same optimisation structure.

6.2.1.3.3.2.3 Variable renamed access modelization

6.2.1.3.3.2.3.1 *Variable Access* class specification

Class: VARIABLE ACCESS

Key-Attribute		: A_Name
Attribute		: Reference Variable
Attribute		: Access Mode [PARTIAL, GLOBAL]
Constraint		: Access Mode = PARTIAL
	Attribute	: Access Path

A_Name:

This attribute allows a unique specification of an access name at the interface between the application layer and the user. The A_Name belongs to the MPS addressing space

Moreover, a variable access A_Name should not be longer than 14 characters.

***Reference* Variable:**

The *Variable Access* class refers to the *Variable* class.

Variable class indicates the application variable with which the access A_Name is associated.

NOTE A variable renamed access name is global, this means that the same access name within several different application entities should refer to the same application layer variable.

Access Mode:

This attribute indicates which access mode is to be used.

When it has the value TRUE , this attributes indicates a global renamed access to an application layer variable.

When it has the Value FALSE, it indicates a partial access to a field of a structured variable or to an array element.

Access Path:

The access path to a structured variable field or to an array element refers, by increasing depth order structure field names or array element index.

NOTE In order to reach a full specification of the access path to a variable component, it is necessary that all the *Named Field* attributes of the *Type Constructor* objects at the various level of the structure have the value TRUE.

6.2.1.3.3.3 Variable transmission validity specification

6.2.1.3.3.3.1 Variable transmission overview

Consumer users may be provided with information relative to transmission validity for a variable.

Two sets of transmission validity information are defined:

- Promptness; relative to transmission validity regarding a user validity delay for the variable that is received: this validity delay is called the consumption period. Semantics associated with this information depends on the synchronous or asynchronous nature of the promptness
- Punctual promptness; that is relative to the transmission validity regarding a time slot associated with a synchronization order issued from the network.

6.2.1.3.3.3.2 Promptness

6.2.1.3.3.3.2.1 Promptness definitons

Promptness attributes associated with variable are optional.

Promptness is relative to the validity of availability of a variable value provided to the user by the network. This validity is elaborated with a maximum consumption period which is fixed by the user.

In the case of synchronous promptness, the semantics of that validity information takes into account the respect of availability by the network of a synchronization order associated with the variable.

Asynchronous Promptness:

When it has the value TRUE, this boolean information indicates in a consumer entity that the variable value has been updated by the network for a delay that is smaller than the variable consumption period.

Synchronous Promptness:

When it has the value TRUE, this boolean information indicates in a consumer entity that the synchronization order has been received and has been followed by (at least) one updating of the associated variable by the network, and that the updating was within the consumption period.

6.2.1.3.3.3.2.2 *Promptness* class specification

This class gathers all the attributes relative to the elaboration of a promptness information associated with a variable within a consuming application entity.

```
Class:  PROMPTNESS
        Attribute          : Consumption period
        Attribute          : Inherit from Time-out
        Attribute          : Promptness characteristic
                                [SYNCHRONOUS, ASYNCHRONOUS]
        Constraint         : Promptness characteristic = SYNCHRONOUS
            Attribute          : Reference (Synchronization) Variable
        Attribute          : Promptness status [TRUE,FALSE]
```

Consumption period:

The consumer user declares a consumption period corresponding with the needs_of the distributed application.

This period corresponds to the minimal period to which the consumer user will access the variable.

Inherit from Time-out:

Promptness class inherits from Time-out class.

Time-out class includes all the attributes relative to a time-out. This resource is mandatory to elaborate an information relative to a variable promptness.

Promptness characteristics:

Promptness may have a characteristic which is proper to the consumer, and that influences the promptness status semantics.

When the characteristic is ASYNCHRONOUS, promptness is elaborated exclusively with attributes proper to the variable.

When the characteristic is SYNCHRONOUS, promptness takes into account not only the variable attributes, but also an event related to the reception of a synchronization order.

***Reference* (Synchronization) Variable:**

This attribute references a *Variable* class for which the *Class* attribute has the value SYNCHRONIZATION. This allows reference to the synchronization order which sets the time-out in the case of synchronous promptness.

Promptness status:

Variable promptness is characterized by a status.

This status is of type boolean and is locally elaborated within each entity having a *Consumed Variable Local Image* associated with the variable.

Promptness status transition conditions from one state to the other are elaborated by the means of

- events corresponding to the variable reception or to the occurrence of the synchronization order associated with the variable,
- the expiration of the time-out associated with the variable,
- the state of the time-out associated with the variable for the processing of synchronous promptness.

6.2.1.3.3.3.2.3 Mechanism

The asynchronous promptness status associated with a variable within a consuming entity is dynamically processed by the mechanism described in Figure 4 and Table 4.

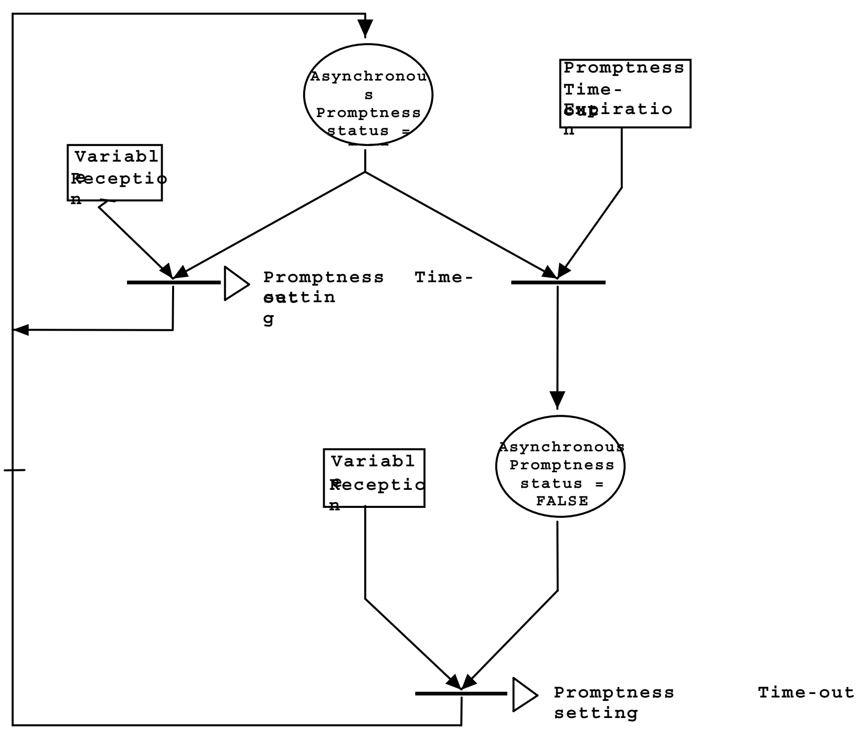

Asynchronous Promptness status =
Promptness Time-out Expiration
Variable Reception
Promptness Time-out setting
Variable Reception
Asynchronous Promptness status = FALSE
Promptness Time-out setting

Figure 4 – Asynchronous promptness status evaluation net

Table 4 – Asynchronous promptness events and actions

Initial state:	**<u>Asynchronous Promptness status = FALSE</u>**
	Promptness time-out state = IDLE
Requests:	**<u>Variable Reception</u>:**
	Variable available from the network
	<u>Promptness time-out expiration</u>:
	Transition of the time-out associated with the mechanism elaborating the asynchronous promptness status from RUNNING state to IDLE state.
Actions:	**<u>Promptness time-out setting</u>**
	Transition of the time-out associated with the mechanism elaborating the asynchronous promptness status from IDLE state to RUNNING state with a preset equal to the *Consumption period* attribute value.

Synchronous promptness status associated with a variable within a consuming application entity is processed by the mechanism described in Figure 5 and Table 5.

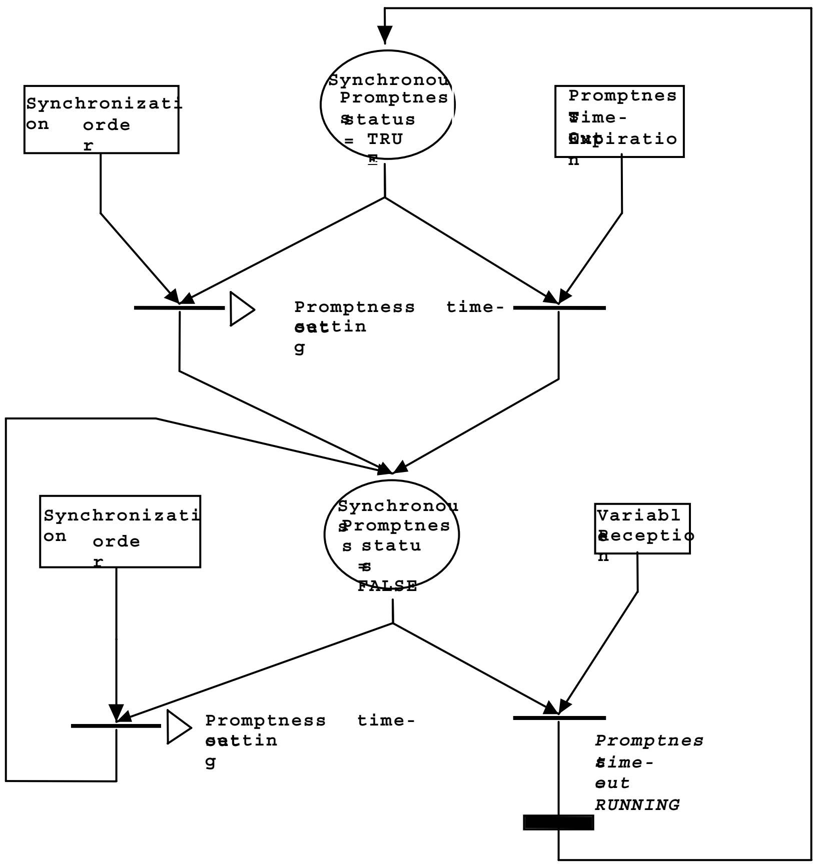

Synchronization order
Synchronous Promptness status = TRUE
Promptness time-out expiration
Promptness time-out setting
Synchronization order
Synchronous Promptness status = FALSE
Variable reception
Promptness time-out setting
Promptness time-out RUNNING

Figure 5 – Synchronous promptness status evaluation net

Table 5 – Synchronous promptness events and actions

Initial state:	**<u>Synchronous promptness status = FALSE</u>**
	Promptness time-out state = IDLE
Requests:	**<u>Variable reception</u>:**
	Variable available from the network
	<u>Synchronization order</u>:
	Occurrence of a synchronization order associated with the synchronous promptness status elaboration mechanism.
	<u>Promptness time-out expiration</u>:
	Transition of the time-out associated with the mechanism elaborating the synchronous promptness status from RUNNING state to IDLE state.
Actions:	**<u>Promptness time-out setting</u>**
	Transition of the time-out associated with the mechanism elaborating the synchronous promptness status from IDLE state to RUNNING state with a preset equal to the *Consumption period* attribute value.

6.2.1.3.3.3.3 Punctual promptness

6.2.1.3.3.3.3.1 Punctual promptness definition

Punctual promptness information associated with a variable is optional.

Punctual promptness is relative to a validity of availability of the variable value to the consumer user from the network. That validity is elaborated by the means of a consumption time-slot that is defined during the configuration step. This time-slot is activated upon reception of a synchronization order from the network.

Punctual Promptness:

When it has the value TRUE this boolean informs a consuming application entity that the variable value has been updated by the network (at least) once in the time slot following the reception of a synchronization order associated with the variable. It indicates also that the variable value has not been updated outside the time slot.

6.2.1.3.3.3.3.2 *Punctual Promptness* class specification

This class gathers all the attributes relative to the elaboration of a punctual promptness information associated with a variable within a consuming application entity.

Class:	PUNCTUAL PROMPTNESS	
	Attribute	: Consumption time slot
	Attribute	: *Inherit from* Time-out
	Attribute	: *Reference* (Synchronization) Variable
	Attribute	: Punctual Promptness Status [TRUE,FALSE]

Consumption time-slot:

Punctual promptness is elaborated by the means of a consumption time slot associated with a variable by a consumer user.

Punctual promptness informs a variable consumer that it has received a new value (at least) once during the time slot associated with the last synchronization order that has been received.

Inherit from Time-out:

Punctual Promptness class inherits from Time-out class.

Time-out class includes all the attributes relative to a time-out (preset, state).

***Reference* (Synchronization) Variable:**

This attribute refers to a *Consumed Variable* class the *Class* attribute of which has the value SYNCHRONIZATION , and that defines the synchronization order that sets the time-out in the case of a punctual promptness.

Punctual promptness status:

A variable punctual promptness is characterized by a status.

That status is of type boolean and is locally elaborated within each entity where a *Consumed Variable Local Image* is declared for the variable.

Promptness status transition conditions from one state to the other are elaborated by the means of

- events corresponding to the reception of the variable or to the occurrence of a synchronization order associated with that variable,
- state of the time-out associated with the variable for the punctual promptness processing.

6.2.1.3.3.3.3.3 Mechanism

Punctual promptness status associated with a variable within a consuming application entity is processed by the mechanism described in Figure 6 and Table 6.

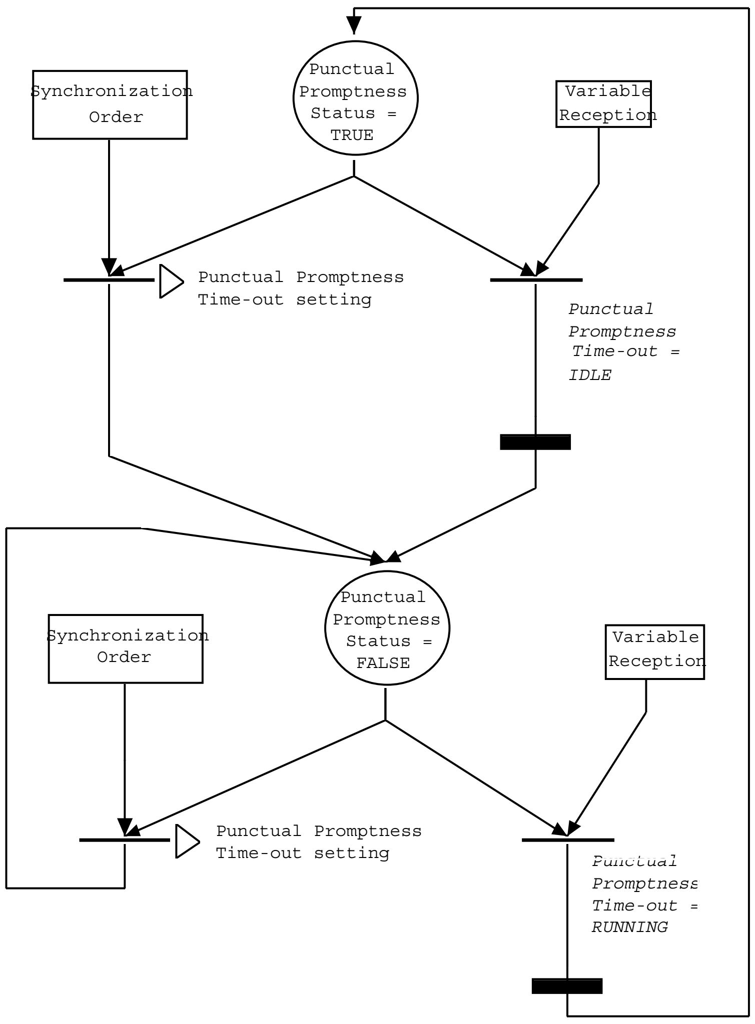

Synchronization Order
Punctual Promptness Status = TRUE
Variable Reception
Punctual Promptness Time-out setting
Punctual Promptness Time-out = IDLE
Synchronization Order
Punctual Promptness Status = FALSE
Variable Reception
Punctual Promptness Time-out setting
Punctual Promptness Time-out = RUNNING

Figure 6 – Punctual promptness status evaluation net

Table 6 – Punctual promptness events and actions

Initial state:	**Punctual Promptness status = FALSE**
	Promptness time-out state = IDLE
Requests:	**Variable Reception:**
	Variable available from the network
	Synchronization order:
	Occurrence of the synchronization order associated with the punctual promptness elaboration mechanism.
Actions:	**Punctual Promptness time-out setting**
	Transition of the time-out associated with the mechanism elaborating the punctual promptness status from IDLE state to RUNNING state with a preset equal to the *Consumption Time slot* attribute value.

6.2.1.3.3.4 Variable production validity specification

6.2.1.3.3.4.1 Variable production validity definition

Production validity may be associated with any variable. Validity information is elaborated by a producing application entity and provided to the consuming entities. Those consuming entities only see a sampled value of the information.

Two categories of production validity information are defined:

- Refreshment, relative to a production validity regarding a maximum delay fixed by the user. Refreshment semantics depends on its characteristic, synchronous or asynchronous, within a producing application entity.
- Punctual refreshment relative to production validity regarding a production time slot associated with a synchronization order issued from the network.

6.2.1.3.3.4.2 Refreshment

6.2.1.3.3.4.2.1 Refreshment definition

This production validity information is elaborated as an option and is characterized with a status.

Refreshment is relative to validity of availability to the network by a producer user of a variable value. This validity is elaborated by the means of a production period that is fixed by the user.

In the case of a synchronous refreshment, the semantics of this validity information denotes the respect of availability by the network of the synchronization order associated with the variable.

That refreshment information, carried with the variable value by the network, is provided to consumer users.

Asynchronous refreshment:

When it has the value TRUE this boolean indicates in a producing application entity that the variable value has been provided to the network by the producer user, with a delay less than the production period.

Synchronous Refreshment:

When it has the value TRUE this boolean indicates within a producing application entity that a synchronization order has been received and followed by a (at least) one sourcing of a new variable value to the network from the producer user with a delay less than the production period.

6.2.1.3.3.4.2.2 *Refreshment* class specification

This class gathers all the attributes relative to the elaboration of a refreshment information associated with a variable within a producing application entity.

Class: REFRESHMENT

Attribute	: Production period
Attribute	: *Inherit from* Time-out
Attribute	: Refreshment characteristic [SYNCHRONOUS,ASYNCHRONOUS]
Constraint	: Refreshment characteristic = SYNCHRONOUS
Attribute	: *Reference* (Synchronization) Variable
Attribute	: Refreshment Status [TRUE, FALSE]

Production period:

The producer user may declare a production period corresponding to the needs of its distributed application.

This period corresponds to the maximum interval during which the producer user will provide the variable to the network.

Inherit from Time-out:

Refreshment class inherits from *Time-out* class.

Time-out class includes all the attributes relative to a time-out. This resource is mandatory to the elaboration of information relative to variable refreshment.

Refreshment characteristic:

Refreshment may be provided with a characteristic proper to a producer and that influences the refreshment status semantics.

When the characteristic is ASYNCHRONOUS, refreshment is elaborated exclusively with attributes proper to the variable.

When the characteristic is SYNCHRONOUS, refreshment takes into account not only the variable attributes, but an event related to the reception of a synchronization order.

***Reference* (Synchronization) Variable:**

The attribute refers to a *Variable* class, the *Class* attribute of which has the value SYNCHRONIZATION. This defines the synchronization order which sets the time-out in the case of a synchronous refreshment.

Refreshment Status:

The variable refreshment provided to a user is characterized by a status.

This status is of type boolean and is locally elaborated within each application entity where a *Produced Variable Local Image* is declared.

The value of the status is associated with the variable value during the exchange on the bus.

Refreshment status is defined by two states, and the transition conditions from one state to the other are elaborated by means of

- events corresponding to the production of the variable,
- events related to the occurrence of the synchronization order associated with the variable,
- expiration of the time-out associated with the variable,
- state of the Time-out associated with the variable for the processing of synchronous refreshment.

6.2.1.3.3.4.2.3 Mechanism

Asynchronous refreshment status associated with a variable within a producing application entity is elaborated by the mechanism described in Figure 7 and Table 7.

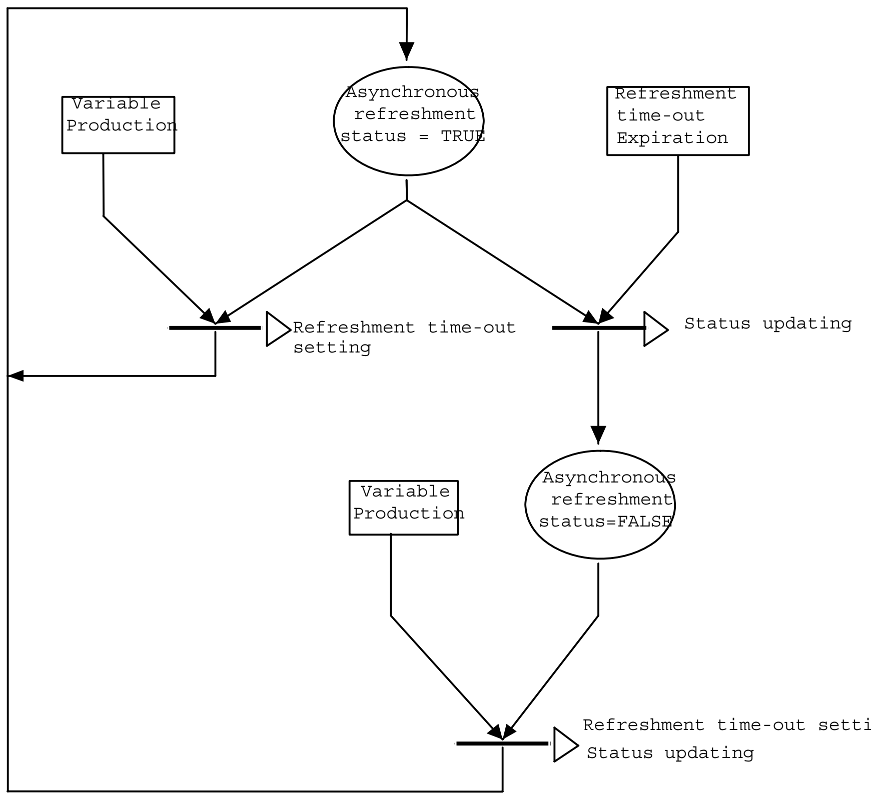

Variable Production
Asynchronous refreshment status = TRUE
Refreshment time-out Expiration
Refreshment time-out setting
Status updating
Variable Production
Asynchronous refreshment status=FALSE
Refreshment time-out setti
Status updating

Figure 7 – Asynchronous refreshment status evaluation net

Table 7 – Asynchronous refreshment events and actions

Initial state:	**Asynchronous refreshment status = FALSE**
	Refreshment time-out state = IDLE
Requests:	**Variable Production:**
	A_WRITELOC, A_WRITEFAR or A_WRITE service invocation by the user
	Refreshment time out expiration:
	Transition of the time-out associated with the asynchronous refreshment evaluation mechanism from the state *RUNNING* to the state *IDLE*
Action:	**Refreshment time-out setting:**
	Transition of the time-out associated with the asynchronous refreshment mechanism from the state *IDLE* to the state *RUNNING,* with a preset equal to the *Production Period* attribute value.
	Status updating:
	Providing of the asynchronous refreshment status value to the network.

Synchronous refreshment status associated with a variable within a producing application entity is elaborated by the mechanism described in Figure 8 and Table 8.

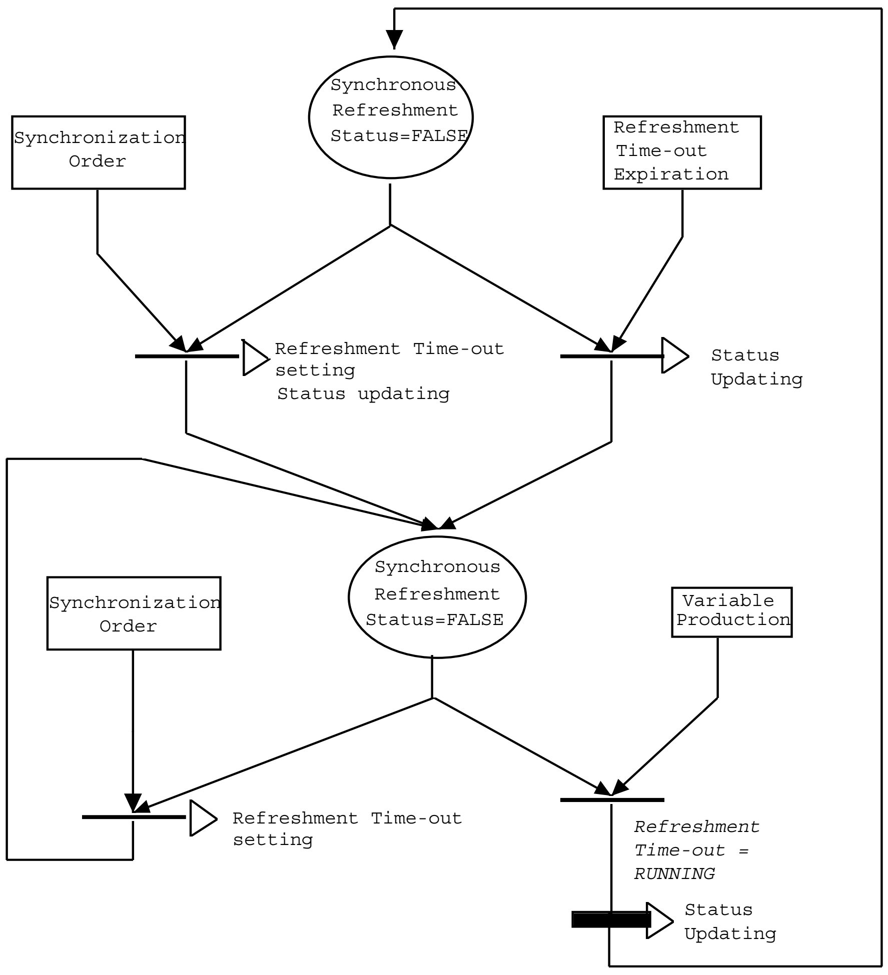

Synchronous Refreshment Status=FALSE
Synchronization Order
Refreshment Time-out Expiration
Refreshment Time-out setting Status updating
Status Updating
Synchronous Refreshment Status=FALSE
Synchronization Order
Variable Production
Refreshment Time-out setting
Refreshment Time-out = RUNNING
Status Updating

Figure 8 – Synchronous refreshment status evaluation net

Table 8 – Synchronous refreshment events and actions

Initial state:	**<u>Synchronous refreshment status = FALSE</u>**
	Refreshment time-out state = IDLE
Requests:	**<u>Variable Production</u>:**
	A_WRITELOC, A_WRITEFAR or A_WRITE service invocation by the user
	<u>Refreshment time out expiration</u>:
	Transition of the time-out associated with the synchronous refreshment evaluation mechanism from the state *RUNNING* to the state *IDLE*
	<u>Synchronization order</u>:
	Occurrence of the synchronization order associated with the synchronous refreshment elaboration mechanism.
Action:	**<u>Refreshment time-out setting</u>:**
	Transition of the time-out associated with the synchronous refreshment mechanism from the state *IDLE* to the state *RUNNING,* with a preset equal to the *Production Period* attribute value.
	<u>Status updating</u>:
	Providing of the asynchronous refreshment status value to the network.

6.2.1.3.3.4.3 Punctual refreshment

6.2.1.3.3.4.3.1 Punctual refreshment definition

Production validity information is optional.

Punctual refreshment is relative to the validity of availability to the network by the producer user of a variable value. This validity is elaborated by the means of a time-slot fixed by the user. This time slot is activated upon the reception of a synchronization order from the network.

Punctual Refreshment:

When it has the value TRUE this boolean indicates within a producing application entity that a variable value has been provided to the network by the producer user (at least) once during the time slot following the reception of a synchronization order. The variable value should not have been provided outside the time slot.

Punctual refreshment status is associated with the variable value and is provided to the network.

6.2.1.3.3.4.3.2 *Punctual Refreshment* class specification

This class gathers all the attributes relative to the elaboration of a punctual refreshment information associated with a variable within a producing application entity.

Class:	PUNCTUAL REFRESHMENT	
	Attribute	: Production time slot
	Attribute	: *Inherit from* Time-out
	Attribute	: *Reference* (Synchronization) Variable
	Attribute	: Punctual Refreshment Status [TRUE,FALSE]

Production Time slot:

Punctual refreshment is elaborated by the means of a production time-slot associated with a variable by the producer user. Punctual refreshment allows a consumer user to check whether the variable producer guarantees its production within the time slot activated by the last synchronization order issued from the network, and associated with it.

Inherit from Time-out:

Punctual Refreshment class inherits from *time-out* class.

Time-out class includes all the attributes relative to a time-out (preset, state) that characterize the production time slot.

***Reference* (Synchronization) Variable:**

This attribute refers to a *Variable* class, the attribute *Class* of which has the value SYNCHRONIZATION, and that permits to define the synchronization order that sets the time-out in the case of a punctual refreshment.

Punctual Refreshment Status:

Variable punctual refreshment is characterized by a status.

This status is of type boolean and is locally elaborated within each entity owning a *Produced Variable Local Image* object of the variable.

Punctual refreshment status is characterized by two states, the transition conditions between which are elaborated by the means of

- events corresponding to the variable production, or to the occurrence of a synchronization order associated with the variable,
- state of the time-out associated with the variable for the processing of the punctual refreshment.

6.2.1.3.3.4.3.3 Mechanism

Punctual refreshment status associated with a variable, within a producing application entity, is elaborated by the mechanism described in Figure 9 and Table 9.

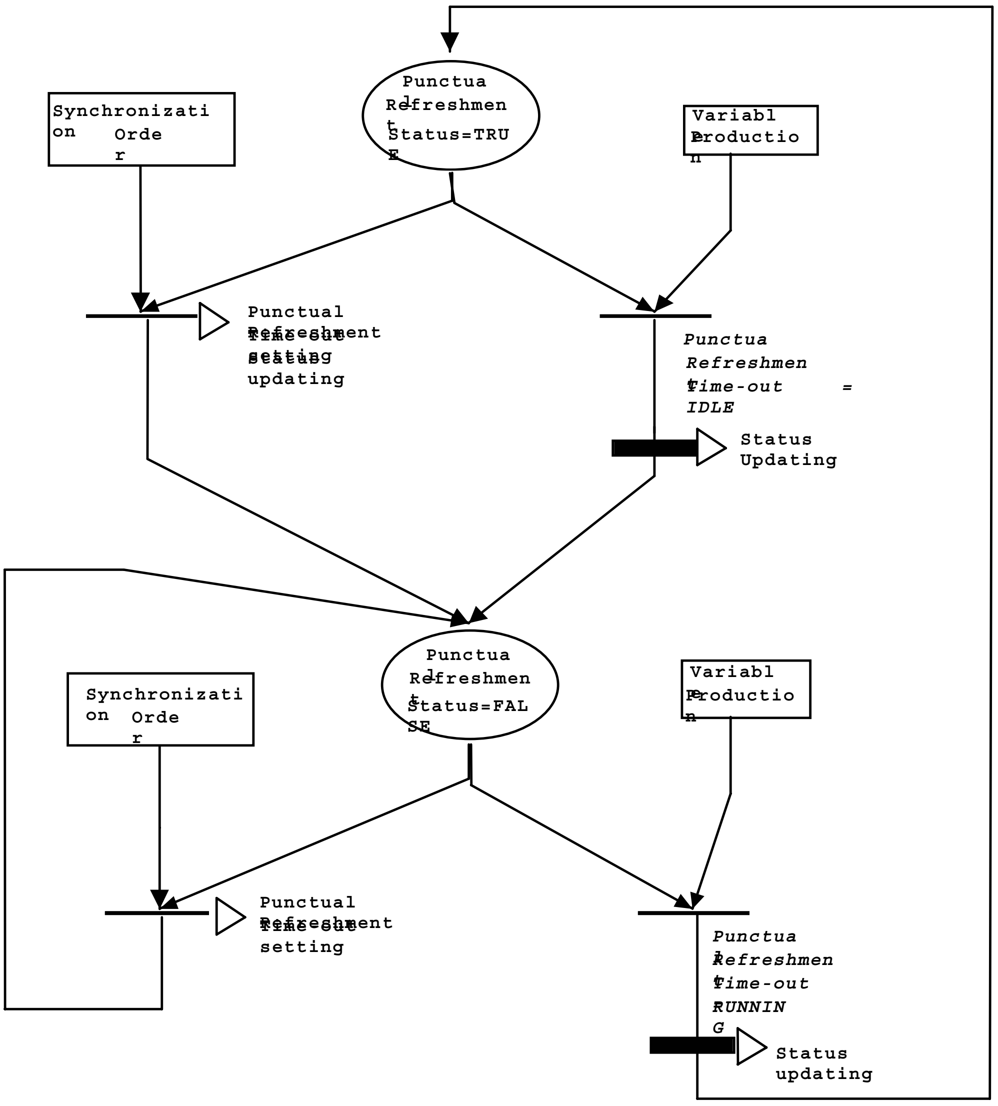

Punctual Refreshment Status=TRUE
Synchronization Order
Variable Production
Punctual Refreshment Time-out setting Status updating
Punctual Refreshment Time-out = IDLE
Status Updating
Punctual Refreshment Status=FALSE
Synchronization Order
Variable Production
Punctual Refreshment Time-out setting
Punctual Refreshment Time-out RUNNING
Status updating

Figure 9 – Punctual refreshment status evaluation net

Table 9 – Punctual refreshment events and actions

Initial state:	**<u>Punctual refreshment status = FALSE</u>**
	Refreshment time-out state = IDLE
Requests:	**<u>Variable Production</u>:**
	A_WRITELOC, A_WRITEFAR or A_WRITE service invocation by the user
	<u>Refreshment time out expiration</u>:
	Transition of the time-out associated with the punctual refreshment evaluation mechanism from the state *RUNNING* to the state *IDLE*
	<u>Synchronization order</u>:
	Occurrence of the synchronization order associated with the punctual refreshment elaboration mechanism.
Action:	**<u>Refreshment time-out setting</u>:**
	Transition of the time-out associated with the punctual refreshment mechanism from the state *IDLE* to the state *RUNNING,* with a preset equal to the *Production Time Slot* attribute value.
	<u>Status updating</u>:
	Providing of the asynchronous refreshment status value to the network.

6.2.1.3.4 Basic services

6.2.1.3.4.1 Basic service overview

The variable access basic services in the MPS environment allow the user to access the associated application objects identified by their specification.

The variable specification corresponds:

- either to the application name for variables accessed in a global way. In this case the application name corresponds to the *A_Name* of the *Consumed Variable Local Image* or *Produced Variable Local Image* or *Third part Variable Local Image* objects.
- or to the partial explicit access name either for structured variables or array type variables partially accessible. This access name is built together with the application variable *A_Name* followed by the access path corresponding to the successive enumeration of field names of the tree of the structure and/or index elements of an array.
- or to the access path in the case of partial or global renamed access on a variable. This name corresponds to the *A_Name* attribute of the Variable *Access* object

6.2.1.3.4.2 Local read service

6.2.1.3.4.2.1 Functionality

With this service the user can read a variable value or a field of a structured variable value or the element of an array type variable value which is available in the local communication entity.

6.2.1.3.4.2.2 Service primitives

A local read is performed by using A_READLOC service primitives, as shown in Table 10:

A_READLOC.Rq (Argument): Local read request

A_READLOC.Cnf (Result): Local read confirmation

Table 10 – A_Readloc service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Result (+)		S
Value		M
Refreshment status		C
Refreshment status		C
Promptness status		C
Punctual Promptness status		C
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Argument:

Information associated with a local read request.

Variable specification:

Corresponds to the identification of a *Produced Variable Local Image* object in the MPS addressing space.

Result (+):

Valid answer associated with a local read request

Value:

It is the value of the variable, or field, or array element specified in the request. This parameter corresponds to the attribute *Public value* of the *Consumed Variable Local Image* object for the non resynchronized variables. For resynchronized variables this parameter corresponds to the attribute *Private value* of the *Consumed Variable Local Image* object.

Refreshment status:

Punctual Refreshment status:

Information related to the production validity.

This information come from the attribute *Transmitted status value* of the object *Consumed Variable Local Image*.

Promptness status:

Punctual Promptness status:

Information related to the consuming validity.

This information came from the attributes with same name within the *Consumed Variable Local Image* object.

Result (-):

This indicates that the local read service failed.

Type of error:

Various error types may be returned in the confirmation of a read request.

Error_1: The variable value is temporarily not accessible.

Error_2: The variable value is not accessible by means of this service. It corresponds to a variable which is not locally declared, or which is accessible only by production services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

6.2.1.3.4.2.3 Service procedure

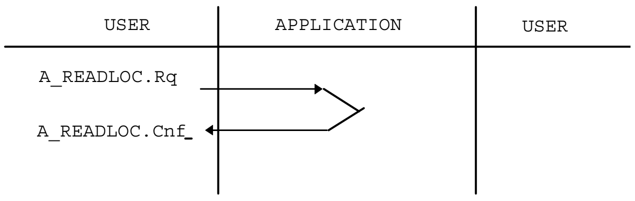


Figure 10 – A_Readloc service procedure

This service, shown in Figure 10, ensures the value integrity of the variable or the field or the element handled.

The value integrity of a variable is ensured in a read operation when all the binary elements of the data associated with this value come from the same update.

Furthermore requests on a variable are processed sequentially: a new request may be made only after reception of confirmation upon the previous one.

6.2.1.3.4.3 Local write service

6.2.1.3.4.3.1 Functionality

With this service the user can write a variable value or a field of a structured variable value or an element of an array type variable value in the local communication entity.

6.2.1.3.4.3.2 Service primitives

A local write is performed using A_WRITELOC service primitive, as shown in Table 11.

A_WRITELOC.Rq (Argument) : Local write request.

A_WRITELOC.Cnf (Result) : Local write confirmation.

Table 11 – A_Writeloc service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Value	M	
Result (+)		S
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Argument:

Information associated with a local write request

Variable Specification:

Corresponds to the identification of a *Consumed Variable Local Image* object in the MPS addressing space. The definition of this parameter corresponds to the one shown in paragraph.3.8

Value:

Value to be written to the specified variable specification, or field of a structured variable, or element of an array type variable.

This parameter corresponds to the attribute *Public value* of the *Produced Variable Local Image* object for the non resynchronized variables. For the resynchronized variables this parameter corresponds to the attribute *Private value* of the *Produced Variable Local Image* object.

Result (+):

No parameters

Result (-):

This indicates that the local write service failed.

Type of error:

Various error types may be returned in the confirmation of a read request.

Different error types can be returned with the local write confirmation.

Error_1: The variable value is temporarily not accessible.

Error_2: The variable is not accessible with use of this service. It corresponds to a variable which is not locally declared, or which is accessible only by consuming services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

6.2.1.3.4.3.3 Service procedure

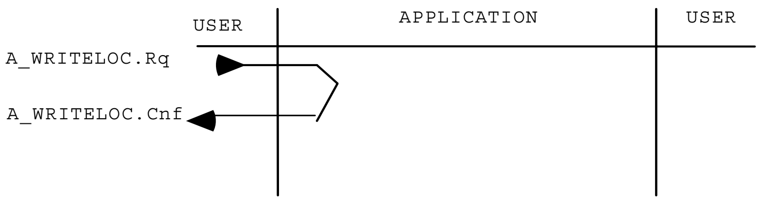


Figure 11 – A_Writeloc service procedure

This service, shown in Figure 11, ensures the integrity of the value of the handled variable.

The integrity of the written variable corresponds to provide the network with a consistent value coming from the same write operation.

All status elaborated by the producing entity and provided to the network should be consistent with the value of the transmitted variable.

Furthermore this service triggers the mechanism associated with the service elements which elaborate refreshment and punctual refreshment status of the *Produced Variable Local Image* object.

Partial access on a variable when writing a value triggers mechanism of production validity status elaboration associated with this variable.

Furthermore request on variable are processed sequentially; a new request can be made only after reception of confirmation upon the previous one.

6.2.1.3.4.4 Updating service

6.2.1.3.4.4.1 Functionality

This service supports the request (to the bus arbitrator) for the updating of a variable value at the consuming entities level. The variable value is locally available in the producer communication entity level.

This service can be used by the application entity which produces the variable, by an application entity which consumes it, or by an application entity which is neither producer nor consumer (ie: a third party entity).

6.2.1.3.4.4.2 Service primitives

An updating request is performed with the following service primitives, as shown in Table 12.

A_UPDATE.Rq (Argument) : Updating request.

A_UPDATE.Cnf (Result) : Updating confirmation.

Table 12 – A_Update service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Priority	M	
Result (+)		S
Result (-)		S
Type of error		M

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.

Arguments:

Information associated with an updating request.

Variable Specification:

Corresponds to the identification of a *Produced Variable Local Image* object or a *Produced Variable Local Image* object or *Third party Variable Local Image* object in the MPS addressing space

Priority:

This parameter allows the user to choose between two flow control possibilities **Urgent** and **Normal** to request the updating of a variable the name of which has been specified in the request.

The flow control ensures that an urgent request, will trigger an updating before a subsequent normal request.

Result (+):

No parameters.

Result (-):

This indicates that the updating service failed.

Type of error:

Various error types may be returned in the service confirmation:

Error_1: The variable is not declared at the AP level of the request initiator.

Error_2: The request cannot be accepted given the local limits concerning the number of outstanding requests.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

6.2.1.3.4.4.3 Service procedure

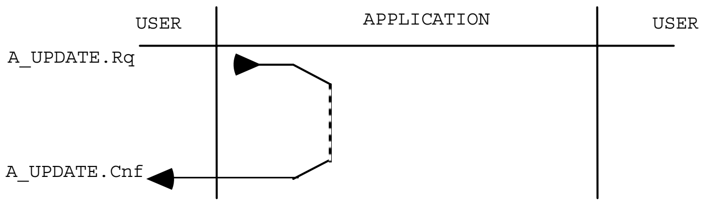


Figure 12 – A_Update service procedure

This service, shown in Figure 12, guarantees that the user will receive a confirmation after a request.

The service confirmation is a positive one when the request is positively confirmed at the data link level.

Requests may be chained together even before receiving all confirmations. However; confirmations are not always issued in the order of requests previously initiated.

For a SYNCHRONIZATION class variable, this service can be initiated only by the variable producer.

NOTE The maximum number of outstanding requests depends on the implementation, and saturation is specified in error codes associated with the confirmation.

6.2.1.3.4.5 Remote read service

6.2.1.3.4.5.1 Functionality

With this service the consumer user of a variable can take the initiative of an information exchange on the bus, before performing a read on the new variable value locally available.

6.2.1.3.4.5.2 Service primitives

Remote read is done with the A_READFAR service primitive, as shown in Table 13.

A_READFAR.Rq (Argument): Remote read request

A_READFAR.Cnf (Result): Remote read confirmation with return of the read value

Table 13 – A_Readfar service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Priority	M	
Result (+)		S
Value		M
Refreshment Status		C
Punctual Refreshment Status		C
Promptness Status		C
Punctual Promptness status		C
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Argument:

Information associated with a remote read request.

Variable specification:

Corresponds to the identification of a *Consumed Variable Local Image* object in the MPS addressing space.

Priority:

This parameter allows the user to choose between two flow control possibilities **Urgent** and **Normal** to request the updating of a variable the name of which has been specified in the request.

The flow control guarantees that an urgent request, will trigger an updating before a subsequent normal request.

Result (+):

This result indicates that the requested service has succeeded.

Value:

The value of the variable or field, or a array element specified in the request.

This parameter corresponds the attribute *Public value* of the object *Consumed Variable Local Image* for the non resynchronized variables. For resynchronized variables this parameter corresponds to the attribute *Private value* of the object *Consumed Variable Local Image*.

Refreshment status:

Punctual Refreshment status:

Information relative to the production validity This information comes from the attribute *Transmitted status value* of the *Consumed Variable Local Image* object.

Promptness status:

Punctual Promptness status:

Information relative to the consumption validity

This information comes from the attributes with the same name within the object *Consumed variable Local Image*.

Result (-):

This indicates that the requested service failed.

Type of error:

Various error types may be returned in the service confirmation:

Error_1: The variable value is temporarily not accessible.

Error_2: The variable value is not accessible by means of this service. It corresponds to a variable which is not locally declared or which is accessible only by production services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

Error_4: The request cannot be accepted given the local limits concerning the number of outstanding requests.

Error_5: The request has been aborted due to expiration of the time-out associated with the reception waiting of the variable value.

6.2.1.3.4.5.3 Service procedure

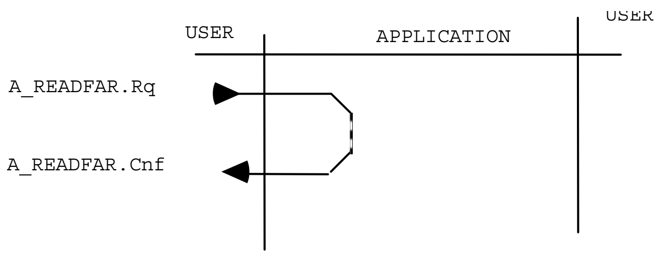


Figure 13 – A_Readfar service procedure

This service, shown in Figure 13, guarantees the integrity of the handled variable value, or field, or array element value.

Requests may be chained together. A new request can be issued without waiting for corresponding confirmations. However, confirmations are not always issued in the same order as the requests.

This service guarantees that the user will receive a confirmation after a request.

The value integrity of a variable value is ensured in a read operation when all the binary elements of the data associated with this value come from the same updating.

6.2.1.3.4.6 Remote write service

6.2.1.3.4.6.1 Functionality

With this service ,the variable producer user may initiate an information exchange on the bus after providing the variable value to the network.

6.2.1.3.4.6.2 Service primitives

Remote write is performed by using the A_WRITEFAR service primitive, as shown in Table 14.

A_WRITEFAR.Rq (Argument): Remote write request

A-WRITEFAR.Cnf (Result): Remote write confirmation

Table 14 – A_Writefar service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Priority	M	M (=)
Value	M	
Result (+)		S
Result (-)		S
Type of error		M

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.

Arguments:

Information associated with a remote request

Variable specification:

Corresponds to the identification of a *Produced Variable Local Image* object in the MPS space

Priority:

This parameter allows to the user to choose between two flow control possibilities **Urgent** and **Normal** to request the updating of a variable which the name of which has been specified in the request.

The flow control ensures that an urgent request, will trigger an updating before a subsequent normal request.

Value:

Upon a remote write the user associates with the variable specification the value he intends to affect it.

This parameter corresponds to the attribute *Public value* of the *Produced Variable Local Image* object for the non resynchronised variables. For the resynchronized variables this parameter corresponds to the attribute *Private value* of the *Produced Variable Local Image* object.

Result (+):

No parameters.

Result (-):

This indicates that the remote write service failed.

Type of error:

Different error types may be returned in the service confirmation:

Error_1: The variable value is temporarily not accessible.

Error_2: The variable is not accessible by means of this service. It corresponds to a variable which is not locally declared or which is accessible only by consuming services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

Error_4: The remote write request cannot be accepted due to local limits concerning the number of outstanding requests. However, the local variable value has been updated.

Error_5: The request has been withdrawn

6.2.1.3.4.6.3 Service procedure

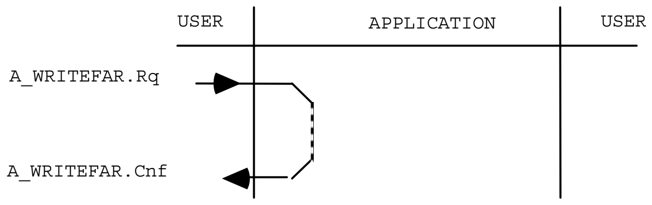


Figure 14 – A_Writefar service procedure

This service, shown in Figure 14, ensures the value integrity of the handled variable or the field, or the element.

Requests may be chained together. A new request can be issued without waiting for corresponding confirmations. However, confirmations are not always issued in the same order as the requests.

This service ensures that the user will receive a confirmation after a request.

The integrity of a written variable value corresponds to an updating of the network with a consistent value coming from only one write operation. This service also ensures the consistency between the produced variable value and statuses related to the production validity which are optionally associated.

Moreover, this service triggers the mechanisms associated with the service elements that elaborate the value of the refreshment status and the punctual refreshment status of the *Produced Variable Local Image* object.

NOTE The value provided to the consuming entities will be the one which was available at the producer level during its network updating.

6.2.1.3.4.7 Transmission indication service

6.2.1.3.4.7.1 Functionality

This service is optional, and indicates to a producer user that a variable has been transmitted on the network.

6.2.1.3.4.7.2 Service primitives

A transmission indication is performed using the A_SENT service primitive, as shown in Table 15.

A_SENT.Ind (Result): Transmission indication of a variable value

Table 15 – A_Sent service parameters

Parameter name	Ind
Result	
Variable specification	M
Result (+)	S
Result (-)	S
Type of error	M

Result:

Variable specification:

Corresponds to the identification of a *Produced Variable Local Image* object in the MPS addressing space.

Result(+):

No parameters

Result(-):

The results indicates that the service failed.

Type of error:

Various error types may be returned by the transmission indication service:

Error_1: The value of the transmitted variable is declared invalid.

6.2.1.3.4.7.3 Service procedure

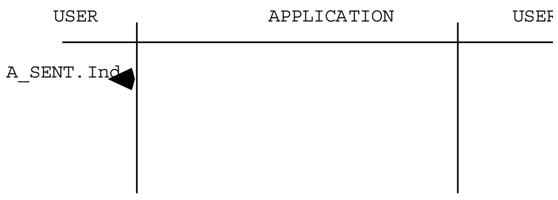


Figure 15 – A_Sent service procedure

This service, shown in Figure 15, informs the producer user of the broadcasting of a variable on the network.

When this variable or some of its fields are locally known at the producer user level by means of names coming from renamed partial access, this service provide an indication to the user for each of the names associated with the same variable.

6.2.1.3.4.8 Reception indication service

6.2.1.3.4.8.1 Functionality

This service informs a consumer user that a variable has been made available by the network.

6.2.1.3.4.8.2 Service primitives

The reception indication is performed by the use of the A_RECEIVED service primitive, shown in Table 16.

A_RECEIVED.Ind(Result): Variable reception indication.

Table 16 – A_Received service parameters

Parameter name	Ind
Result	
Variable specification	M
Result (+)	S
Result (-)	S
Type of error	M

Result:

Variable specification:

Corresponds to the identification of a *Consumed Variable Local Image* object in the MPS addressing space.

Result(+):

No parameters

Result (-):

This indicates that the indication service failed.

Type of error:

Different error type can be returned by the reception indication service:

Error_1: The value of the received variable is declared invalid by the producing application entity.

Error_2: The transmission of this variable failed.

6.2.1.3.4.8.3 Service procedure

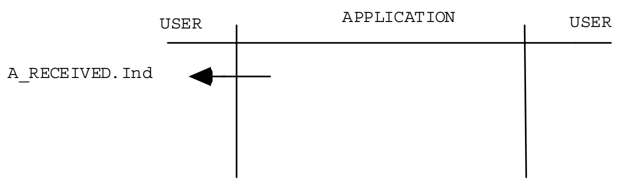


Figure 16 – A_Received service procedure

This service, shown in Figure 16, informs the user about the provision of a variable by the network.

6.2.1.3.5 Enhanced services

6.2.1.3.5.1 Enhanced services defintion

Enhanced services are a further level of abstraction and build on the basic services to allow the user to access variables without the need to specify either the type of service (local or remote) or the priority used.

6.2.1.3.5.2 Universal read service.

6.2.1.3.5.2.1 Functionality

This service allows the user to read a variable value without knowing the kind of read service (local or remote) to be used; the service is determined by the value of the attribute *Universal services range* of the class *Identified Variable.*

Furthermore when it is a remote read the priority used by the flow control is determined by the value of the attribute *Priority* of the class *Identified Variable.*

6.2.1.3.5.2.2 Service primitives

The universal read is performed using the A_READ service primitives, shown in Table 17.

A_READ.Rq (Argument): Universal read request

A_READ.Cnf (Result): Universal read confirmation with the read value

Table 17 – A_Read service parameters

Parameter name	**Req**	**Cnf**
Argument		
Variable specification	M	M (=)
Result (+)		S
Value		M
Refreshment Status		C
Punctual Refreshment Status		C
Promptness Status		C
Punctual Promptness status		C
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Argument:

Information associated with a universal read request.

Variable specification:

Corresponds to the identification of a *Consumed Variable Local Image* object in the MPS addressing space.

Result (+):

Valid answer associated with an universal read request.

Value:

It is the value of the variable, or field, or array element specified in the request. This parameter corresponds to the attribute Public value of the object *Consumed Variable Local Image* for non-resynchronized variables. For resynchronized variables this parameter corresponds to the attribute *Private value* of the object *Consumed Variable Local Image*.

Refreshment status:

Punctual Refreshment status:

Information related to the production validity.

This information is derived from the attribute *Transmitted status value* of the *Consumed Variable Local Image* object.

Promptness status:

Punctual promptness status:

Information related to the consuming validity.

This information is derived from the attributes with same name within the object *Consumed Variable Local Image*.

Result(-):

This indicates that the universal read service failed.

Type of error:

Various error types may be returned in the service confirmation:

Error_1: The variable value is temporarily not accessible.

Error_2: The variable value is not accessible with use of this service. It corresponds to a variable which is not locally declared, or which is accessible only by production services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

Error_4: The request cannot be accepted given the local limits concerning the number of outstanding requests.

6.2.1.3.5.2.3 Service procedure

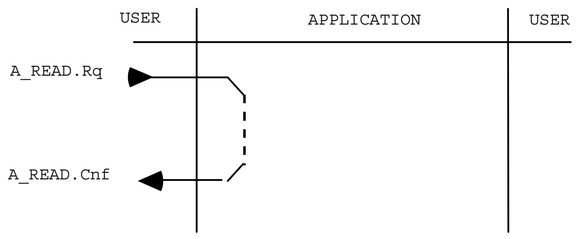


Figure 17 – A_Read service procedure

According to the value of the attribute *Universal services range* of the *Consumed Variable Local Image* object, the invocation of this service implies either the call of the local read service or the call of the remote read service. The universal read service procedure, Figure 17, is the one associated with the invoked service (local or remote).

The priority used in the case of a remote service invocation depends on the value of the attribute *Priority* of the class *Identified variable*.

Figure 18 shows the mechanism for chaining the basic services:

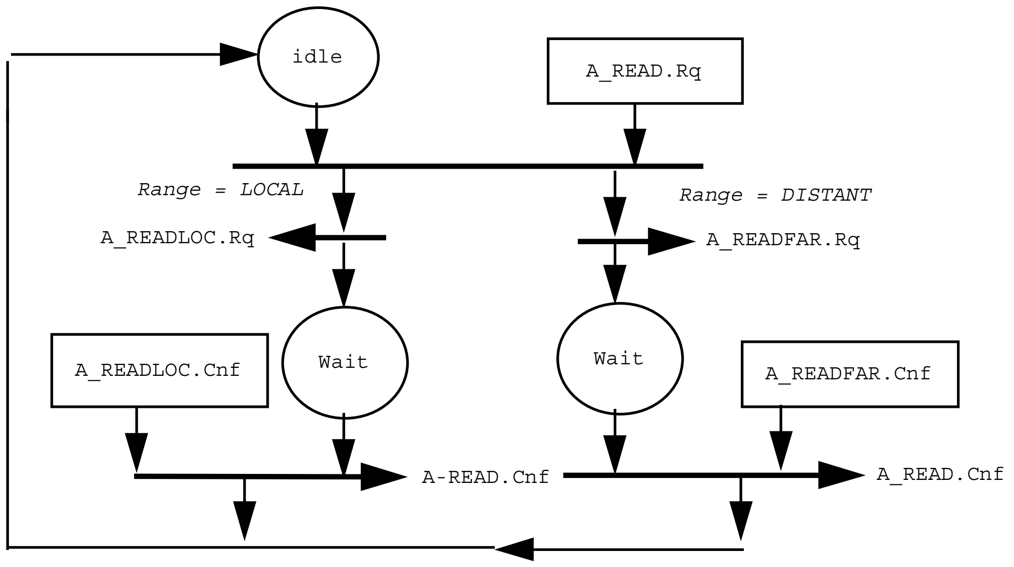


Figure 18 – A_Read service state machine

6.2.1.3.5.3 Universal write service

6.2.1.3.5.3.1 Universal write service functionality

This service allows the user to perform a write of the variable value without having to known the kind of write service (local or remote) to be used. The service is determined by the value of the attribute *Universal service range* of the *Produced Variable Local Image* object.

Furthermore when it is a remote write the priority used by the flow control is determined by the value of the attribute *Priority* of the class *Identified Variable.*

6.2.1.3.5.3.2 Service primitives

The universal write is performed by using the A_WRITE service primitives, shown in Table 18.

A_WRITE.Rq (Argument) : Universal write request

A_WRITE.Cnf (Result) : Universal write confirmation

Table 18 – A_Write service parameters

Parameter name	Req	Cnf
Argument		
Variable specification	M	M (=)
Priority	M	
Result (+)		S
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Arguments:

Information associated with a universal write request.

Variable specification:

Corresponds to the identification of a Produced Variable Local Image object in the MPS addressing space.

Value:

It is the value of the variable, or field, or array element specified in the request. This parameter corresponds to the attribute *Public Value* of the *Produced Variable Local Image* object for non-resynchronized variables. For synchronized variables this parameter corresponds to the attribute *Private Value* of the *Produced Variable Local Image* object.

Result(+):

No parameters.

Result(-):

This indicates that the universal write service failed.

Type of error:

Different error types may be returned in the confirmation of a universal write:

Error_1: The variable value is temporarily not accessible.

Error_2: The variable value is not accessible by means of this service. It corresponds to variable which is not locally declared which is accessible only by consuming services.

Error_3: The variable is declared invalid at the network management level with reference to consistency checking of the data base.

Error_4: The request cannot be accepted due to local limits concerning the number of outstanding requests. However, the local variable value has been updated.

Error_5: The request has been withdrawn

6.2.1.3.5.3.3 Service procedure

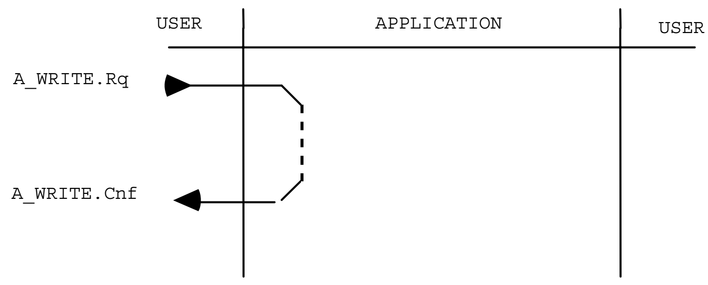


Figure 19 – A_Write service procedure

According to the value of the attribute *Universal services range* of the *Produced Variable Local Image* object, the invocation of this service implies either the call of the local write service or the call of the remote write service. The universal write service procedure, Figure 19, is the one associated with the invoked service (local or remote).

The priority used in the case of a remote service invocation depends on the value of the attribute *Priority* of the class *Identified variable*.

This service triggers the mechanism associated with the service elements that elaborate the refreshment status value and the punctual refreshment status value of the *Produced Variable Local Image* object.

Figure 20 shows the mechanism for chaining the basic services used by the universal write service:

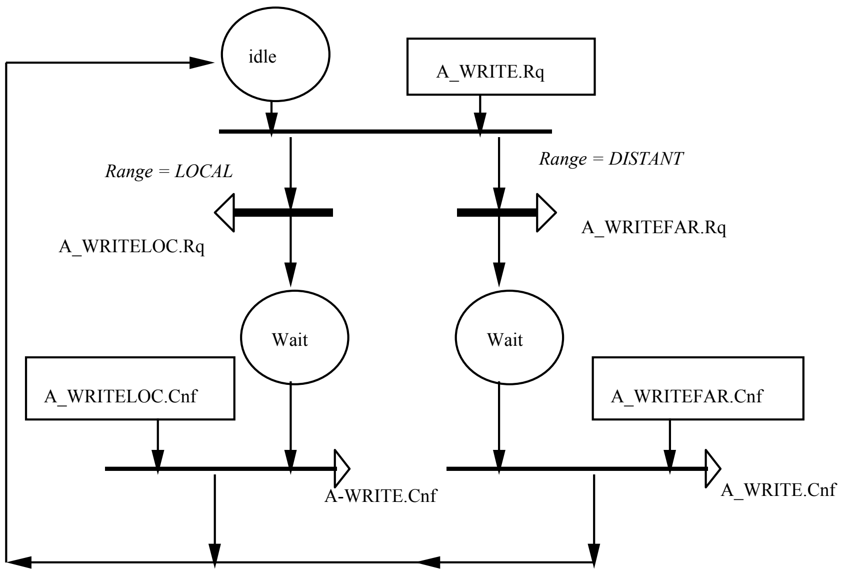


Figure 20 – A_Write service state machine

6.2.1.3.6 Advanced mechanisms

6.2.1.3.6.1 Synchronization

6.2.1.3.6.1.1 Synchronous application concept

The synchronization services provided by the MPS service elements were defined in order to allow the execution of distributed applications.

A distributed application is composed of several Application Processes (AP) in several devices of the control system.

Between the APs which participate in a distributed application, it is necessary to distinguish:

– those which are termed ASYNCHRONOUS, because their execution is independent of the network,

– those which are termed SYNCHRONOUS, because their execution is associated with indications issued from the network; these indications may be periodic or aperiodic.

Several synchronous APs, the execution of which are associated with the same indications, form a synchronous distributed application.

6.2.1.3.6.1.2 Resynchronization needs

Some APs can only support asynchronous operating mode, i.e. they are managed independent of the communication environment.

NOTE This exclusively asynchronous operating mode is usually the characteristic of APs located on devices whose age or simplicity does not offer the possibility of synchronization.

The resynchronization mechanism permits the sample/hold function of the variable values produced and consumed by an AP asynchronously with respect to the Network. This function allows asynchronous APs to participate in a synchronous distributed_application.

6.2.1.3.6.1.3 Synchronization variables

The variables in the MPS environment described in the previous chapter correspond to passive elements which are exchanged on the network.

The synchronization variables are elements associated with actions concerning:

– synchronization processing at the level of the producing application entity and consuming application entity of this synchronization variable,
– procedure execution orders for different APs in a distributed application.

At the application entity level, some variables from the MPS environment take into account the event associated with the transmission of a synchronization variable to elaborate the synchronous validity informations, such as synchronous promptness and synchronous refreshment, or the punctual promptness and the punctual refreshment.

6.2.1.3.6.1.4 Synchronization at transmission and reception

Some services provided to the user may be used to synchronize the distributed application procedures using the network.

Among these services, it is necessary to distinguish those which allow:

– synchronization at emission time to ensure the activation of various local tasks inside a single AP,
– synchronization at reception time to ensure the activation management of various tasks of several APs located in several devices of the control system.

This type of synchronization is used by a synchronous distributed application.

6.2.1.3.6.1.5 Synchronization variable definition.

6.2.1.3.6.1.5.1 Synchronisation model description

A synchronization variable in the MPS environment is modelled in the same manner as variables using the following objects:

– an object *Produced Variable Local Image* including all the attributes required by a synchronization variable in a producing application entity,
– an object *Consumed Variable Local Image* including all attributes required by a synchronization variable in a consuming application entity.

These two types of object correspond to special instantiations of the class *Identified variable* for which the attribute *Class* has the value SYNCHRONIZATION.

An object *Produced Variable Local Image* or *Consumed Variable Local Image* associated with a synchronization variable differs from the one associated with a normal variable since the value of some of its attributes are predetermined.

6.2.1.3.6.1.5.2 Predetermined attribute values of the *Identified variable* class

The *Identified variable* class associated with a synchronization variable is characterised by predetermined values for some of its attributes:

Class:

This attribute takes the value: *SYNCHRONIZATION*

All the other attribute values are not predetermined.

6.2.1.3.6.1.5.3 Predetermined attribute values of *Produced Variable Local Image* object

The *Produced Variable Local Image* object associated with a synchronization variable is characterised by predetermined values for some of its attributes:

Resynchronized variable:

This attribute take the value: *FALSE*

All the other attribute values are not predetermined.

6.2.1.3.6.1.5.4 Predetermined attribute values of *Consumed Variable Local Image* object

The *Consumed Variable Local Image* object associated with a synchronization variable is characterised by predetermined values for some of its attributes:

Resynchronized variable:

This attribute takes the value: *FALSE*

All the other attribute values are not predetermined.

6.2.1.3.6.1.5.5 Access to synchronization variables

The synchronization variables may be handled by a subset of services provided to the user for normal variables.

The services which provide access to synchronization variables are:

- A_WRITELOC / A_WRITEFAR / A_WRITE
- A_READLOC
- A_SENT
- A_RECEIVED
- A_UPDATE

All the others services offered to the user for a normal variable are not authorized for a synchronization variable.

6.2.1.3.6.1.5.6 Synchronization variable type

The synchronization variables may have a value of any type coming from the instantiation of the *Type constructor* class.

However, a synchronization variable used to meet the requirements of the application service element which elaborate a spatial consistency status, should contain in its value the network exchange number of the list of variables. In this case the variable has a predetermined type.

The exchange number is global data in the MPS environment, produced by a specific application entity. This exchange number qualifies the value of a variable exchanged in a periodic or aperiodic way, relative to the previous exchange.

This exchange number is accessed by the user in the same way as the value of a normal variable, and it is also used by an application service element for the elaboration of the spatial consistency status.

This predetermined type is described by the following instance of the *Type constructor* class.

A_type:	K_UNS16
Construction:	SIMPLE
Class of type:	UNSIGNED
Size:	16

6.2.1.3.6.2 Resynchronization

6.2.1.3.6.2.1 Resynchronisation mechanism principle

The resynchronization mechanism is applied to variables of NORMAL class in order to provide a sample/hold function on asynchronous produced or consumed variable values. This resynchronization mechanism requires that the network transmits synchronization orders in order to:

– trigger the sample/hold of the variables produced by the user,

– trigger the sample/hold of the variables consumed by the user.

Definition:

A resynchronization order corresponds to the synchronization order used by the resynchronization mechanism.

The resynchronization mechanism associates a second buffer with a variable at the application entity level, as shown in Figure 21. A resynchronized variable requires:

– A private buffer (TPP) exclusively accessible by the user.

– A public buffer (TPU) accessible by the network.

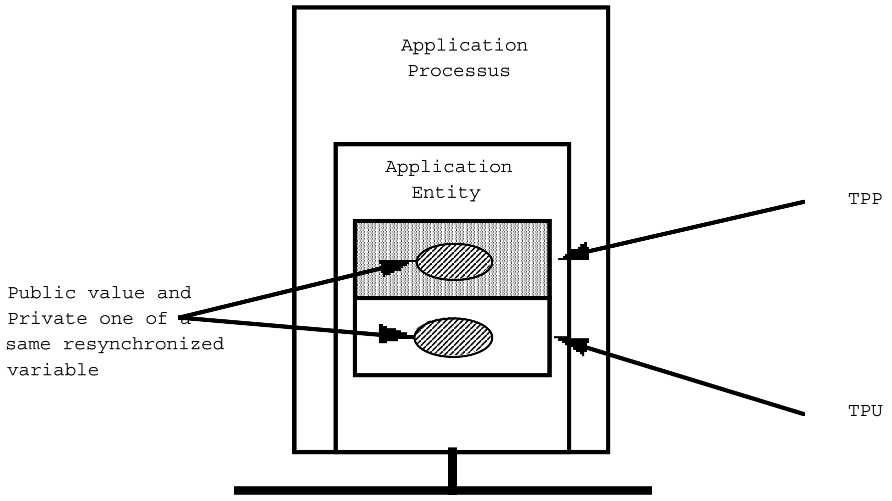

Application Processus
Application Entity
TPP
Public value and Private one of a same resynchronized variable
TPU

Figure 21 – Model of a resynchronised variable

6.2.1.3.6.2.2 Resynchronization of a produced variable

6.2.1.3.6.2.2.1 Principle

Assume an AP produces a variable in the private buffer (TPP) with a Tp production period. The availability of the value of this variable in the public buffer (TPU) is synchronized by the network by means of a resynchronization order. This synchronization order is broadcast with a period Tr.

The resynchronization mechanism in production holds the value of the produced variable during the time interval between two occurrences of the same resynchronization order.

Figure 22 shows these principles.

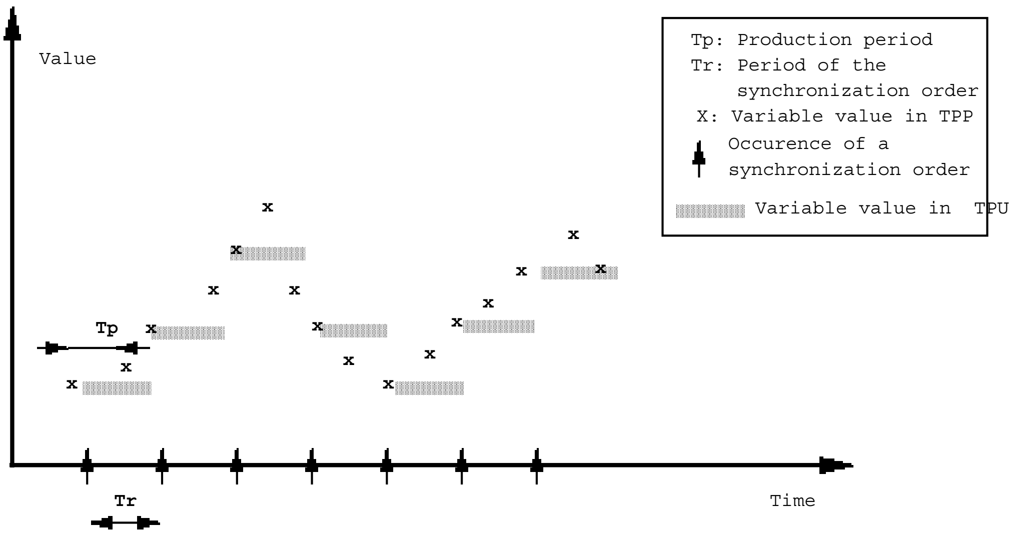


Figure 22 – Principles for resynchronisation of a produced variable

NOTE The resynchronization mechanism of a produced variable is useful only when $T_r >> T_p$.

The resynchronization service implies the use of extra resources like additional buffers for the private values associated with the public values of the resynchronized variables.

A refreshment status elaboration time out and a punctual refreshment elaboration time out are optionally associated with each public buffer of a resynchronized variable.

The resynchronization service requires the use of a private time-out associated with the private buffer in order to allow the production status to preserve their semantics when the variables are resynchronized.

The elaboration of the production validity status for a resynchronized variable at the producer entity level involves the use of two mechanisms associated with the public and private values of the resynchronized variable.

6.2.1.3.6.2.2.2 Specification of the resynchronization in production class

This class describes additional resources used to resynchronize a produced variable at the application entity level.

The class used to describe a resynchronized variable at the producing entity level inherits from the attributes of the *Resynchronization in production* class.

Class:	RESYNCHRONIZATION IN PRODUCTION	
	Attribute	: Private value
	Constraint	: Refreshment elaborated = TRUE
	Attribute	: Private Refreshment status
	Attribute	: *Inherit from* Time-out
	Constraint	: Punctual Refreshment elaborated = TRUE

Attribute	:	Private Punctual Refreshment status
Attribute	:	*Reference* Synchronization variable

Private value:

The resynchronization mechanism principle is based on data which is double_buffered. It is necessary to add a private value to the public value of the variable. The private value may now be written asynchronously.

Refreshment elaborated:

This attribute, both in the private context and in the public context, conditions the existence of a refreshment status associated with a variable.

When this attribute is TRUE, a resynchronized variable is provided with a refreshment status and a private refreshment status.

This conditional attribute is declared in the *Produced variable* class.

Private Refreshment status

This private status corresponds to internal information from the production entity of the resynchronized variable, from which is built the value of the refreshment status which will be transmitted with the public value of the variable.

The characteristic of this private status is SYNCHRONOUS or ASYNCHRONOUS according to the global declaration associated with the resynchronized variable in production which is made in the *Refreshment* class.

In the case of a synchronous private status the synchronization variable used by the private mechanism associated with this status is declared globally in the *Refreshment* class.

Inherit from Time-out:

This set of resources allows the user to maintain the semantics of the refreshment status associated with a resynchronized variable.

In fact, the use of a synchronous or asynchronous refreshment status requires the use of an extra time-out to preserve the whole semantics of this status.

Punctual Refreshment elaborated:

This attribute, both in the private context and in the public context, conditions the existence of a punctual refreshment status associated with a variable.

When this attribute is TRUE, a resynchronized variable is provided with a punctual refreshment status and a private punctual refreshment status.

This conditional attribute is declared in the *Produced variable* class.

Private Punctual Refreshment status:

This private status corresponds to internal information from the production entity of the resynchronized variable, from which is built the value of the refreshment status which will be transmitted with the public value of the variable.

In the case of a private punctual status, the synchronization variable used by the private mechanism associated with this status is globally declared in the *Punctual Refreshment* class.

***Reference* (Synchronization) variable:**

The reference to a synchronization variable indicates the resynchronization order associated with a resynchronized variable.

This resynchronization order conditions the transfer of variable values, production status values and current values of time-outs from the private domain to the public domain. This reference indicates the *A_Name* of the *Produced Variable Local Image* object.

6.2.1.3.6.2.2.3 Mechanism associated with the produced value

The resynchronization mechanism in production of the local variable value is made by the transfer from the private buffer to the public buffer, at the reception of resynchronization order.

The evaluation net of this service element which manages the resynchronization actions within a producing application entity for a resynchronized variable is shown in Figure 23.

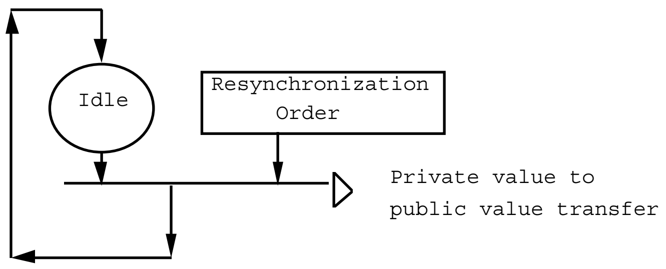


Figure 23 – Resynchronisation mechanism state machine for a produced variable

6.2.1.3.6.2.2.4 Mechanism associated with an asynchronous refreshment

The mechanism which elaborates the asynchronous refreshment status for a resynchronized variable may be described with two evaluation nets one of which describes the private asynchronous refreshment status and the other the asynchronous refreshment status associated with the public value of the variable.

Private mechanism:

The private time-out associated with refreshment is preset with the production period of the variable and set by the user with the act of writing a new private value, as shown in Figure 24 and Table 19.

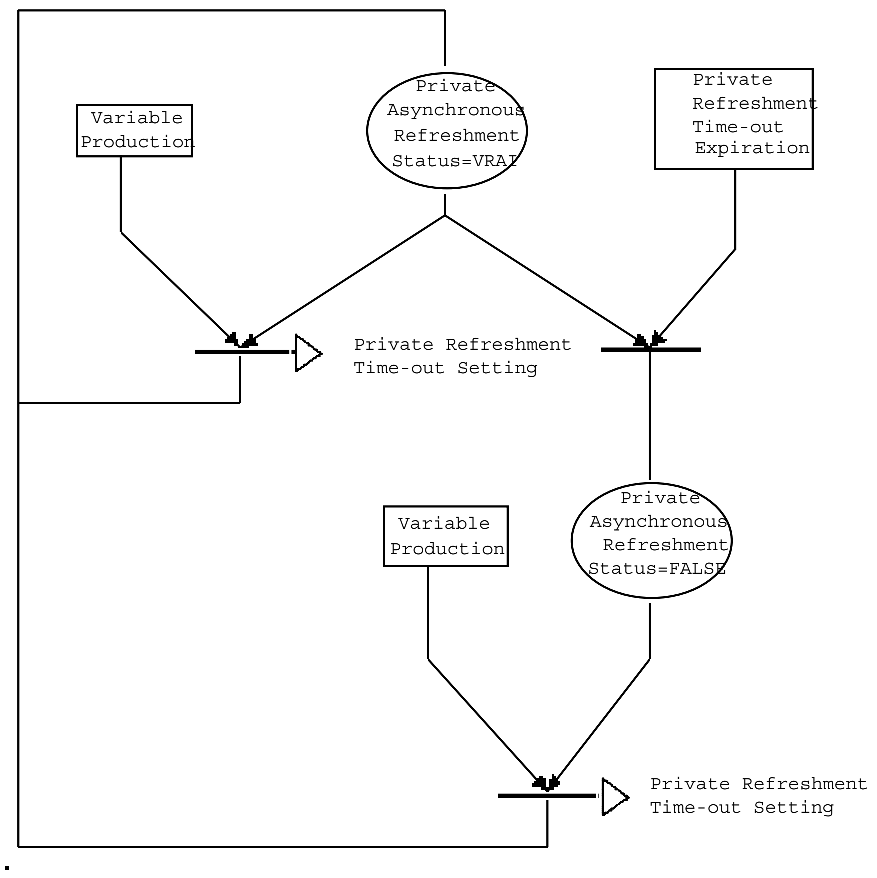

Variable Production
Private Asynchronous Refreshment Status=VRAI
Private Refreshment Time-out Expiration
Private Refreshment Time-out Setting
Variable Production
Private Asynchronous Refreshment Status=FALSE
Private Refreshment Time-out Setting

Figure 24 – Asynchronous refreshment private mechanism evaluation net

Table 19 – Asynchronous refreshment private mechanism events and actions

Initial state:	**Private asynchronous refreshment status = *FALSE***
	State of the private refreshment time-out = *IDLE*
Requests:	**<u>Variable Production</u>:**
	Invocation of the services A_WRITELOC, A_WRITEFAR or A_WRITE by the user
	<u>Private Refreshment Time-out Expiration</u>:
	Switch of the private time-out associated with the private asynchronous refreshment status from the *RUNNING* state to the *IDLE* state.
Action:	**<u>Private Refreshment Time-out Setting</u>**
	Switch of the private time-out associated with the private asynchronous status from the *IDLE* state to the *RUNNING* state, with the preset value equal to the Production *period* attribute value.

Public mechanism:

The public time-out is preset with the current value of the private time-out and set on the resynchronization order associated with this status.

The public mechanism to elaborate the asynchronous refreshment status of a resynchronized variable is represented by the following evaluation net, shown in Figure 25 and Table 20.

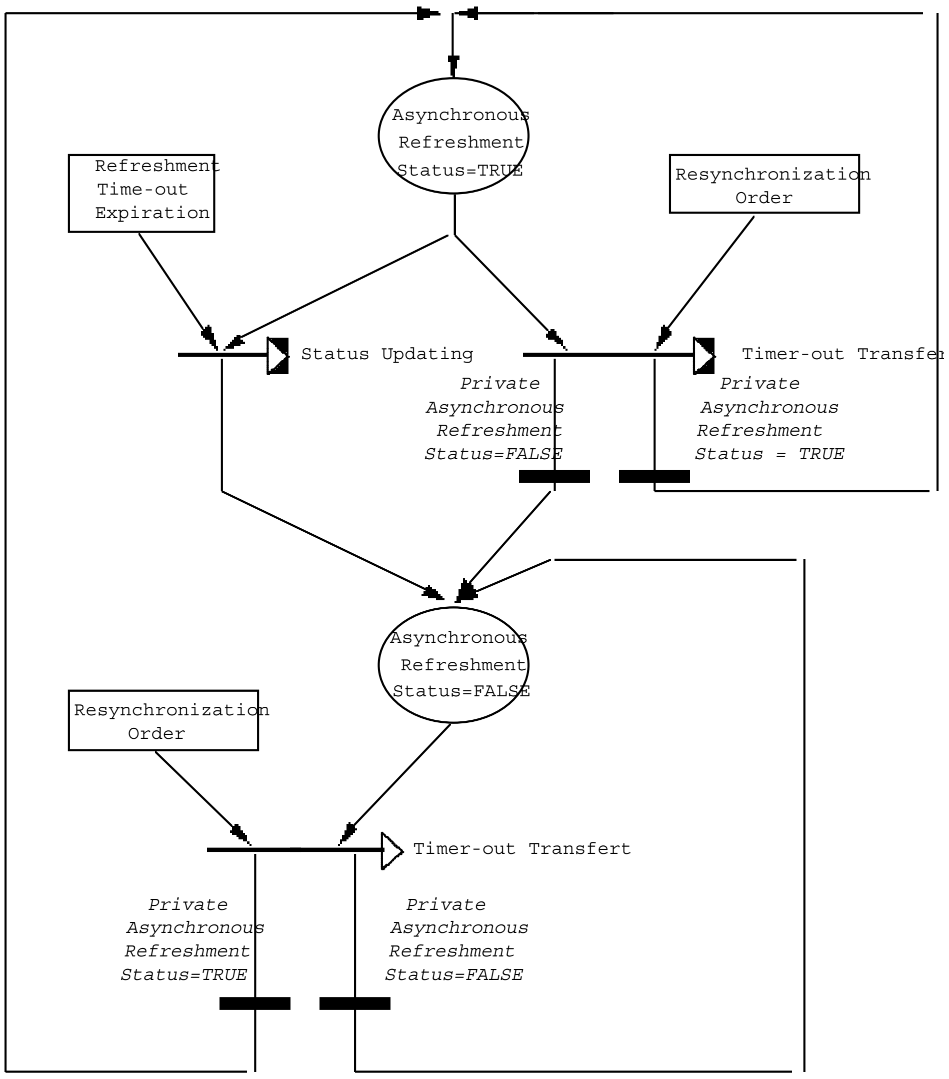

Asynchronous Refreshment Status=TRUE
Refreshment Time-out Expiration
Resynchronization Order
Status Updating
Timer-out Transfer
Private Asynchronous Refreshment Status=FALSE
Private Asynchronous Refreshment Status = TRUE
Asynchronous Refreshment Status=FALSE
Resynchronization Order
Timer-out Transfert
Private Asynchronous Refreshment Status=TRUE
Private Asynchronous Refreshment Status=FALSE

Figure 25 – Asynchronous refreshment public mechanism evaluation net

Table 20 – Asynchronous refreshment public mechanism events and actions

Initial state:	**Asynchronous refreshment status = *FALSE***
	State of the refreshment time-out = *IDLE*
Request:	**Refreshment Time-out Expiration:**
	Evolution of the public time-out associated with the asynchronous refreshment status from the *RUNNING* state to the *IDLE* state.
	Resynchronization Order
	Occurrence of the asynchronization order associated with the public resynchronization mechanism.
Action:	**Time-outs Transfer**
	Transfer in the *State* attribute value and *Current attribute value* of the private time-out of the private asynchronous refreshment status, of the attributes *State* and *Preset* belonging to the public time-out associated with the asynchronous refreshment status.

6.2.1.3.6.2.2.5 Mechanism associated with the synchronous refreshment

The mechanism which elaborates the synchronous refreshment status for a resynchronizes variable may be described with two evaluation nets which one describes the private synchronous refreshment status and the other the synchronous refreshment status associated with the public value of the variable.

Private mechanism:

The private time-out associated with the refreshment is preset with the production period of the variable and set at the receiving time of a new synchronization order associated with this status, as shown in Figure 26 and Table 21.

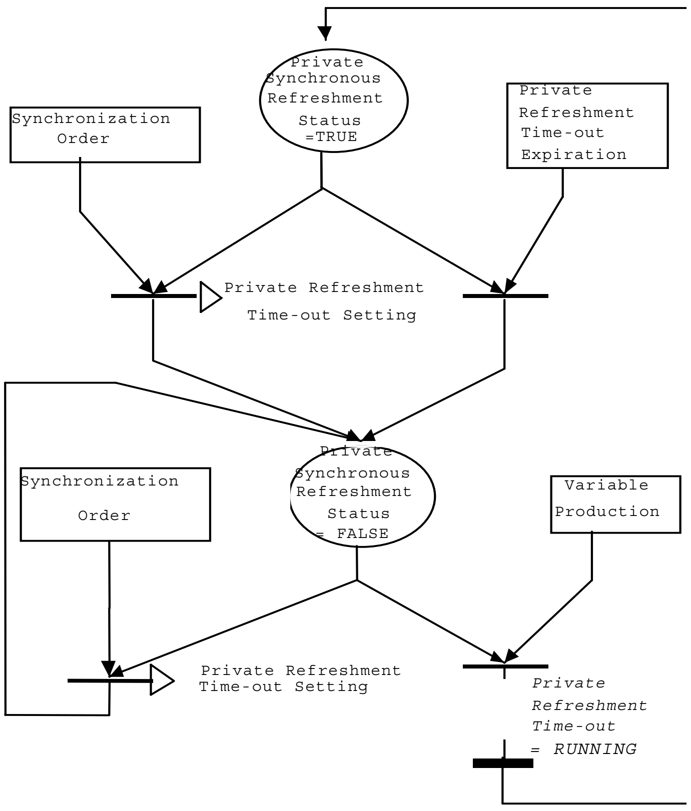

Private Synchronous Refreshment Status =TRUE
Synchronization Order
Private Refreshment Time-out Expiration
Private Refreshment Time-out Setting
Private Synchronous Refreshment Status = FALSE
Synchronization Order
Variable Production
Private Refreshment Time-out Setting
Private Refreshment Time-out = RUNNING

Figure 26 – Synchronous refreshment private mechanism evaluation net

Table 21 – Synchronous refreshment private mechanism events and actions

Initial state:	**Private synchronous refreshment status = FALSE**
	State of the private refreshment time-out = IDLE
Requests:	**Variable Production:**
	Invocation of the services A_WRITELOC, A_WRITEFAR or A_WRITE by the user
	Private Refreshment Time-out Expiration:
	Switch of the private time-out associated with the private synchronous status from the RUNNING state to the IDLE state.
	Synchronisation Order:
	Occurrence of a synchronization order associated with the public and private synchronous refreshment status.
Action:	**Private Refreshment Time-out Setting**
	Switch of the private time-out associated with the private asynchronous status from the *OUT* state to the *SET* state, with the preset value equal to the Production *period* attribute value.

Public mechanism:

The time-out associated with the public mechanism is preset with the current value of the private time-out and set on the occurrence of the resynchronization order.

The public mechanism to elaborate the synchronous refreshment status of a resynchronized variable is represented by the following evaluation net, shown in Figure 27 and Table 22.

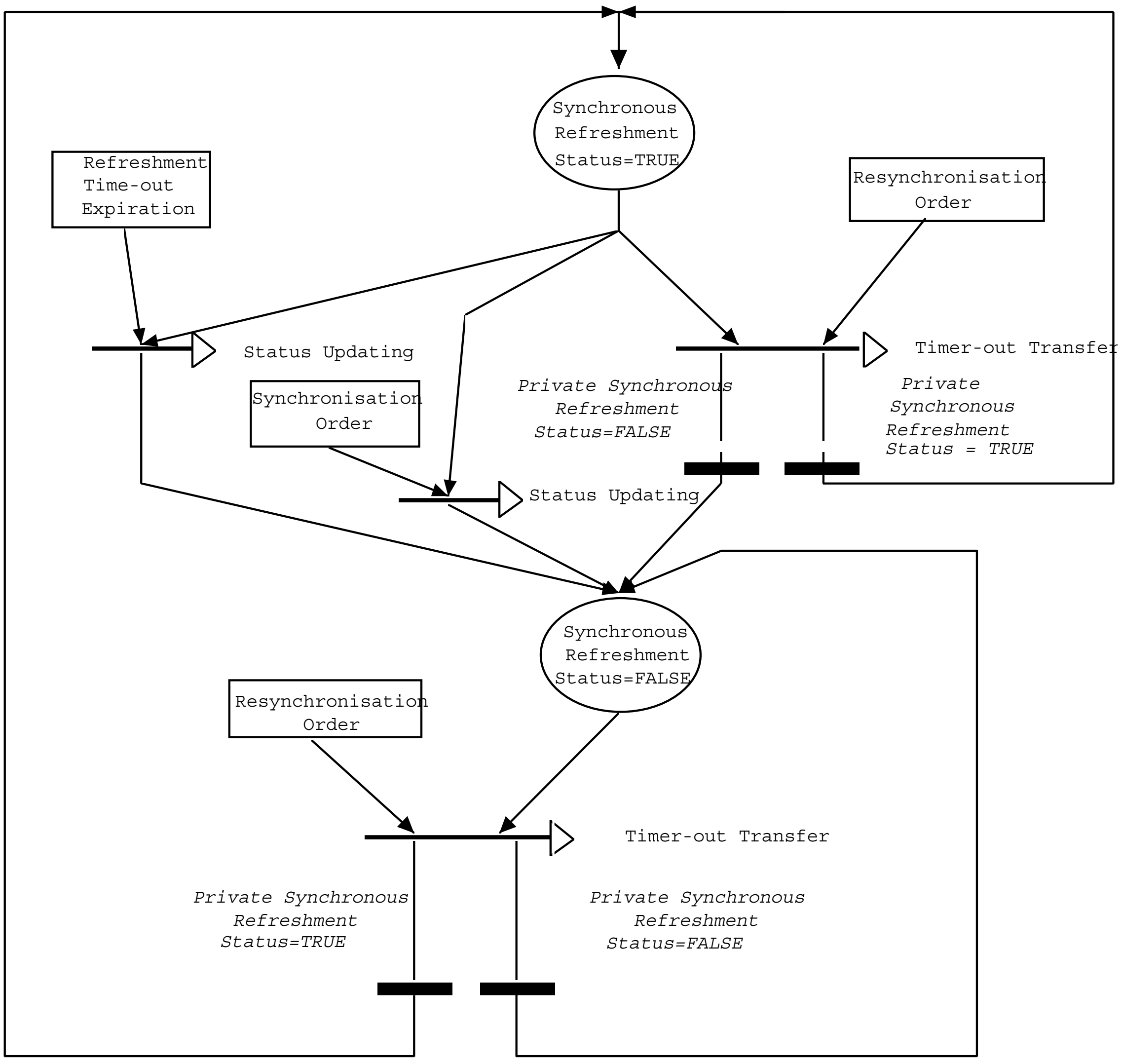

Synchronous Refreshment Status=TRUE
Refreshment Time-out Expiration
Resynchronisation Order
Status Updating
Timer-out Transfer
Private Synchronous Refreshment Status=FALSE
Private Synchronous Refreshment Status = TRUE
Synchronisation Order
Status Updating
Synchronous Refreshment Status=FALSE
Resynchronisation Order
Timer-out Transfer
Private Synchronous Refreshment Status=TRUE
Private Synchronous Refreshment Status=FALSE

Figure 27 – Synchronous refreshment public mechanism evaluation net

Table 22 – Synchronous refreshment public mechanism events and actions

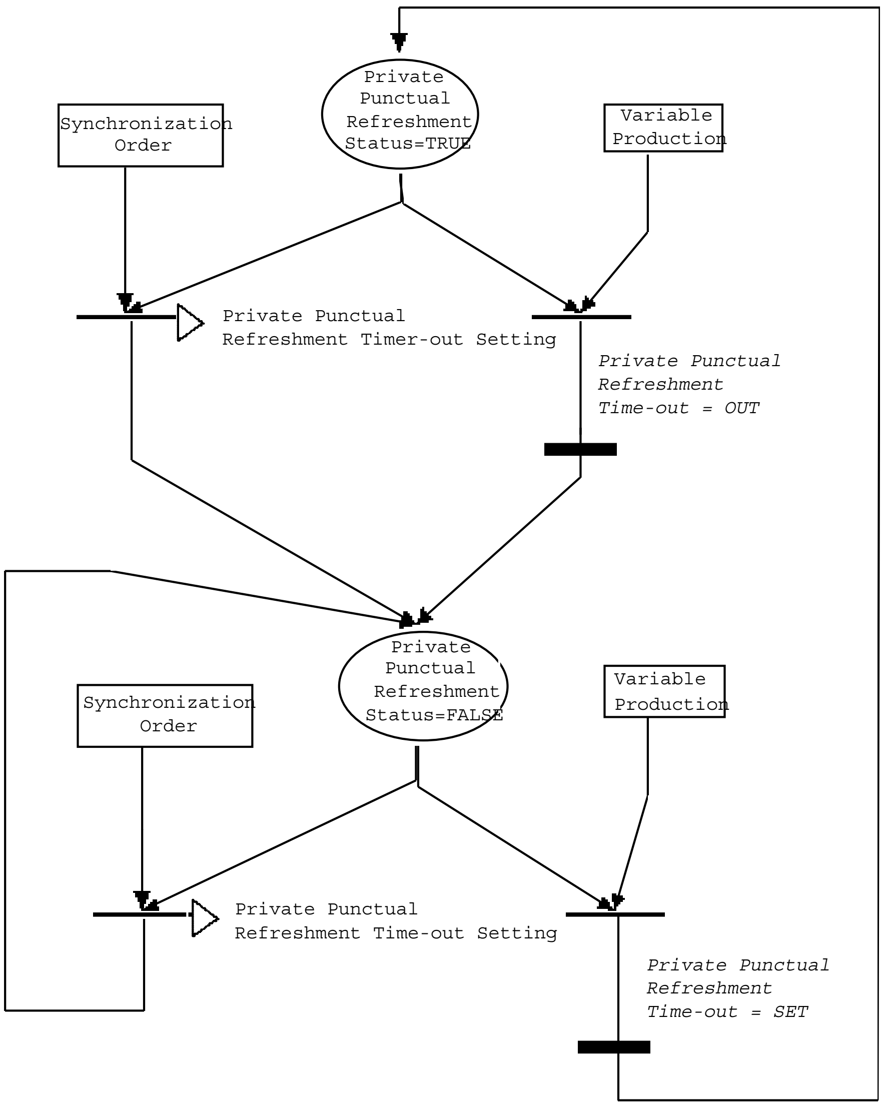
Initial state:	**Synchronous refreshment status = FALSE**
	State of the refreshment time-out = IDLE
Requests:	**Refreshment Time-out Expiration:**
	Switch of the public time-out associated with the synchronous refreshment status from the RUNNING state to the IDLE state.
	Resynchronization Order:
	Occurrence of the synchronization order associated with the public resynchronisation mechanism.
	Synchronization Order:
	Occurrence of the synchronisation order associated with the refreshment status and to the private synchronous refreshment state.
Action:	**Time-outs Transfer:**
	Transfer in the *State* attribute value and *Current* attribute value of the private time-out of the private asynchronous refreshment status , of the attributes State and Preset belonging to the public time-out associated with the refreshment status.

6.2.1.3.6.2.2.6 Mechanism associated with the punctual refreshment

The mechanism which elaborates the punctual refreshment for a resynchronized variable may be described with two evaluation nets one of which describes the private punctual refreshment status associated with the private variable value, and the other the punctual refreshment status associated with the public variable value.

Private mechanism:

The private time-out associated with the punctual refreshment is preset with the production time slot of the variable and set at the occurrence of the synchronization order associated with this status, as shown in Figure 28 and Table 23



Private Punctual Refreshment Status=TRUE
Synchronization Order
Variable Production
Private Punctual Refreshment Timer-out Setting
Private Punctual Refreshment Time-out = OUT
Private Punctual Refreshment Status=FALSE
Synchronization Order
Variable Production
Private Punctual Refreshment Time-out Setting
Private Punctual Refreshment Time-out = SET

Figure 28 – Punctual refreshment private mechanism evaluation net

Table 23 – Punctual refreshment private mechanism events and actions

Initial state:	**Private punctual refreshment status = FALSE**
	State of the private punctual refreshment time-out = IDLE
Requests	**<u>Variable Production</u>:**
	Invocation of services A_WRITELOC, A_WRITEFAR or A_WRITE by the user
	<u>Synchronization Order</u>:
	Occurrence of the synchronization order associated with the punctual refreshment status and to the private punctual refreshment.
Action:	**<u>Private Punctual Refreshment Time-out Setting</u>**
	Switch of the private time-out associated with the private punctual refreshment status from the IDLE state to the RUNNING state, with the preset value equal to the *Production time slot* as attribue value.

Public mechanism:

The public mechanism which elaborates the punctual refreshment status of a resynchronized variable is represented by the following evaluation net, shown in Figure 29 and Table 24.

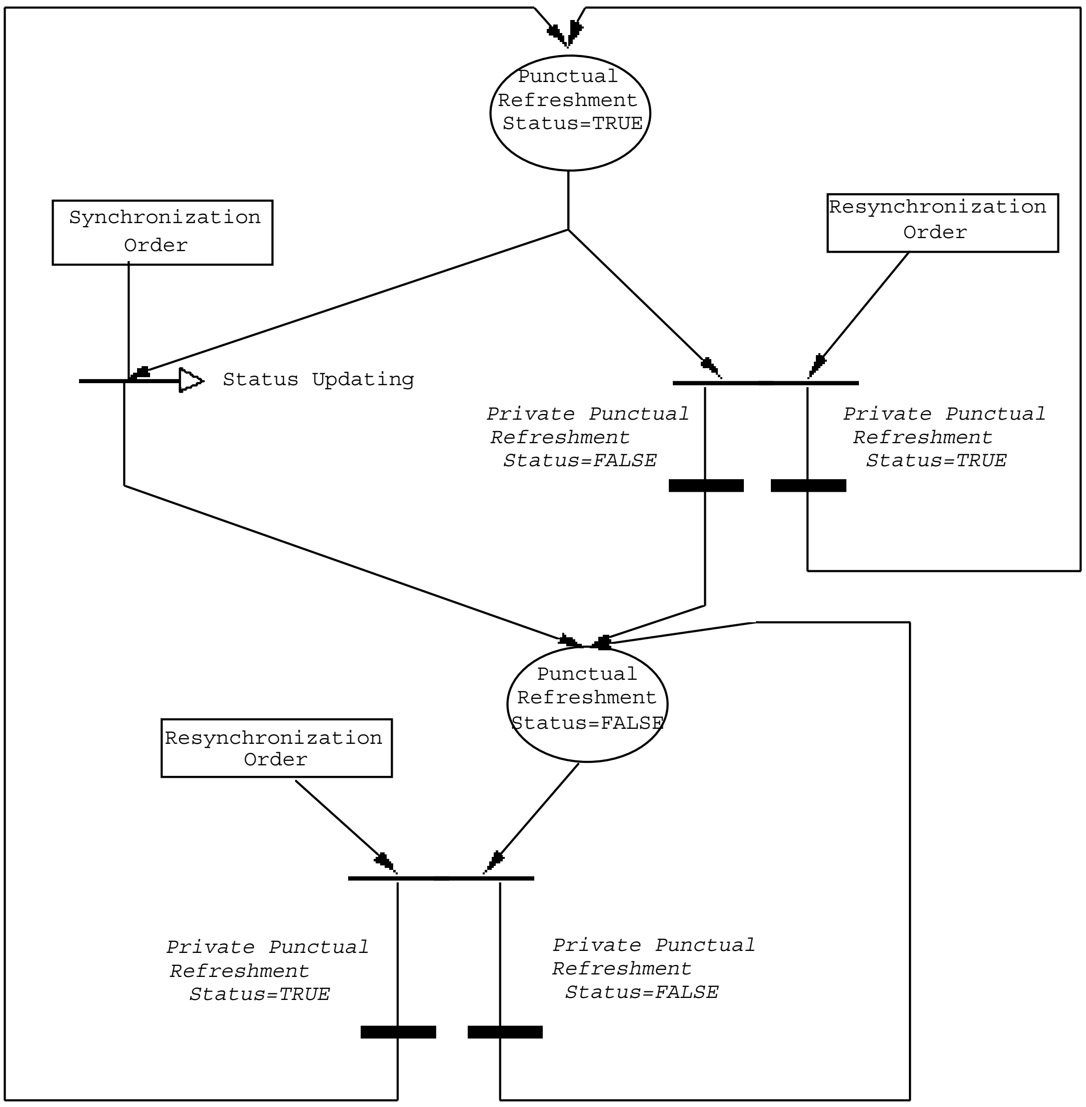

Punctual Refreshment Status=TRUE
Synchronization Order
Resynchronization Order
Status Updating
Private Punctual Refreshment Status=FALSE
Private Punctual Refreshment Status=TRUE
Punctual Refreshment Status=FALSE
Resynchronization Order
Private Punctual Refreshment Status=TRUE
Private Punctual Refreshment Status=FALSE

Figure 29 – Punctual refreshment public mechanism evaluation net

Table 24 – Punctual refreshment public mechanism events and actions

Initial state	**Punctual refreshment status = FALSE**
Requests:	**<u>Resynchronization Order</u>**
	Occurrence of the synchronization order associated with the public resynchronization mechanism.
	<u>Synchronization Order</u>:
	Occurrence of synchronization order associated with the punctual refreshment status and to the private punctual refreshment status.

The elaboration of synchronous refreshment status and punctual refreshment status requires specific precautions with regard to the respective choice of the synchronization variables associated with synchronous status and those associated with the resynchronization.

NOTE The specific choice consisting in using the same synchronization variable results in status that will be FALSE whenever the user performs a write.

The choice of two distinct synchronization variables, which transmission on the bus is separated by a time interval smaller than the production periods or the production time slots, may lead to status FALSE if the resynchronization order arrival time precedes the user writing time.

6.2.1.3.6.2.3 Resynchronization of a consumed variable

6.2.1.3.6.2.3.1 Principle

If the network provides a variable value in the public buffer (TPU) with a Tr transmission period, and at the same time an AP consumes this value in the private buffer (TPP), then the transfer of the variable value from the public buffer to the private buffer is performed on the reception of a resynchronization order with a Tc period.

The consumer resynchronization mechanism holds in the private buffer the same value of the consumed variable during the time interval between two occurrences of the same resynchronization order. Figure 30 shows these principles.

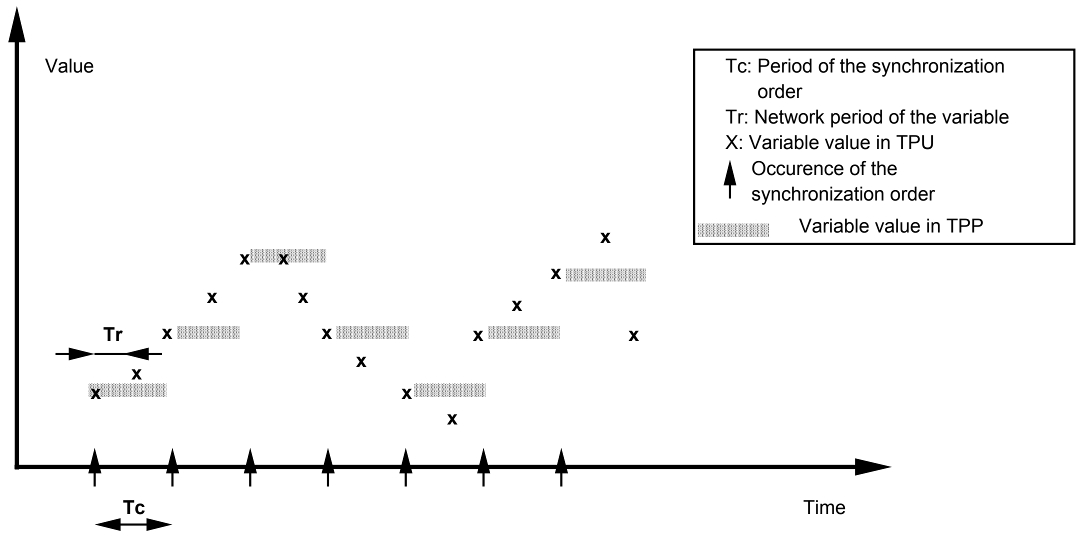

Value
Tc: Period of the synchronization order
Tr: Network period of the variable
X: Variable value in TPU
Occurence of the synchronization order
Variable value in TPP
Tr
Tc
Time

Figure 30 – Principles for the resynchronisation of a consumed variable

NOTE The resynchronization mechanism of a consumed variable is useful only when $T_r << T_c$

The resynchronization service implies the use of extra resources like additional buffers for private values associated with the public values of the resynchronized variables.

With each public buffer of a resynchronized variable a time-out of promptness status elaboration time-out, and punctual promptness elaboration time-out, are optionally associated.

The resynchronization service requires the use of a private time-out associated with the private buffer in order to allow the transmission status to preserve their semantics when the variables are resynchronized.

The elaboration of the transmission validity status for a resynchronized variable at the consumer entity level involves the use of two mechanisms associated respectively with the public and private values of the resynchronized variable.

6.2.1.3.6.2.3.2 Specification of the resynchronization in consumption class

This class describes additional resources used to resynchronize a consumed variable at an application entity level.

The class used to describe a resynchronized variable within consuming entity inherits from attributes of the *Resynchronization in consumption* class.

Class: RESYNCHRONIZATION IN CONSUMPTION

Attribute	:	Private value
Constraint	:	Promptness elaborated = TRUE
Attribute	:	Private Promptness status
Attribute	:	*Inherit from* Time-out
Constraint	:	Punctual Promptness elaborated = TRUE
Attribute	:	Private Punctual Promptness status
Attribute	:	*Reference* Synchronization variable

Private value:

The resynchronization principle is based on data which is double buffered. It is necessary to add a private value to the public value of the variable. The private value may now be read asynchronously.

Promptness elaborated:

This attribute, both in the private context and in the public context, conditions the existence of a promptness status associated with a variable.

When this attribute is TRUE a resynchronized variable has the use of a promptness status and a private promptness status.

This conditional attribute is declared in the *Consumed variable* class.

Private promptness status

This private status corresponds to internal information from the consuming entity of the resynchronized variable, from which is built the value of the promptness status.

The characteristic of this status is SYNCHRONOUS or ASYNCHRONOUS according to the global declaration associated with resynchronized variable in consumption which is made in the *Promptness* class.

In the case of a private synchronous status the synchronization variable used by the private mechanism associated with this status is declared globally in the *Promptness* class.

Inherit from Time-out:

This set of resources allows the user to maintain the semantics of the promptness status associated with a resynchronized variable.

In fact, the use of a synchronous or asynchronous promptness status requires the use of an extra time-out to preserve the whole semantics of this status.

Punctual Promptness elaborated

This attribute conditions globally in the private context and in the public context the existence of a punctual promptness status associated with a variable.

When this attribute is TRUE, a resynchronized variable has the use of a punctual promptness status and a private punctual promptness status.

This conditional attribute is declared in the *Consumed variable* class.

Private Punctual Promptness status

This private status corresponds to internal information from the consuming entity of the resynchronized variable, from which is built the value of the punctual promptness status.

In the case of a private punctual status the synchronization variable used by the private mechanism associated with this status is declared globally in *Punctual Promptness* class

***Reference* (Synchronization) variable:**

The reference to synchronization variable indicates the resynchronization order associated with a resynchronized variable.

This resynchronization order conditions the transfer of variable values, transmission statuses and current values of time-outs from the private domain to the public domain. This reference indicates the *A_Name* of the *Consumed Variable Local Image* object.

6.2.1.3.6.2.3.3 Mechanism associated with the consumed value

The resynchronization mechanism in consumption of the local variable value is the transfer from the private buffer to the public buffer, on the resynchronization order.

The evaluation net of this service element which manages the resynchronization actions within a consuming application entity for a resynchronized variable is shown in Figure 31.

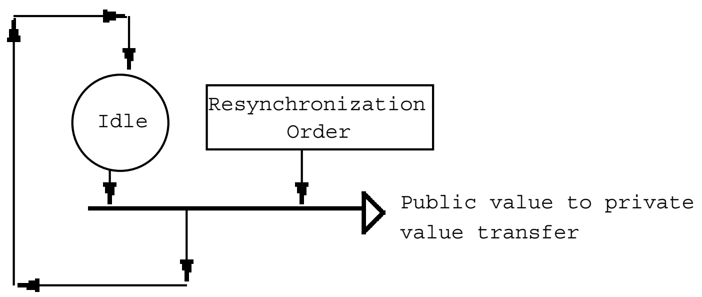


Figure 31 – Resynchronisation mechanism state machine for consumed variable

6.2.1.3.6.2.3.4 Mechanism associated with asynchronous promptness

The mechanism which elaborates the asynchronous promptness status for a resynchronized variable may be described with two evaluation nets one of which describes the private asynchronous promptness and the other the asynchronous promptness status associated with the public value of the variable.

Public mechanism:

The public time-out associated with the promptness is preset with the consumption period of the variable and set at the receiving time of a new public variable value, as shown in Figure 32 and Table 25.

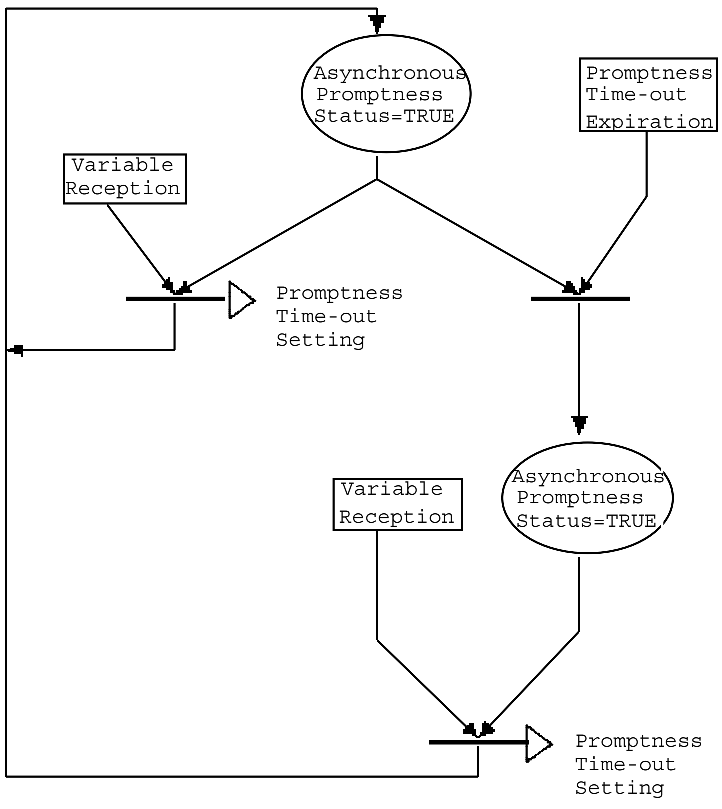

Asynchronous Promptness Status=TRUE
Promptness Time-out Expiration
Variable Reception
Promptness Time-out Setting
Variable Reception
Asynchronous Promptness Status=TRUE
Promptness Time-out Setting

Figure 32 – Asynchronous promptness public mechanism evaluation net

Table 25 – Asynchronous promptness public mechanism events and actions

Initial state:	**Asynchronous promptness status = IDLE**
	State of the promptness time-out = OUT
Requests:	**<u>Variable Reception</u>:**
	Updating of the variable value by the network
	<u>Promptness Time-out Expiration</u>:
	Switch of the public time-out associated with the public asynchronous promptness status from the RUNNING to the IDLE state.
Actions:	**<u>Promptness Time-out Setting</u>:**
	Switch of the public time-out associated with the public asynchronous status from IDLE state to RUNNING state, with the preset value equal to the *Consumption period* attribute value.

Private mechanism:

The private time-out is preset with the current value of the public time-out and set on the resynchronization order associated with this status.

The mechanism to elaborate the asynchronous private promptness status of a resynchronized variable is represented by the following evaluation net, shown in Figure 33 and Table 26.

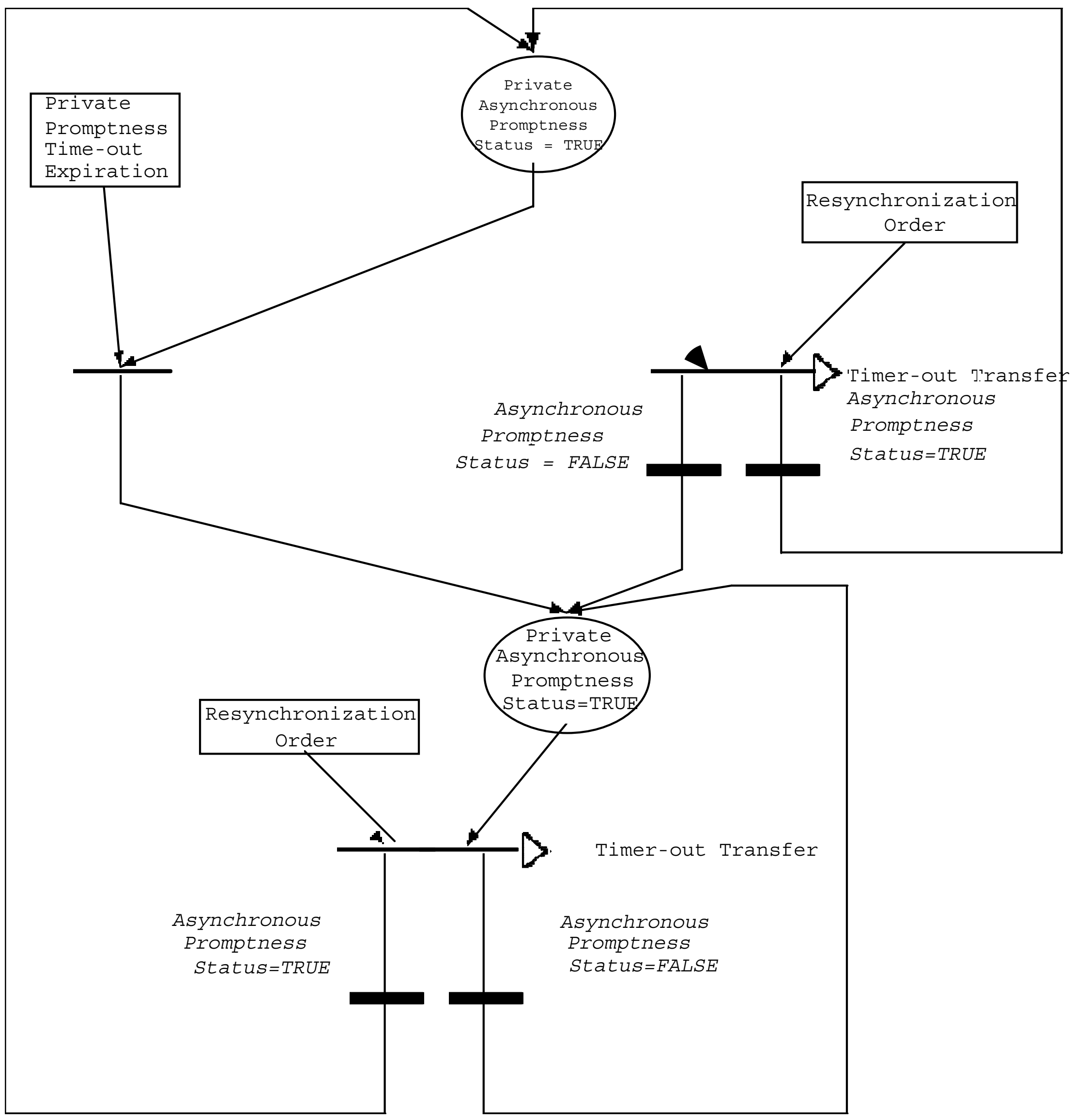

Private Asynchronous Promptness Status = TRUE
Private Promptness Time-out Expiration
Resynchronization Order
Timer-out Transfer
Asynchronous Promptness Status = FALSE
Asynchronous Promptness Status=TRUE
Private Asynchronous Promptness Status=TRUE
Resynchronization Order
Timer-out Transfer
Asynchronous Promptness Status=TRUE
Asynchronous Promptness Status=FALSE

Figure 33 – Asynchronous promptness private mechanism evaluation net

Table 26 – Asynchronous promptness private mechanism events and actions

Initial state:	**Private asynchronous promptness status = FALSE**
	State of the private promptness time-out = IDLE
Requests:	**Private Promptness Time-out Expiration**
	Switch of the private time-out associated with the private asynchronous promptness status from the RUNNING state to the IDLE state.
	Resynchronization Order
	Occurrence of a synchronization order associated with the resynchronization mechanism.
Action:	**Time-outs Transfer**
	Transfer in the State attribute value and Current attribute value of the public time-out of the public asynchronous promptness status, of the attributes State and Preset belonging the private time-out associated with the asynchronous promptness status.

6.2.1.3.6.2.3.5 Mechanism associated with synchronous promptness

The mechanism which elaborates the synchronous promptness status for a resynchronized variable may be described with two evaluation nets one of which describes the private synchronous promptness status and the other the synchronous promptness status associated with the public value of the variable.

Public mechanism:

The public time-out associated with the promptness is preset with the consumption period of the variable and set at the receiving time of a new synchronization order, as shown in Figure 34 and Table 27.

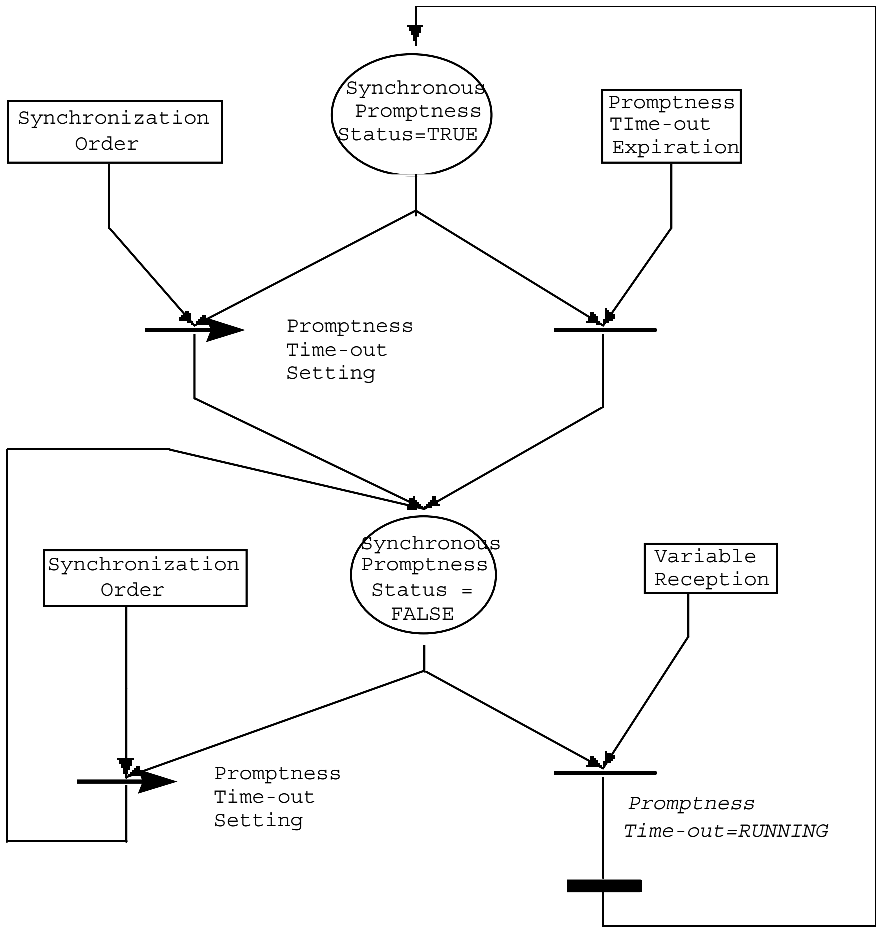

Synchronization Order
Synchronous Promptness Status=TRUE
Promptness TIme-out Expiration
Promptness Time-out Setting
Synchronization Order
Synchronous Promptness Status = FALSE
Variable Reception
Promptness Time-out Setting
Promptness Time-out=RUNNING

Figure 34 – Synchronous promptness public mechanism evaluation net

Table 27 – Synchronous promptness public mechanism events and actions

Initial state:	**Synchronous promptness status = FALSE**
	State of the promptness time-out = IDLE
Requests:	**Variable Reception:**
	Updating of the variable value by the network
	Synchronization Order:
	Occurrence of a synchronization order associated with the promptness status and to the private synchronous promptness status.
	Promptness Time-out Expiration:
	Switch of the public time-out associated with the synchronous promptness status from the RUNNING state to the IDLE state.
Action:	**Promptness Time-out Setting:**
	Switch of the public time-out associated with the public synchronous status from IDLE state to the RUNNING state with the preset value equal to the Consumption period attribute value.

Private mechanism:

The private time-out is preset with the current value of the public time-out and set on the Occurrence of the resynchronization order.

The private mechanism to elaborate the synchronous promptness status of a resynchronized variable is represented by the following evaluation net, shown in Figure 35 and Table 28.

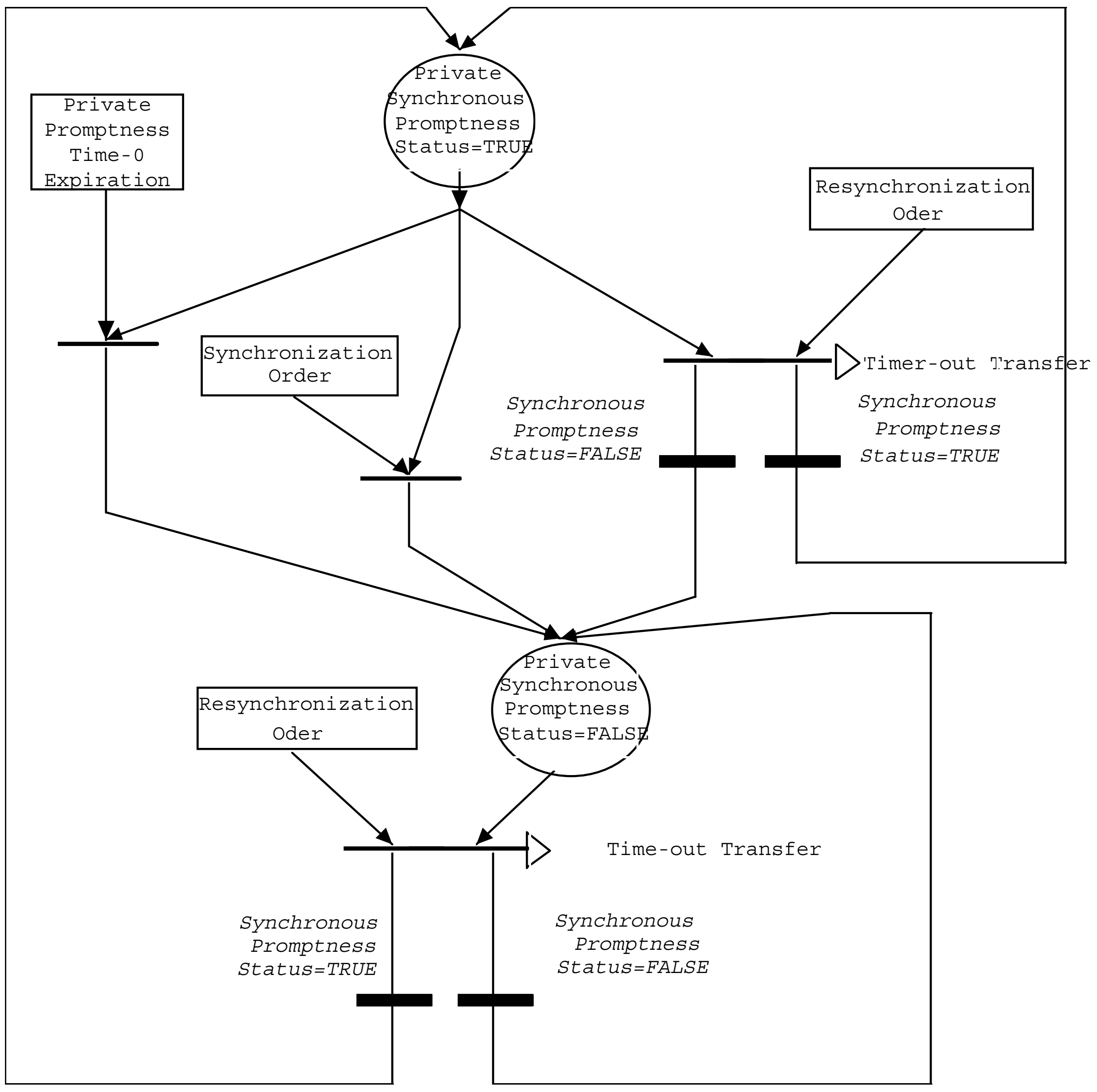

Private Synchronous Promptness Status=TRUE
Private Promptness Time-0 Expiration
Resynchronization Oder
Synchronization Order
Timer-out Transfer
Synchronous Promptness Status=FALSE
Synchronous Promptness Status=TRUE
Private Synchronous Promptness Status=FALSE
Resynchronization Oder
Time-out Transfer
Synchronous Promptness Status=TRUE
Synchronous Promptness Status=FALSE

Figure 35 – Synchronous promptness private mechanism evaluation net

Table 28 – Synchronous promptness privatemechanism events and actions

Initial state:	**Private synchronous promptness status = FALSE**
	State of the private promptness time-out = IDLE.
Requests:	**Private Promptness Time-out Expiration**
	Switch of the private time-out associated with the synchronous promptness from the RUNNING state to the IDLE state.
	Resynchronization Order
	Occurrence of a synchronization order associated with the resynchronization mechanism
	Synchronization Order
	Occurrence of a synchronization order associated with the promptness status and with the private synchronous promptness
Action:	**Time-outs Transfer:**
	Assignation of the attributes value State and Current value of the public synchronous promptness status, to the attributes State and Preset of the private timer associated with the synchronous promptness status.

6.2.1.3.6.2.3.6 Mechanism associated with the punctual promptness

The mechanism which elaborates the punctual promptness for a resynchronized variable may be described with two evaluation nets which one described the private punctual promptness status associated with the private value, and the other the punctual promptness status associated with the public variable value.

Public mechanism:

The public time-out associated with the punctual promptness is preset with the consumption time slot of the variable and set at the occurrence of the synchronization order associated with this status, as shown in Figure 36 and Table 29.

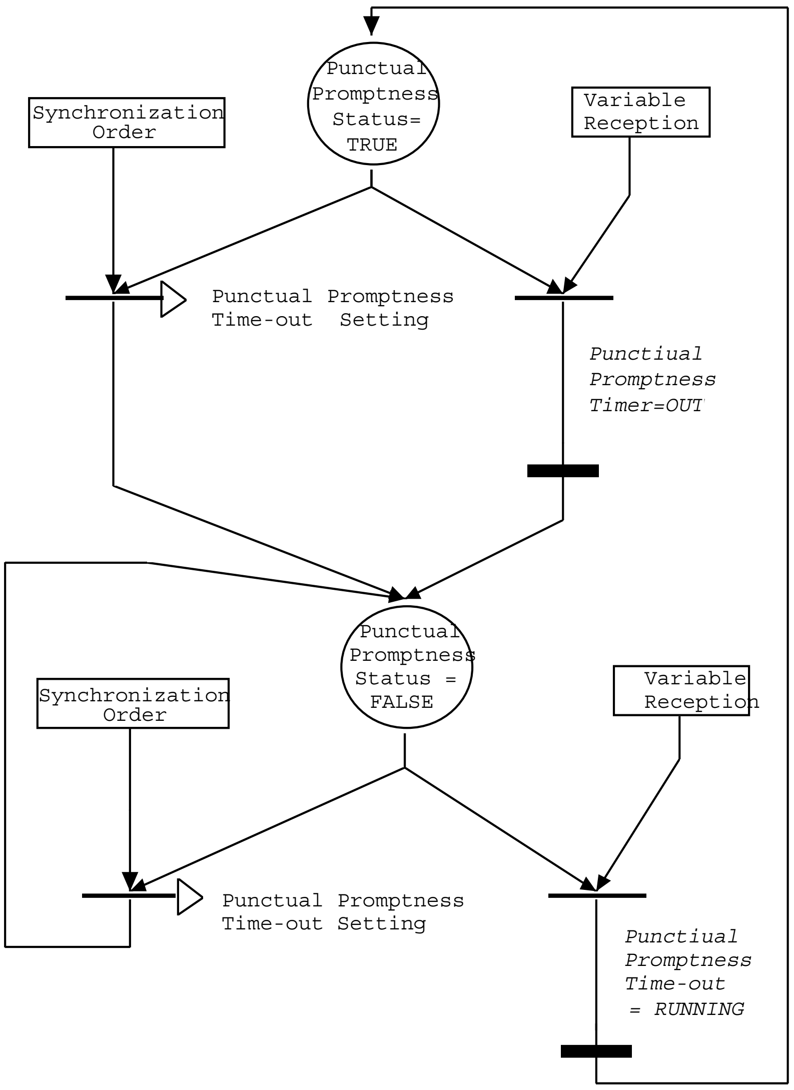

Punctual Promptness Status= TRUE
Synchronization Order
Variable Reception
Punctual Promptness Time-out Setting
Punctiual Promptness Timer=OUT
Punctual Promptness Status = FALSE
Synchronization Order
Variable Reception
Punctual Promptness Time-out Setting
Punctiual Promptness Time-out = RUNNING

Figure 36 – Punctual promptness public mechanism evaluation net

Table 29 – Punctual promptness public mechanism events and actions

Initial state	**Punctual promptness status = FALSE**
	State of the promptness time-out = OUT
Requests:	**<u>Variable Reception</u>:**
	Updating of the variable value by the network.
	<u>Synchronization Order</u>:
	Occurrence of a synchronization order associated with the punctual promptness status and to the private punctual promptness status.
Action:	**<u>Punctual Promptness Time-out Setting</u>**
	Switch of the public time-out associated with the public punctual promptness status from the IDLE state to the RUNNING state, with the preset value equal to the *Consumption time slot* attribute value.

Private mechanism:

The private mechanism which elaborates the punctual promptness status of resynchronized variable is represented by the following evaluation net, shown in Figure 37 and Table 30.

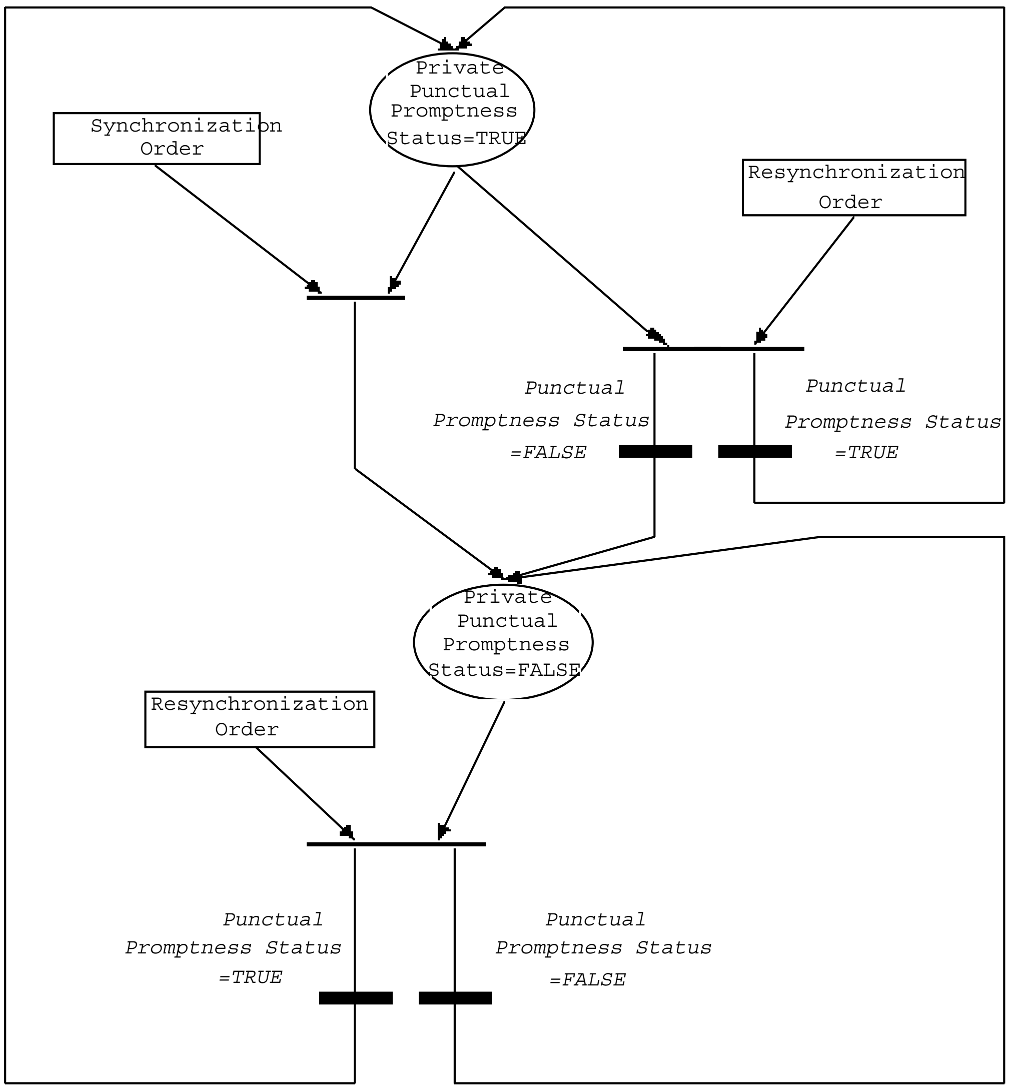

Private Punctual Promptness Status=TRUE
Synchronization Order
Resynchronization Order
Punctual Promptness Status =FALSE
Punctual Promptness Status =TRUE
Private Punctual Promptness Status=FALSE
Resynchronization Order
Punctual Promptness Status =TRUE
Punctual Promptness Status =FALSE

Figure 37 – Punctual promptness private mechanism evaluation net

Table 30 – Punctual promptness privatemechanism events and actions

Initial state	**Private punctual promptness status = FALSE**
Requests	**Resynchronization Order**: Occurrence of asynchronization order associated with the resynchronization mechanism. **Synchronization Order**: Occurrence of the synchronization order associated with the punctual promptness status and to the private punctual promptness status.

The elaboration of a synchronous promptness and a punctual promptness status requires specific precautions for respective choices of the synchronization variables associated with synchronous status and those associated with the resynchronization.

NOTE The specific choice consisting in using the same synchronization variable results in status that will be FALSE whatever the time of the network updating.

The choice of two distinct synchronization variables, for which transmission on the bus is separated by a time interval smaller than the consumption period or the consumption time slot, may lead to status FALSE if the time of the arrival of the resynchronization order precedes the updating time by the network.

6.2.1.4 Variable lists access sub-ASE

6.2.1.4.1 Concepts

6.2.1.4.1.1 List definition

The application layer supports definition and handling of variable lists.

A list is an ordered set of variables of NORMAL class. A variable list cannot include variables of SYNCHRONIZATION or DESCRIPTION classes.

A variable list is globally defined and instantiated at the application entity level. It is composed exclusively of consumed variables.

Several lists can be defined within a single system, but they should all be separated two by two:

$$\forall_{i,j} \ \mathbf{list_i} \cap \mathbf{list_j} = \varnothing$$

However ; several instances of a same list can be defined, within a system, because_several APs can be consumers of the same list.

A variable list defined in this way can only be handled by an appropriate read service permitting global access to the whole list. However, all the variables belonging to a list can also be handled individually by the variable read services.

NOTE There is no support for the concept of a recursive list at the level of the application services provided to the user. (Therefore, there is no list of list.)

The variables declared by the user as belonging to a variable list cannot be grouped together into an structure, because it is necessary for them to be optimisation provided with individual validity information.

Most of the variable lists implemented in the MPS environment are composed of periodic variables having the same period, but lists of non periodic variables are also envisaged.

6.2.1.4.1.2 Status associated with a list

At the time of a list read, the user can get additional information relative to the variable consistency of this list. These status are elaborated or not according to the configuration associated to the list. They inform the user about the integrity of all the variables composing the list.

These status are returned by the list access service.

In the MPS environment the various status associated with the variable lists inform the user regarding:

• the TRANSMISSION CONSISTENCY of the list

• the PRODUCTION CONSISTENCY of the list

• the PUNCTUAL TRANSMISSION CONSISTENCY of the list

• the PUNCTUAL PRODUCTION CONSISTENCY of the list

• the SPATIAL CONSISTENCY of the list

All these status associated with a list by a user are elaborated using:

- information local to a consuming AE, and relative to the transmission validity of the variables of the list,

- information elaborated by the remote producers of the variables of the list, and relative to their production validity.

The information relative to the transmission validity, involved in the elaboration of the consistency status for each of the list variables is

- the asynchronous or synchronous promptness,
- the punctual promptness

The information relative to the production validity involved in the elaboration of the consistency status for each of the list variables is

- the asynchronous or synchronous refreshment,
- the punctual refreshment.

NOTE the production validity information elaborated within the producing entities of the list variables is carried on the network with the values of the variables.

6.2.1.4.1.3 Control elements and reliability

The reliability of transmission of the variables of a list can be enhanced by using a recovery mechanism ; This mechanism performs a retransmission request for a number of times limited to a maximum defined for each of the instances of this list.

The evaluation of the spatial consistency status is locally derived from a purely logical function based on the consistency variable values.

The concept of spatial consistency is based on:

- The existence of a consistency variable produced by every subscriber consuming a local image of the list, as well as on the existence of an interchange mechanism of these consistency variables between the different subscribers.
- The existence of a local mechanism of value management of the produced consistency variable.
- The definition of a certain sequential ordering action for the interchange of the variables of the list, and the consistency variables.

Sequential ordering of the variable interchange on network

In order to elaborate a spatial consistency status on a variable list, it is necessary to define a cycle corresponding to a transmission of all the list variables in order to be able to set up a temporal reference for the consistency variable management.

This cycle is delimited by a Vs synchronization order whose occurrence defines the beginning of a new variable interchange cycle. All the list variables of the list need to be received and all the consistency variables need to be interchanged between two consecutive occurrences of the Vs synchronization order. This is shown in Figure 38.

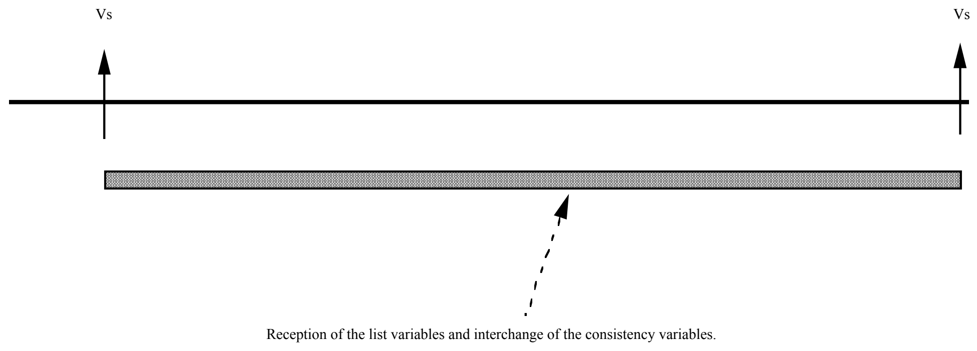

Vs
Vs
Reception of the list variables and interchange of the consistency variables.

Figure 38 – Spatial consistency list variables interchange mechanism

Moreover, a condition of using the lists requires that the consistency variable interchange be performed after interchange of all the list variables, and within the current cycle, as shown in Figure 39.

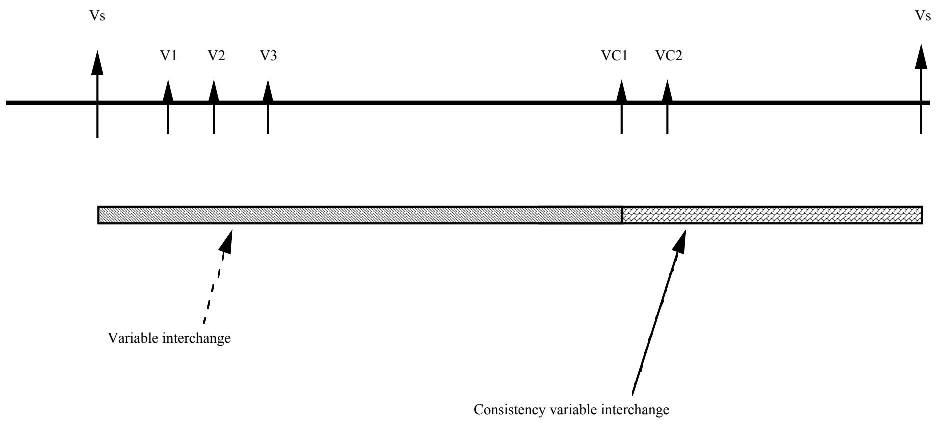


Figure 39 – Spatial consistency – consistency variable interchange mechanism

When the spatial consistency status elaboration mechanism is involved with a recovery mechanism, as shown in Figure 40, the eventual recovery on variables concerned by transmission errors need to be performed after the theoretical reception of all the list variables, and before the consistency variable interchange. This makes the recovery mechanism and the spatial consistency mechanism meaningful.

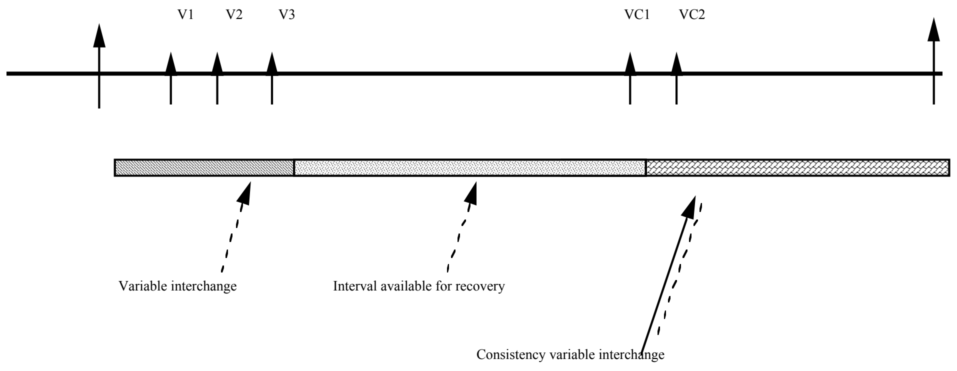

V1
V2
V3
VC1
VC2
Variable interchange
Interval available for recovery
Consistency variable interchange

Figure 40 – Spatial consistency – list recovery mechanism

Finally, the spatial consistency status locally elaborated inside an AE and made available to the user is significant only when all the consistency variables have been interchanged. This leads to defining a validity interval of the spatial consistency status, as shown in Figure 41.

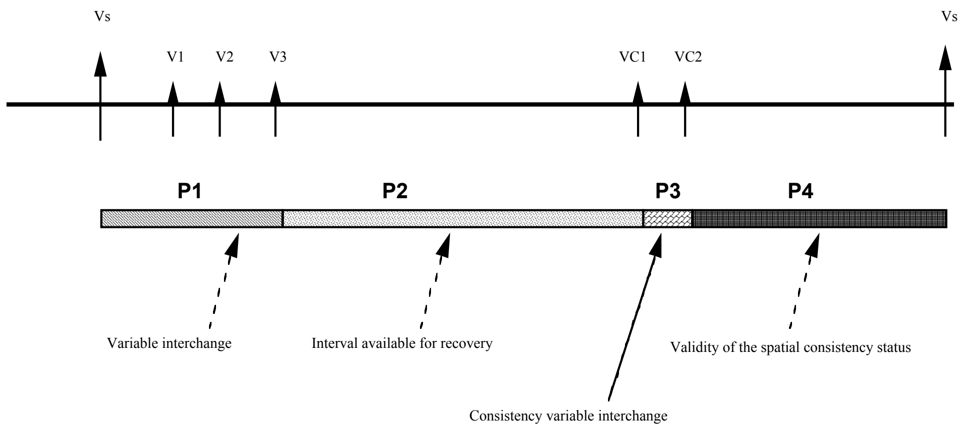

Vs
V1
V2
V3
VC1
VC2
Vs
P1
P2
P3
P4
Variable interchange
Interval available for recovery
Validity of the spatial consistency status
Consistency variable interchange

Figure 41 – Spatial consistency – validity of the spatial consistency status

6.2.1.4.1.4 Object model of a variable list

A variable list in the MPS environment is modeled by using the *Variable List Local Image* object which contains all the attributes required by an application entity consuming this variable list.

This object comes from the instantiation of the *Identified Variable List* class which contains all the attributes characterizing a variable list.

The common attributes of a variable list in the different entities, described in the *Identified variable List* class come from the instantiation of a *Variable List* generic class which describes the whole of the generic attributes of a variable list.

Moreover, it is pointed out that the *Variable List* generic class refers to the *Variable* generic class in order to describe the variables composing this variable list. This is all shown in Figure 42.

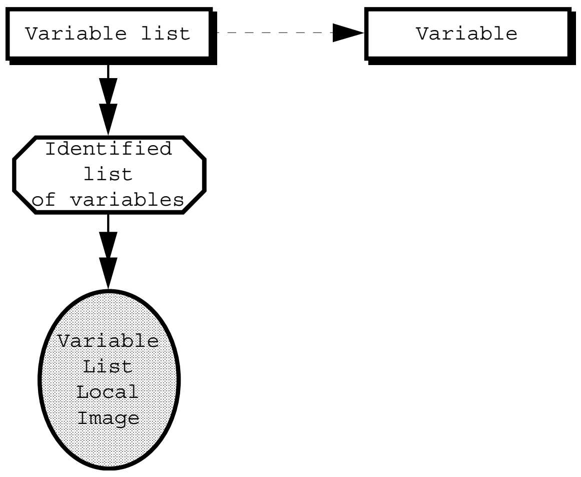


Figure 42 – Object model of a variable list

6.2.1.4.2 Variable list class specification

6.2.1.4.2.1 *Variable List* generic class specification

6.2.1.4.2.1.1 Variable list generic class model

FAL ASE: **MPS ASE**

CLASS:			Variable list
CLASS ID:			not used
PARENT CLASS:			not used
Generic Class:			VARIABLE LIST
CLASS ATTRIBUTES:			
Key-Attribute :			A_Name
Attribute :			List of Reference Consumed Variable
Attribute :			Spatial consistency required [TRUE,FALSE]
Attribute :			Recovery required [TRUE,FALSE]
Constraint :			Spatial consistency required = TRUE ***OR*** Recovery required = TRUE
	Attribute		: *Reference* (Synchronization) Variable
	Constraint		: Spatial consistency required = TRUE
		Attribute :	Inconsistency detection [TRANSITORY,PERMANENT,UNDEFINED]
		Attribute :	*List of*
		Attribute:	*Reference* (Consistency) Variable
Constraint :			Recovery required = TRUE
	Attribute		: Recovery period
Instance Attributes:			
Attribute :			Transmission consistency required [TRUE,FALSE]
Constraint :			Transmission consistency required = TRUE
	Attribute		: Transmission consistency status [TRUE,FALSE]
Attribute :			Production consistency required [TRUE,FALSE]
Constraint :			Production consistency required = TRUE
	Attribute		: Production consistency status [TRUE,FALSE]
Attribute :			Punctual transmission consistency required [TRUE,FALSE]
Constraint :			Punctual transmission consistency required = TRUE
	Attribute		: Punctual transmission consistency status [TRUE,FALSE]
Attribute :			Punctual production consistency required [TRUE,FALSE]
Constraint :			Punctual production consistency required = TRUE
	Attribute		: Punctual production consistency status [TRUE,FALSE]
Constraint :			Spatial consistency required = TRUE
	Attribute		: *Reference* (Consistency) Produced Variable
	Attribute		: Spatial consistency status [TRUE,FALSE]
Constraint :			Recovery required = TRUE
	Attribute		: Recovery list size
	Attribute		: Recovery list contents
	Attribute		: Recovery Nature [FRAGMENTED,INDIVISIBLE]
	Attribute		: Recovery List Identifier
	Attribute		: *Inherit from* Time-out

6.2.1.4.2.1.2 Attributes

A_Name:

This attribute supports unique identification at the interface between the application layer and the user. The A_Name of a variable list belongs to the MPS addressing space

Moreover, the maximum length of an A_Name of a variable list should not exceed 14 characters.

List Of Reference Consumed Variable:

This attribute allows a variable list to refer to the constituent variablesThis set of references between an *Identified Variable List* class and *Consumed variable* classes is identical for each local imag

Spatial consistency required:

The spatial consistency status associateda variable list is optional.

A "TRUE" value for this boolean attribute indicates that a spatial consistency status should be elaborated at the list level.

Recovery required:

The implementation of the recovery mechanism is optional.

A "TRUE" value for this boolean attribute indicates that a recovery mechanism should be implemented for the variable list.

***Reference* (synchronization) Variable:**

The variable lists refer to a synchronization order when a spatial consistency status is elaborated or when the recovery mechanism is implemented. This synchronization order is used on one hand by the service elements of various subscribers which elaborate the values of the consistency variables which are involved in the spatial consistency status elaboration, and on the other hand by the service elements that manage locally the recovery mechanism at the level of every application entity.

Inconsistency detection:

This attribute specifies the type of the consistency variables that are involved in the elaboration of the spatial consistency status.

The inconsistency detection is TRANSITORY when the consistency variable value type takes into account the transmission faults during the last interchange.

The inconsistency detection is PERMANENT when the consistency variable value type takes into account the transmission faults of the last 2^{16} previous interchanges.

The inconsistency detection is UNDEFINED when the consistency variable value type is freely defined by the user for an elaboration of a spatial consistency status in his user application.

***Reference* (consistency) Variable:**

This set of references to consistency Variables locally supports the transmission status of the variables of the list within the other application entities consuming this list.

A consistency variable characterizes a variable list at the level of a particular application entity. It supplies information regarding the transmission validity of each variable of this list from the transmission of the last synchronization variable associated to the list.

Recovery period:

This attribute represents the maximum duration allowed between two reinitialisations of the contents of the recovery list.

This period is expressed in milliseconds.

Transmission consistency required:

Transmission consistency associated with a variable list is optional.

When it has the value 'TRUE" this attribute indicates that a transmission consistency status should be elaborated for this list.

Transmission consistency status:

The transmission consistency status provided to the user is of type boolean.

This status is elaborated at the level of every application entity receiving variables of a list defined with a transmission consistency status.

Production consistency required:

Production consistency associated with a variable list is optional.

When it has the value TRUE this attribute indicates that a production consistency status should be elaborated for this list.

Production consistency status:

Production consistency is a status provided to the user.

This status of type Boolean is elaborated at the level of every application entity receiving the variables of a list with a production consistency status.

Punctual transmission consistency required:

Punctual transmission consistency associated with a variable list is optional.

When it has the value TRUE this attribute indicates that a punctual transmission consistency status should be elaborated for this list.

Punctual transmission consistency status:

Punctual transmission consistency is a status provided to the user.

This status of type Boolean is elaborated at the level of every application entity receiving the variables of a list defined with a punctual transmission consistency status.

Punctual production consistency required:

The punctual production consistency associated with a variable list is optional.

This attribute of boolean type indicates that a punctual production consistency status should be elaborated for this list when it has the value TRUE.

Punctual production consistency status:

Punctual production consistency is a status provided to the user.

This status of type boolean is elaborated at the level of every application entity receiving the variables of a list defined with a punctual production consistency status.

Spatial consistency status:

Spatial consistency is a status provided to the user.

This status of type boolean is elaborated at the level of every application entity receiving variables of a list defined with a spatial consistency status.

***Reference* (consistency) Produced Variable:**

This reference designates the consistency variable locally produced and transmitted to the other application entities consuming the list in order to inform them about the transmission operation of the variables locally within the entity producing the consistency variable.

Recovery list size:

This attribute characterizes the maximum number of elements of the variable list for which a retransmission will be requested during the same cycle. The size of the recovery list is always smaller or equal to the number of elements which compose the variable list.

Recovery list contents:

This attribute characterizes a set of identifiers associated with elements of a variable list that were not successfully received after the last reception on the network of the synchronization variable associated to this list.

These contents are not accessible to the user, but they are directly interpretable by a data link service element to recover the failed transmissions during the last interchange.

The contents of a recovery list is used to perform a transmission recovery request of the maximum number of elements defined by the recovery list size.

The encoded value of the recovery list is empty in case of non recovery, i. e. when all the variables of the variable list have been correctly transmitted during the last interchange.

Recovery list identifier:

This attribute specifies the identifier with which the contents of the recovery list are associated. This identifier references in a unique way this recovery list associated to a local image of a variable list within a MPS application entity.

Inherit from time-out:

The management of the recovery list contents takes into account the event associated with the time-out expiration which indicates a time which is too long without initialization of the recovery list, as well as an event associated with the occurrence of the synchronization order which initializes the recovery list contents. This time-out is set upon occurrence of the recovery list synchronization and reset automatically when it is over.

Recovery nature:

This attribute defines the quality of service associated with the recovery_mechanism on a variable list. When this attribute has value INDIVISIBLE, the recovery is performed immediately after transmission of the recovery list contents on the network. When this attribute has the value FRAGMENTED the recovery is delayed in a time slot reserved for aperiodic traffic ; moreover, it should be performed only according to the network load.

6.2.1.4.2.2 *Identified Variable List* class specification

The *Identified Variable List* class comes from the instantiation of the *Variable List* generic class

6.2.1.4.2.3 *Variable List Local Image* object specification

The *Variable List Local Image* object comes from the instantiation of the *Identified Variable List* class

6.2.1.4.3 Services

6.2.1.4.3.1 List read service

6.2.1.4.3.1.1 Function

This function allows the user to perform a local read of all the values of the variables composing a list locally declared as consumed.

In addition to the list variable values, this service optionally provides various consistency status associated with this variable list.

6.2.1.4.3.1.2 Service primitives

The read of a variable list is performed using the A_READLIST service primitives, shown in Table 31:

A_READLIST.Rq (Arguments): List read request

A_READLIST.Cnf (Results): Return of the read value.

Table 31 – A_Readlist service parameters

Parameter name	**Req**	**Cnf**
Argument		
List specification	M	M (=)
Result (+)		S
Value		M
Transmission consistency status		C
Production consistency status		C
Punctual consistency status		C
Punctual production consistency status		C
Spatial consistency status		S
Result (-)		S
Type of error		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. See 1.2.		

Argument

List specification:

This argument corresponds to the A_Name attribute of the *Variable List Local Image* object which is to be accessed.

Result (+)

Value

List of the variable values belonging to the list which is read.

Transmission consistency status

Optional status describing the transmission consistency of all the variables of the list.

Production consistency status

Optional status describing the production consistency of all the variables of the list.

Punctual transmission consistency status

Optional status describing the punctual transmission consistency of all the variables of the list.

Punctual production consistency status

Optional status describing the punctual production consistency of all the variables of the list.

Spatial consistency status

Optional status describing the spatial consistency of all the variables of the list.

Result (-)

Error type

Description of the various error types returned after a non successful read request:

Error_1: One of the buffers, where is located the value of a variable of the list is not accessible.

Error_2: The list specification does not correspond, within the addressing space, with a list identification declared as consumed in the AP in consideration.

Error_3: The list is declared locally as invalid.

6.2.1.4.3.1.3 Service procedure

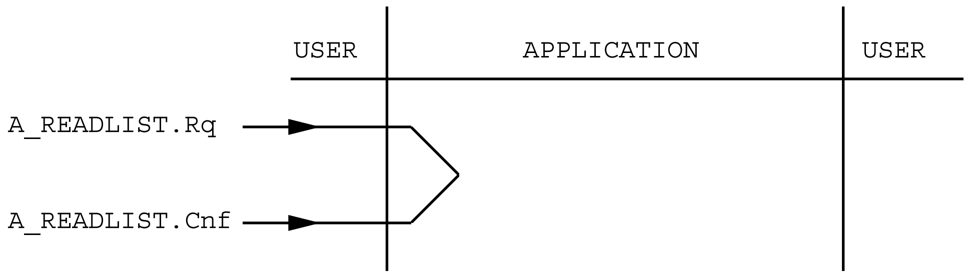


Figure 43 – A_Readlist service procedure

This service, shown in Figure 43, provides all the values locally available of the variables of a list at a given time.

The various elaborated status describe the various consistency levels applied to the variables of the list.

Read requests of a list are sequentially processed ; a new request can be initiated only after confirmation of the previous one.

6.2.1.4.4 Variable list consistency and recovery mechanisms

6.2.1.4.4.1 Transmission consistency

6.2.1.4.4.1.1 Description

Information relative to the transmission consistency of a variable list can be elaborated within a consuming entity, and provided to the user.

This consistency information is provided with two possible semantics:

- the asynchronous transmission consistency informs the consuming user about the respect, for all the variables of this list, of their respective consumption period by the network,
- the synchronous transmission consistency informs the consuming user about the respect, for all the variables of this list, of an availability within their respective consumption period initialized upon occurrence of a single synchronization order associated with the list.

Moreover, these synchronous or asynchronous promptnesses are elaborated with a mandatory value of the *Consumption Period* attribute which is identical for all the variables of this list.

In the case of an asynchronous transmission consistency, all the variables composing this list should elaborate an asynchronous promptness status.

In the case of a synchronous transmission consistency, all the variables composing this list should elaborate a synchronous promptness status.

6.2.1.4.4.1.2 Composition rule

The transmission consistency status is the logical product of the promptness status of the different variables of the list. According to the synchronous or asynchronous characteristics of the promptness status associated with the variables of the list, the resulting transmission consistency status should represents the transmission consistency which is respectively synchronous or asynchronous.

6.2.1.4.4.2 Production consistency

6.2.1.4.4.2.1 Description

Information relative to the production consistency of a variable list can be elaborated at the level of a consuming entity and made available to the user.

These consistency information are provided with two possible semantics:

- the asynchronous production consistency informs the consuming user about the respect, by all the users producing the variables of this list, of their respective production period,
- the synchronous production consistency informs the consuming user about the respect, by all the users producing the variables of this list, of a refreshment within their respective production period initialized by the producing entity upon occurrence of a synchronization order associated with the variable list.

In the case of an asynchronous production consistency, all the variables composing the list should elaborate an asynchronous refreshment status, whereas in the case of a synchronous production consistency, all the variables composing the list should elaborate a synchronous refreshment status. Moreover, these asynchronous and synchronous refreshment status are elaborated with a mandatory value of the *Production Period* attribute which is identical for all the variables of the list.

6.2.1.4.4.2.2 Composition rule

The production consistency status is the logical product of the refreshment status of the various variables of the list.

According to the synchronous or asynchronous characteristics of the refreshment status elaborated by the entities producing the variables of the list, the status should represent the production consistency which is respectively synchronous or asynchronous.

6.2.1.4.4.3 Punctual transmission consistency

6.2.1.4.4.3.1 Description

Information relative to the punctual transmission consistency of a variable list can be elaborated within a consuming entity and provided to the user.

The punctual transmission consistency status informs the consuming user about the respect of an availability by the network of all the variables of this list within their respective consumption time slot.

These respective consumption time slots are initialized by the consuming entity upon occurrence of the synchronization order associated to the list.

All the variables composing the variable list elaborating a punctual transmission consistency status should elaborate a punctual promptness status with the same value of the *consumption time slot* attribute.

6.2.1.4.4.3.2 Composition rule

The punctual transmission consistency status is the logical product of the punctual promptnesss status of all the variables composing this list.

6.2.1.4.4.4 Punctual production consistency

6.2.1.4.4.4.1 Description

Information relative to the punctual production consistency of a variable list can be elaborated within a consuming entity and provided to the user.

The punctual production consistency status informs the user consuming the variable list about the respect, by the all the users producing the variables of this list, of a production within their respective time slot.

All the production time slots of the variables of the list are initialized by the producing entities upon occurrence of the synchronization order associated with the list. The variables composing the variable list elaborating a punctual refreshment consistency status should elaborate a punctual promptness status with the same value of the *production time slot* attribute.

6.2.1.4.4.4.2 Composition rule

The punctual production consistency status is the logical product of the punctual refreshment status of all the variables composing the list.

6.2.1.4.4.5 Spatial consistency

6.2.1.4.4.5.1 Description

A status relative to the spatial consistency of a variable list can be elaborated at the level of a consuming entity and made available to the user.

This spatial consistency status is a piece of information from which the user will be able to build a consistency status whose semantics are adapted to the needs of his application ; (For example, the semantics of the user consistency status can be the equality of the values of all the multiple copies of the list variables).

The elaboration mechanism of a spatial consistency status relies on the broadcast by all the entities consuming the same list declared with a spatial consistency characteristics of a consistency variable. This consistency variable reflects locally the transmission validity of each of the variables of the list.

A consistency variable is elaborated by each of the entities consuming a single variable list and provided to the other entities consuming this list.

The elaboration of this spatial consistency status requires that each of the AE consuming a single variable list is provided with a reception report of the list variables of the other consuming AEs. To provide reception report, additional interchanges allow every AE to broadcast to the others its consistency variable relative to this same list.

6.2.1.4.4.5.2 Composition rule

At the level of a entity consuming a variable list, the processing associated with the spatial consistency relies on the values of consistency variables associated with this list. the spatial consistency status is elaborated from the comparison of the values of the consistency variables associated with a list.

The spatial consistency status value is

TRUE: when there is equality between all the values of the consistency variables associated with this list.

FALSE: in all the other cases.

6.2.1.4.4.5.3 Consistency variable specification

When a spatial consistency status is associated with a variable list, it necessary to elaborate a consistency variable at the level of every application entity consuming this variable list.

This consistency variable is provided to the other entities consuming this variable list.

A consistency variable in the MPS environment is modelled in the same way as for the variables by using the following objects:

– a (consistency) *Produced Variable Local Image* object which contains all the attributes required for a producing application entity,

– one or several (consistency) *Consumed Variable Local Image* objects which contain all the attributes required for consuming application entities.

These objects correspond to particular instantiation of the classes describing the variables for which the *Class* attribute of the object has the value 'SYNCHRONIZATION'.

A consistency variable is different from the other variable classes by a reference to the associated variable list, in order that the service element producing this variable can elaborate the corresponding value.

6.2.1.4.4.6 Predetermined values used by the list consistency mechanisms

6.2.1.4.4.6.1 Predetermined attribute value of the *Identified Variable* class

An *Identified Variable* class corresponding to a consistency variable is characterized by predetermined values for the following attributes:

Class:

This attribute has the value: SYNCHRONIZATION

Consistency Variable:

This attribute has the value: TRUE

6.2.1.4.4.6.2 Predetermined attribute value of the *Produced Variable Local Image* class

A *Produced Variable Local Image* object corresponding to a consistency variable is characterized by predetermined values for the following attributes:

Resynchronized Variable:

This attribute has the value: FALSE.

All the other non quoted attributes are not given predetermined values.

6.2.1.4.4.6.3 Predetermined attribute value of the *Consumed Variable Local Image* object

A *Consumed Variable Local Image* object corresponding to a consistency variable is characterized by predetermined values for the following attributes:

Resynchronized Variable:

This attribute has the value: FALSE.

All the other non quoted attributes are not given predetermined values.

6.2.1.4.4.6.4 Consistency variable type specification

6.2.1.4.4.6.4.1 Consistency variable functionality

The consistency variable values are assigned with a type issued from the instantiation of the *Type Constructor* class.

When the *Inconsistency Detection* attribute has the value 'TRANSITORY', the consistency variable type should be 'K_SCONS'.

When the *Inconsistency Detection* attribute has the value 'FRAGMENTED', the consistency variable type should be 'K_LCONS'.

When the *Inconsistency Detection* attribute has the value 'UNDEFINED', the consistency variable type can be described by any instance of the *Type Constructor* class.

6.2.1.4.4.6.4.2 Predetermined attribute value of the *Type Constructor* class.

Instances of the *Type Constructor* class associated with a consistency variable to detect a TRANSITORY spatial inconsistency:

```
A_Name:              K_SCONS
Construction       :    STRUCTURE
     Named field   :    FALSE
     Reference     :    K_UNS_16 -- Interchange Nr.
     Reference     :    K_BOOLAC64  -- Transmission status
A_Name             :    K_UNS_16
Construction       :    SIMPLE
     Class of type      UNSIGNED
     Size          :    16
A_Name             :    K_BOOLACnn
Construction       :    ARRAY
     Compacted     :    TRUE
     Dimension     :    nn (list variable number)
     Reference     :    K_BOOL
A_Name             :    K_BOOL
Construction       : SIMPLE
     Class of type      BOOLEAN
```

Instances of the *Type Constructor* class associated with a consistency variable to detect a PERMANENT spatial inconsistency:

```
A_Name:              K_LCONS
Construction       :    STRUCTURE
     Named field   :    FALSE
     Reference     :    K_UNS_16 -- Interchange Nr.
     Reference     :    K_UNS_16ACnn     -- Transmission_date
A_Name             :    K_UNS_16ACnn
Construction       :    ARRAY
     Compacted     :    TRUE
     Dimension     :    nn (list variable number)
```

Reference : K_UNS_16

6.2.1.4.4.6.4.3 Field semantics

The semantics of the consistency variable value fields when the *Inconsistency Detection* attribute does not have the value UNDEFINED is as follows:

Structure fields associated with the 'K_SCONS' type:
Interchange number:

The value of the variables of the list is characterized by the interchange number during which they have been updated by the network. This interchange number is a global data of the MPS environment produced by a specific application entity and broadcast to the entities elaborating spatial consistency information by using the synchronization variable associated with the list.

This interchange number is used to check that the processed consistency variable values dates are identical during the spatial consistency processing.

Transmission_status:

The transmission status of the variable list is an array whose elements represent respectively the transmission status for each of the list variables.

The variable transmission status at the level of a consuming application entity indicates whether this variable has been received since the last occurrence of the synchronization variable associated to the list.

Structure fields associated with the 'K_LCONS' type:

Interchange number:

This field is provided with the same semantics as that with the same name in the 'K_SCONS' type.

Transmission_date:

The transmission date of the variable list is an array whose elements represent respectively the number of the last interchange of each of the list variables.

The number of the last interchange of a variable at the level of a consuming application entity corresponds to that taken into account during the last reception of this variable.

This interchange number, taken into account for a variable during its reception, corresponds to the synchronization variable value of the list which this variable belongs to.

6.2.1.4.4.7 Elaboration mechanism specification of the consistency variable values

This mechanism is involved only when the *Inconsistency detection* attribute associated with the variable list has a value other than 'UNDEFINED'.

This service element elaborates the predetermined type value involved in the spatial consistency status elaboration of a variable list, as shown in Figure 44.

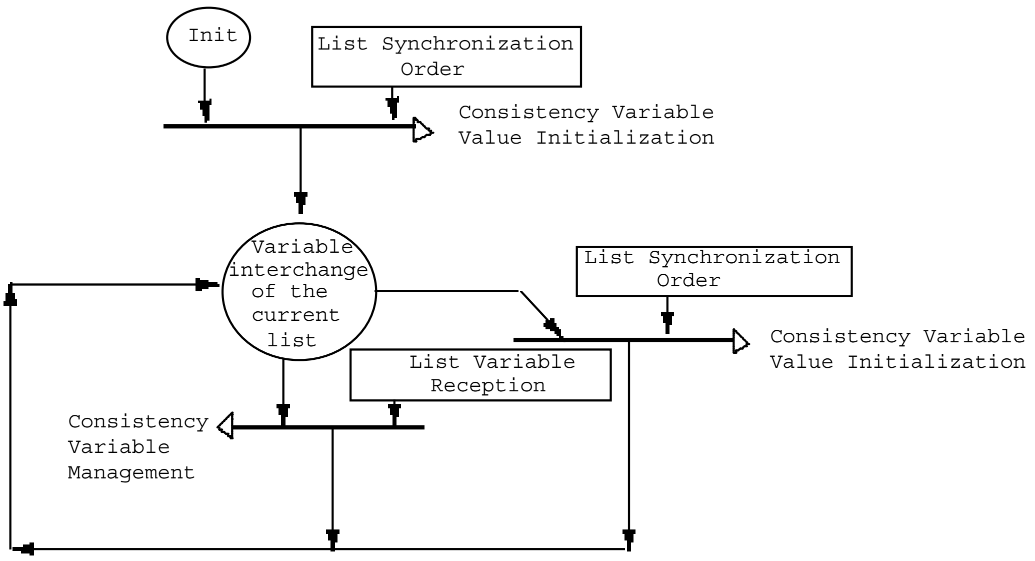

Init
List Synchronization Order
Consistency Variable Value Initialization
Variable interchange of the current list
List Synchronization Order
Consistency Variable Value Initialization
List Variable Reception
Consistency Variable Management

Figure 44 – Consistency variable value evaluation net

The initialization of the consistency variable value upon occurrence of the synchronization order associated with a variable list consists in giving its different fields a specific value that characterizes the implementation of the consistency processing.

The value of the consistency variable at the end of the initialization is as follows:

– the ' Interchange number ' field specifies the interchange number corresponding to the synchronization variable value which triggered this initialization,

– the ' Transmission status ' field specifies, for each variable of the list, a transmission status 'FALSE',

– the ' Transmission date ' field specifies for each the variable composing the variable list with which the consistency variable is associated, an interchange number corresponding to that which triggered the initialization.

The initialization of a consistency cycle is performed upon occurrence of the synchronization order associated with the variable list. This initialization corresponds to an assignation of the consistency variable field ' *Interchange number* ' of the synchronization variable value which corresponds to the synchronization order of the list. The consistency variable value management upon reception of a variable consists in modifying the value of the Transmission_Status and Transmission_Date according to the selected predetermined type.

In the case of the Transmission_Status field, the value management consists in making a change of the transmission status of each of the variables of the received list from FALSE to TRUE.

In the case of the Transmission_date field, the management value consists in memorizing the current interchange number in the transmission date associated with the variable.

<u>Example</u>

Given the list {V1, V2, V3, V4, V5} and the associated synchronization variable: S_LIST

Interchange timing diagram:

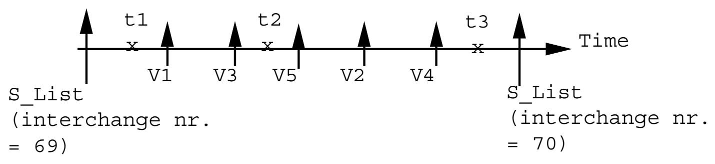


Figure 45 – Consistency interchange timing diagram

If we consider that all the variables were received during the previous interchange, the consistency variable associated with the various instants of the interchange has the following values:

t1 : Consistency variable value	
Inconsistency Detection:= TRANSITORY	{69; 0,0,0,0,0}
Inconsistency Detection:= PERMANENT	{69; 68,68,68,68,68}
t2 : Consistency variable value	
Inconsistency Detection:= TRANSITORY	{69; 1,0,1,0,0}
Inconsistency Detection:= PERMANENT	{69; 69,68,69,68,68}
t3 : Consistency variable value	
Inconsistency Detection:= TRANSITORY	{69; 1,1,1,1,1}
Inconsistency Detection:= PERMANENT	{69; 69,69,69,69,69}

6.2.1.4.4.8 Access to the consistency variables.

The consistency variables are handled by a subset of the services provided to the user for normal variables.

The services permitting access to the consistency variables are those existing for the synchronization variables, with the following restriction:

A_WRITELOC: Only when the *Inconsistency detection* attribute has a value other than UNDEFINED.

6.2.1.4.4.9 Specification of the recovery mechanism

A variable list can be provided with a recovery mechanism whose implementation depends on this list according to the user needs concerning the reliability.

This recovery mechanism elaborates recovery list contents corresponding to an ordered set of references to elements of the variable list which were not successfully received since the last reception of the list synchronization variable, under the condition that this synchronization variable has arrived within a time interval smaller than the recovery period.

The sequence operation of the variable references in the recovery list is performed in the declaration order of the list variables.

The references to the list variables, stored in the recovery contents by this mechanism, corresponds to the variable identifiers of this list. These recovery contents which conditions the initiation of new interchanges are limited to a maximum number of references defined at the time of configuration of the variable list.

NOTE The use of the recovery mechanism, with a recovery period equivalent to the network period of the synchronization variable of the list, releases all the losses which appeared during the list synchronization variable transmission.

Figure 46 shows the evaluation net of the service element which elaborates the contents of the recovery list associated with a variable list at the application level.

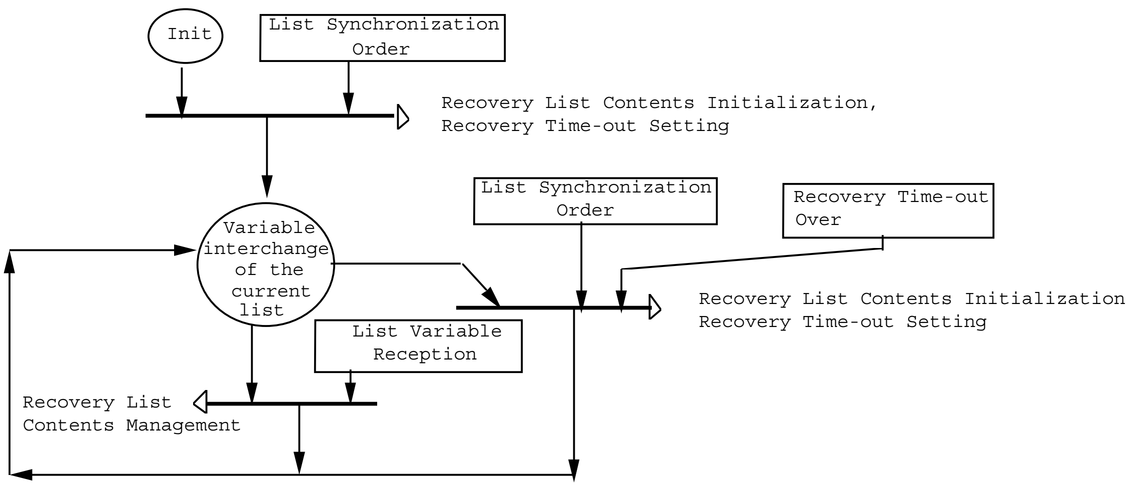

Init
List Synchronization Order
Recovery List Contents Initialization, Recovery Time-out Setting
Variable interchange of the current list
List Synchronization Order
Recovery Time-out Over
Recovery List Contents Initialization Recovery Time-out Setting
List Variable Reception
Recovery List Contents Management

Figure 46 – Recovery mechanism evaluation net

• The initialisation of the recovery list contents, upon occurrence of the synchronization order associated with the variable list, consists in giving it the list of all the variable list identifiers as contents value.

As the synchronization variable associated with the list precedes all the list variables during an interchange, it should be considered that all the list variables are not received at the instant of the synchronization order occurrence.

- The recovery list management upon reception of a variable, consists in removing the identifier associated with this variable of this recovery list.
- The setting of the recovery time-out is performed upon occurrence of the list synchronization order and also automatically when it is expired. When it is set, the value of the *Preselection* attribute of this time-out is that of the *Recovery period* attribute of the *Variable List Local Image* object.

Example:

Given the list {V1, V2, V3, V4, V5} and the associated synchronization variable: S_LIST. The maximum recovery list size is limited to 4 elements.

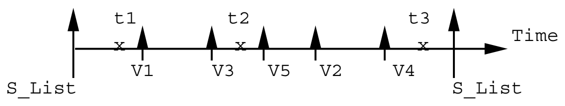


Figure 47 – Recovery interchange timing diagram

The recovery list, shown in Figure 47, has the following values at the different interchange instants:

t1 : Recovery list contents = { V1, V2, V3, V4}

t2 : Recovery list contents = { V2, V4, V5}

t3 : Recovery list contents = { ∅ }

6.2.1.5 Description of the configuration

The description specification of the application layer objects refers to static attributes of the objects:

– Variable of class normal, synchronization (by limiting to those attributes shared by the producer and the consumer plus those specific to the producer).

– Type of a variable.

– Access to a variable.

– Variable list (by limiting to those attributes shared by the consumers of this list).

6.2.1.5.1 Description variables

The configuration description accessible to the user anywhere on the network should be addressed at the interface between the application layer and the user.

For this purpose, the configuration description associated with the various objects of the application layer is modelled by description variables.

These description variables are themselves subjected to particular constraints which endows them with the same configuration on the network, in order not to define recursive description variables describing the description variable configuration.

These particular constraints are translated at the application layer level, into predefined values of the *Consumed Variable Local Image* and *Produced Variable Local Image* objects associated to the description variables.

6.2.1.5.2 Specification of a description variable

6.2.1.5.2.1 Description variable overview

A description variable in the AL environment is modeled in the same way as the other variables using the following objects.

- A *Produced Variable Local Image* object, which includes all the attributes required for the definition of a description variable in a producing application entity.

– A *Consumed Variable Local Image* object, which includes all the attributes required for the definition of a description variable in a consuming application entity.

Both these object categories correspond to particular instantiation of the *Identified Variable* class, for which the *Class* attribute of the object has the value DESCRIPTION.

A *Produced Variable Local Image* or *Consumed Variable Local Image* object corresponding to a variable of class DESCRIPTION are different from those corresponding to ' normal ' variables by predetermined values of some of its attributes.

6.2.1.5.2.2 Predetermined values of the *Identified Variable* class attributes.

An *Identified Variable* class corresponding to a description variable is characterized by values predetermined for the following attributes:

Transmitted Status:

This attribute has the value ' FALSE '.

Class:

This attribute has the value ' DESCRIPTION '.

All the non quoted attributes are not given predetermined values.

6.2.1.5.2.3 Predetermined values of the attributes of the *Produced Variable Local Image* object

A *Produced Variable Local Image* object corresponding to a description variable is characterized by values predetermined for the following attributes:

Resynchronized Variable:

This attribute has the value ' FALSE '.

Elaborated Refreshment:

This attribute has the value ' FALSE '.

Elaborated Punctual Refreshment:

This attribute has the value ' FALSE '.

Required Universal Services:

This attribute has the value ' FALSE '.

All the non quoted attributes are not given predetermined values.

6.2.1.5.2.4 Predetermined values of the attributes of the *Consumed Variable Local Image* object

A *Consumed Variable Local Image* object corresponding to a description variable is characterized by values predetermined for the following attributes:

Resynchronized Variable:

This attribute has the value ' FALSE '.

Required Universal Services:

This attribute has the value ' FALSE '.

All the non quoted attributes are not given predetermined values.

6.2.1.5.2.5 Description variable names

The description variable names handled at the interface between the application layer and the user, belong to the unique addressing space referencing the application objects. In this MPS addressing space, the standard defines four (reserved name sets) to address the description variables:

A_Name of the variable starting by:

"**V_**" Description of a variable

"**A_**" Description of a variable access

"**T_**" Description of a variable type

"**L_**" Description of a variable list.

6.2.1.5.2.6 Description variable types

6.2.1.5.2.6.1 Description variable type definition

The values of description variables are given a type which depends on the nature of the description, corresponding to predefined instances of the *Type Constructor* class.

6.2.1.5.2.6.2 Predefined instances of the *Type Constructor* class.

Four predefined instances provide semantics to the types of the description variables.

- variables of NORMAL, SYNCHRONIZATION class.
- renamed accesses to variables of NORMAL, SYNCHRONIZATION class.
- types of variables.
- lists of variables.

Instance of the *Type Constructor* class associated with the type of a description variable of a variable of NORMAL, SYNCHRONIZATION class:

A_Name	:	K_DVAR
Construction	:	PREDEFINED

Instance of the *Type Constructor* class associated with the type of a description variable of a renamed access to a variable:

A_Name	:	K_DACCESS
Construction	:	PREDEFINED

Instance of the *Type Constructor* class associated with the type of a description variable of a type:

A_Name	:	K_DTYPE
Construction	:	PREDEFINED

Instance of the *Type Constructor* class associated with the type of a description variable of a variable list:

A_Name	:	K_DLIST
Construction	:	PREDEFINED

NOTE It has to be stated that the predefined type description of the environment means only that they are predefined. The precise knowledge of the semantics of the predefined types in the AL environment is part of the conformance to the MPS standard.

6.2.1.5.2.6.3 Semantics of the predefined types of the description variables

The types of the description variables provide a semantics to these variables. These semantics reflect the values of the static attributes shared by all the instances of the described objects as well as some attributes specific to the producer of the object.

The semantics of description variable type of a variable of NORMAL or SYNCHRONIZATION class describe the values of the following attributes, if they exist:

A_Name

Type Constructor Reference

Transmitted Status

Significant Status

Identifier

Transmission Mode

Network Period

Class

Consistency Variable

Variable List Reference

Resynchronized Variable

Synchronization Variable Reference

Elaborated Refreshment

Refreshment Characteristics

Production Period

Synchronization Variable Reference

Elaborated Punctual Refreshment

Time slot

Synchronization Variable Reference

The semantics of the description variable type of a renamed access to a variable describe the values of the following attributes, if they exist:

A_Name

Variable Reference

Access Mode

Access Path

The semantics of the description variable type of a variable type describe the values of the following attributes, if they exist:

A_Name

Construction

Primitive Type

Size

Compacted

Dimension

Reference Type Constructor

Named Field

Field Name

Reference Type Constructor

The semantics of the description variable type of a list variable describe the values of the following attributes, if they exist:

A_Name

List of Reference Variable

Spatial Consistency Required

Recovery Required

Reference Synchronization Variable

Inconsistency Detection

List of Reference Consistency Variable

Recovery Period.

6.2.1.5.2.6.4 Identifier of the description variables

The identifiers accepted for the description variables belong to a reserved subset defined by the network management standard.

Moreover, there exists an addressing relationship between identifiers of the variables and those of the description variables which is defined by the network management standard.

6.2.1.5.2.6.5 Access to the description variables

The description variables can be handled by a subset of services provided to the user for normal variables.

The services providing access to the description variables are

- A_WRITELOC
- A_WRITEFAR
- A_READLOC
- A_READFAR
- A_SENT
- A_RECEIVED
- A_UPDATE

All other services, provided to the user for a normal variable, are not permitted for a description variable.

6.2.2 Virtual model of a device (VMD) ASE

6.2.2.1 Overview

The modelling of a Sub-MMS VMD within an application is similar to its equivalent MMS.

6.2.2.2 Concepts

6.2.2.2.1 Scope of objects

In order to simplify object identification, the listed classes of objects do not have the scope (in the MMS sense) explicitly specified.

In other words appurtenance of an object of a given class to another object of another class is implicitly known (variable belonging to a particular domain for example) and should not appear in the object identification.

6.2.2.2.2 Object identification

The identification of objects "variable", "variable-list", "pi", "domain" and "event" is done by an identifier capable of taking either the form of an integer value (Index), or the form of a character string (Name). The number of characters in the string is either undetermined or determined by the companion standards.

Taking into consideration the elimination of the concept of scope, the identification of an object should be unique, either within its class or within a space common to all the classes. An object can be identified by an index and/or a name.

6.2.2.2.3 Environment management

6.2.2.2.3.1 Environment management services

The Sub-MMS environment management services are

1- Initiate, allows negotiating the establishment of a Sub-MMS environment.

2- Conclude, allows proposing the closing of a negotiated Sub-MMS environment.

3- Abort, allows suddenly breaking a negotiated Sub-MMS environment.

The initiate and Abort services are compulsory for the devices supporting the management of the negotiated Sub-MMS environment. The Conclude service is negotiable.

The Reject service allows the notification of protocol errors. It is compulsory for all the equipment.

6.2.2.2.3.2 Type of communication

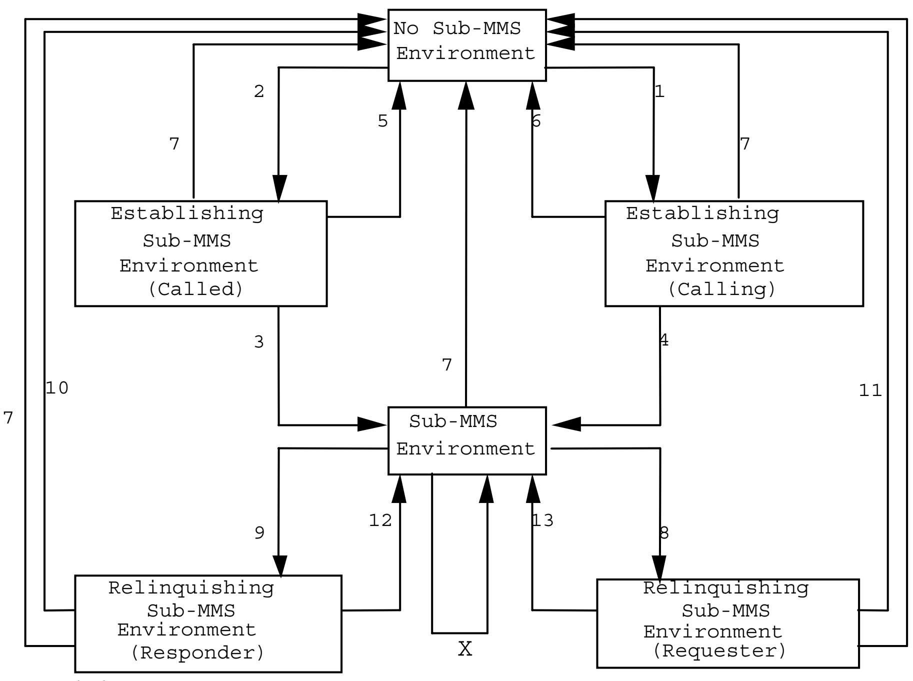
6.2.2.2.3.2.1 Supported communcation types

A device can support the following types of communication:

a) communication in a negotiated Sub-MMS environment,

b) communication in a predefined Sub-MMS environment,

c) communication without Sub-MMS environment.


No Sub-MMS Environment
Establishing Sub-MMS Environment (Called)
Establishing Sub-MMS Environment (Calling)
Sub-MMS Environment
Relinquishing Sub-MMS Environment (Responder)
Relinquishing Sub-MMS Environment (Requester)
1
2
3
4
5
6
7
8
9
10
11
12
13
X

Transitions :

1-initiate.request
2-initiate.indication
3-initiate.response +
4-initiate.confirm +
5-initiate.response -
6-initiate.confirm -
7-Abort.req or abort.indication

8-conclude.request
9-conclude.indication
10-conclude.response +
11-conclude.confirm +
12-conclude.response -
13-conclude.confirm -
X-other services.Req/ind

Figure 48 – Flowchart of the sub-MMS environment management state

6.2.2.2.3.2.2 Communication in a negotiated sub-MMS environment

The Sub-MMS environment is negotiated between a user of the calling Sub-MMS and a user of the called Sub-MMS.

The resources allocated to this environment are reserved for these two users.

A Sub-MMS environment known as association has several states, as shown in Figure 48. The initiate, conclude and abort services can act on the association.

The initial state for the calling Sub-MMS as well as the called should be the state "No Sub-MMS Environment".

In the state "No Sub-MMS Environment", a user of the sub-MMS should only invoke the request of the initiate service primitive.

In the "Establishing Sub-MMS Environment (Calling)" state, a user of the sub-MMS should only invoke the request of the Abort service primitive.

In the "Establishing Sub-MMS Environment (Called)" state, a user of the sub-MMS can only invoke the response to the initiate service primitive or the request of the Abort service primitive.

In the "Relinquishing Sub-MMS Environment (Requester)" state, the only request for a primitive which a user of the sub-MMS can invoke is the request of the Abort service primitive. It is noted that the responses (+) or (-) can continue to be invoked.

In the "Relinquishing Sub-MMS Environment (Responder)" state, a user of the Sub-MMS can only invoke the request of the Abort service primitive and the response to the Conclude service primitive.

The only events which provoke the output of the "Sub-MMS environment" state are the invocations of the Abort service primitive request, the Conclude service primitive request as well as the reception of the indications of the Abort service primitive and the Conclude service primitive.

In the "Sub-MMS Environment" state, a user of the sub-MMS can invoke any of the requests or responses of the previously negotiated service primitives, on condition that the following points are observed:

a) other sections of this document restraining the use of the services through sequencing constraints;
b) a response to a primitive should not be invoked unless a request of the primitive corresponding to a service indication has been received;
c) the request of the initiate service primitive should not be invoked.

6.2.2.2.3.2.3 Communication in a predefined sub-MMS environment

The SUB-MMS environment is established implicitly between two or more users. The resources allocated to this environment are reserved to its users.

The Sub-MMS environment management services (Initiate, Conclude, Abort) are not signficant.

If an Initiate or Conclude Request PDU is received, a Reject PDU is issued with the parameters Reject PDU type equal to PDU ERROR and Reject Code equal to ILLEGAL-MAPPING.

If a Request PDU of a confirmed service not supported in this environment is received, a Reject PDU message is issued with the parameters Reject PDU Type equal to CONFIRMED. REQUEST PDU and Reject Code equal to UNRECOGNIZED SERVICE.

NOTE 1 A Sub-MMS environment established between more than two users only supports unconfirmed services.

NOTE 2 The reception of an Abort.Indication is ignored.

6.2.2.2.3.2.4 Communication without sub-MMS environment

No Sub-MMS environment is established between two or more users.

The resources allocated to this type of communication are available to all the potential remote users.

The Sub-MMS environment management services (Initiate, Conclude, Abort) are not supported.

If an Initiate or Conclude Request PDU is received, a Reject PDU is issued with the parameters Reject PDU Type equal to PDU ERROR and Reject code equal to ILLEGAL MAPPING.

If a Request PDU of a confirmed service not supported by the equipment is received, a Reject PDU is issued with the Reject PDU Type parameters equal to CONFIRMED.REQUEST PDU and Reject Code equal to UNRECOGNIZED-SERVICE.

NOTE The reception of an Abort.Indication is ignored.

6.2.2.2.3.3 Error types

6.2.2.3 VMD class specification

6.2.2.3.1 VMD class model

FAL ASE:	**VMD ASE**
CLASS: VMD	
CLASS ID:	not used
PARENT CLASS:	not used
Object: VMD	
(m) Key Attribute:	Executive Function
(m) Attribute:	Vendor Name
(m) Attribute:	Model Name
(m) Attribute:	Revision
(m) Attribute:	Logical Status (STATE-CHANGES-ALLOWED,NO-STATE-CHANGES-ALLOWED, OTHER)
(m) Attribute:	Physical Status (OPERATIONAL, PARTIALLY-OPERATIONAL, INOPERABLE, NEEDS-COMMISSIONING)
(m) Attribute:	List of Capabilities
(m) Attribute:	List of Program Invocations
(m) Attribute:	List of Domains
(m) Attribute:	List of Variables
(m) Attribute:	List of Variable Lists
(m) Attribute:	List of Events
(o) Attribute:	Additional Detail

6.2.2.3.2 Attributes

Executive function:

This attribute represents the set of software ensuring the service procedures.

Vendor name:

This attribute identifies the constructor of the device.

Model name:

This attribute identifies the device model which supports the VMD.

Revision:

This attribute identifies the version index of the device system supporting the VMD. The value of this attribute is assigned by the vendor.

Logical status:

Sub-MMS distinguishes two levels of functions which are described in this attribute. Other levels of functions could be defined eventually without altering the interoperability of the device.

1-STATE-CHANGES-ALLOWED:

In this status all the VMD supported services can be carried out,

2-NO-STATE-CHANGES-ALLOWED:

In this status only the following services can be carried out, if they are VMD supported:

- Initiate
- Conclude
- Abort
- Identify
- Status
- Read
- Get Alarm summary
- Get Name List
- Get Domain Attributes
- Get Program Invocation Attributes
- Get Variable Access Attributes
- Get Variable List Attributes
- Get Event Condition Attributes

3-OTHER:

Other statuses can be defined. These statuses should be described in the PICS.

Physical Status:

This attribute gives the hardware status of the device

List of capabilities:

This attribute enables defining a set of characteristics specific to the VMD.

List of program invocations:

This attribute gives the set of invocation programs belonging to the VMD. The program invocations can be predefined in the VMD or created dynamically by a specific Sub-MMS service or following a domain loading.

List of domains:

This attribute gives the set of Domains belonging to the VMD. The domains can be predefined in the VMD or created dynamically by the loading services of the SUB-MMS domains.

List of variables:

This attribute gives the set of objects of the variable class belonging to the VMD. The variables can be predefined in the VMD or created dynamically following a domain loading.

List of variable lists

This attribute gives the set of object variable lists belonging to the VMD. The variable lists can be predefined in the VMD or created dynamically by a specific Sub-MMS service or following a domain loading.

List of events:

This attribute gives the set of events belonging to the VMD. The events could be predefined in the VMD or created dynamically following a domain loading.

Additional detail:

This attribute can contain additional information

Besides the VMD object defined above, the Sub-MMS application layer also supports the objects mentioned below:

- Domain objects,
- Program Invocation objects,
- Variable objects,
- Variable list objects,
- Event objects…

The C.S can introduce other classes of objects.

6.2.2.4 Services

6.2.2.4.1 Confirmed initiate service

6.2.2.4.1.1 Functionality

The initiate service should be used to establish the environment of the Sub-MMS (association) in order to authorize the exchange of information between two users of the Sub-MMS according to their resources and requirements.

6.2.2.4.1.2 Service primitives

The structure of the service is shown in Table 32.

Table 32 – Confirmed initiate service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument				
Quality of service calling	M	M (=)		
Extension Calling	C	C (=)		
Proposed Max Serv Outstanding Calling	M	M		
Proposed Max Serv Outstanding Called	M	M		
Proposed Data Structure Nesting	M	M		
Init Request Detail	M	M		
Result(+)			S	S (=)
Quality of service called			M	M (=)
Extension Called			C	C (=)
Negotiated Max Serv Outstanding Calling			M	M (=)
Negotiated Max Serv Outstanding Called			M	M (=)
Negotiated Data Structure Nesting			M	M (=)
Init Response Detail			M	M
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

This parameter should transport the service parameters specific to the initiate service request.

For the parameters of the request primitive, the Sub-MMS supplier in the calling system can reduce the values supplied by the calling Sub-MMS user. For the parameters of the indication primitive, the supplier of the Sub-MMS in the called system can reduce the values supplied by the InitiateRequestPDU except for the Indication Services Support Calling parameter. The reduction of the values should follow the reduction rules as defined in the parameter descriptions. No other modification of these values is authorized.

NOTE The fact of authorizing the service suppliers to reduce the values proposed by the users, gives a mechanism which can be used to check the adequation of the values given by the user to the resources of the service supplier. Its implementation is a local problem.

Quality of the calling service:

This parameter should indicate the choice of the service quality. This standard distinguishes between two service qualities. The level 1 service quality is reserved for communications without object access protection. Whereas the level 2 quality is that using object access protection. In this case, an access right verification mechanism is installed and checks the compatibility of the Password and Access Groups parameters provided during invocation of the Initiate service request, with the parameters Password, Access Groups and Access Rights of the objects which are accessed by the calling user.

The information necessary for the service 2 quality are those supplied in the Extension Calling parameter.

New service qualities can be specified. We recommend that the information necessary for these new service qualities are provided in the Extension calling parameter.

Extension calling:

The structure of this parameter is shown in Table 33.

Table 33 – Detailed structure of the extension calling parameter

Parameter name: Extension Calling	**Req**	**Ind**
Quality of service 1	C	C (=)
Null	M	M (=)
Quality of service 2	C	C (=)
Password	M	M (=)
Access Groups	M	M (=)
Others Qualities of service	C	C (=)
Local Detail Calling	U	U (=)

Password:

This parameter, present for service 2 quality, defines the password, unique for any association. It will be used for access to all the objects of the called user on this association. If access by a password is not requested, this parameter should take value 0.

Access groups:

This parameter, present for a ,service 2 quality, defines the access groups to which the calling user belongs. This belonging is applied for the access to all the objects of the Server on this association.

Local detail calling:

This parameter can specify information concerning the service quality extensions.

Proposed max serv outstanding calling:

This parameter, proposed by the calling user, should identify the maximum number of indications of confirmed services waiting for a response on the calling user side on this association.

The value of this parameter can be reduced by the supplier of the Sub-MMS service (this will then be different in the service indication).

Proposed max serv outstanding called:

This parameter, proposed by the calling user, should identify the maximum number of indications of confirmed services awaiting response from the called user on this association.

The value of this parameter can be reduced by the supplier of the Sub-MMS service (this will then be different in the service indication).

Proposed data structure nesting:

This parameter should indicate the maximum number of overlapping levels in the data structures used on this association between the two users of the Sub-MMS. The value of this parameter can be reduced by the supplier of the Sub-MMS service. The value taken by this parameter should be higher than or equal to 1.

Init Request detail:

The structure of this parameter is shown in Table 34.

Table 34 – Detailed structure of the init request detail parameter

Parameter name: Init Request Detail	Req	Ind
Proposed Version Number	M	M
Proposed Parameter CBB	M	M
Indication Services Support Calling	M	M
Extension	U	U (=)
Request Services Support Calling	M	M (=)
Access by Name Support Calling	M	M (=)

Proposed version number:

This parameter specifies the minor revision number of the Sub-MMS protocol services proposed by the calling user.

The value of this parameter can be reduced by the supplier of the Sub-MMS service (this will then be different in the service indication) but should always be higher than 1.

Proposed parameter CBB:

This parameter should specify the negotiated set of conformity parameters relative to the variables (CBBs) which will be supported on this association. The value of this parameter in the service indication primitive should represent the intersection between the set of CBBs supported by the calling user and the set of CBBs supported by the supplier of the Sub-MMS service.

Indication services support calling:

This parameter defines the indications of services supported by the calling user. The value of this parameter can be reduced by the supplier of the Sub-MMS service supplier of the calling user.

Extension:

This parameter, if present, includes two items of information: Request Services Support Calling and Access by Name Support Calling.

Request services support calling:

This parameter defines the requests of services supported by the calling user.

Access by name support calling:

This parameter defines if the access to the objects by their name is supported by the calling user as requester or responder of the service.

Result(+)

This selection indicates that the requested service has been executed with success. In this case the following parameters should be entered:

Quality of called service:

This parameter should indicate the choice of the called user in terms of service quality. This standard distinguishes two qualities of service. The level 1 quality service is reserved for communications without access protection for the objects whereas the level 2 quality service is that using access protection for the objects. In this case, a mechanism to check the access rights is installed and checks the compatibility of the Password and Access Group parameters provided during the invocation of the initiate service request with the Password, Access Groups and Access Rights parameters of the objects which are accessed by the called user.

The information necessary for the quality of service 2 are supplied in the Extension Called parameter.

New service qualities can be specified. We recommend that the information necessary for these new service qualities are supplied in the Extension called parameter.

Extension called:

The structure of this parameter is shown in Table 35.

Table 35 – Detailed structure of the extension called parameter

Parameter name: **Extension Called**	**Rsp**	**Cnf**
Quality of service 1	C	C (=)
Null	M	M (=)
Quality of service 2	C	C (=)
Password	M	M (=)
Access Groups	M	M (=)
Others Qualities of service	C	C (=)
Local Detail Called	U	U (=)

Password:

This parameter, present for a service 2 quality, defines the password, unique for all associations. It will be used for access to all the objects of the calling user on this association. If access with the help of the password is not requested, this parameter should take value 0.

Access groups:

This parameter, present for a service 2 quality, defines the access groups to which the calling user belongs. This belonging applies for the access to all the objects of the calling user on this association.

Local detail called:

This parameter can specify the information concerning the service quality extensions.

Negotiated max serv outstanding calling:

This parameter should identify the maximum number of indications of confirmed services waiting for a response on the calling side of this association.

The value of this parameter can be reduced in the response primitive with respect to the value contained in the indication primitive.

Negotiated max serv outstanding called:

This parameter should indicate the maximum number of indications of confirmed services waiting for a response on the called side of this association.

The value of this parameter should be reduced in the response primitive with respect to the value contained in the indication primitive.

Negotiated data structure nesting:

This parameter should indicate the maximum number of confirmed services waiting for a response on the side of the called party in this association.

The value of this parameter should be reduced in the response primitive with respect to the value contained in the indication primitive.

Negotiated data structure nesting:

This parameter should indicate maximum number of nesting levels in the data structures used on this association between the two users of the Sub-MMS.

The value of this parameter can be reduced in the response primitive with respect to the value contained in the indication primitive. The value taken by this parameter should be greater than or equal to 1.

Init response detail:

The structure of this parameter is shown in Table 36.

Table 36 – Detailed structure of the init request detail parameter

Parameter name: **Init Response Detail**	**Req**	**Cnf**
Negotiated Version Number	M	M (=)
Negotiated Parameter CBB	M	M (=)
Indication Services Support Called	M	M
Extension	C	C (=)
Request Services Support Called	M	M (=)
Access by Name Support Called	M	M (=)

Negotiated version number:

This parameter specifies the minor revision number of the Sub-MMS protocol proposed by the called user.

The value of the parameter should be less than or equal to the proposed value; but should always be higher than 1.

Negotiated parameter CBB:

This parameter should specify the negotiated set of CBBs which will be supported on this association. The value of this parameter in the service response primitive should represent the intersection between the set of CBBs supported by the called user and the set of CBBs supplied in the indication primitive.

Indication services support called:

This parameter defines the indications of services supported by the called. The value of this parameter can be reduced by the supplier of the Sub-MMS service of the called user.

Extension:

This parameter should be present if the extension parameter is included in the request. This parameter specifies two items of information: Request Services Support Called and Access by Name Support Called.

Requester services support called:

This parameter defines the services supported by the called user.

Access by name support called:

This parameter defines if the access to the objects by their name is supported by the called user as service requester or responder.

Result(-):

This parameter should indicate that the requested service is unsuccessful. The type of error is indicated by the Error Type parameter.

6.2.2.4.1.3 Service procedure

The called user transmits a positive response if he accepts the proposed values or if he is capable of proposing others in compliance with the rules for reduction of the values. Otherwise he transmits a negative response.

The success of the execution of the initial service should result in the establishment of a Sub-MMS environment. If an Initiate Request PDU is received on an existing association, a Reject PDU should be issued with the parameters Reject PDU Type equal to PDU-ERROR and Reject Code equal to ILLEGAL-MAPPING.

NOTE For reasons of simplicity, this document recommends a single abstract syntax and a single transfer syntax per association. Consequently, an Initiate Request PDU will be accepted or refused according to the proposed context.

6.2.2.4.2 Confirmed conclude service

6.2.2.4.2.1 Functionality

The Conclude service can be used to provoke the ordered termination of the Sub-MMS environment. A Sub-MMS user invokes the Conclude service to indicate that he has accomplished the requests which have been scheduled and that no other request will be invoked.

6.2.2.4.2.2 Service primitives

The structure of the Conclude service is shown in Table 37.

Table 37 – Conclude service parameter

Parameter Name	Req	Ind	Rsp	Cnf
Argument				
Result(+)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

There is no parameter specific to this service in the Conclude service request.

Result(+)

This parameter indicates that the requested service has been successfully executed.

Result(-)

This parameter should indicate that the service request has failed. The Error Type parameter indicates the reason for this failure.

6.2.2.4.2.3 Service procedure

Calling procedure:

1 The invocation of the Conclude.Request primitive is forbidden on an association via which a domain loading is in progress and whose "State" attribute of the object domain has a value different from "READY", "IN-USE".

2 After the invocation of the Conclude.Request primitive:

a) the following actions should be performed:

- pass the Sub-MMS environment in the "Relinquishing Sub-MMS Environment" state (Requester),
- continue to invoke the response primitives in order to serve the requests of his correspondent,
- continue to process the received service confirmations.

b) the following constraint should be observed:

- no service request can be invoked besides Abort.

3 After reception of the Conclude.Cnf(+) primitive:

a) the following action should be performed:

– pass the Sub-MMS environment to the "No Sub-MMS Environment" state.

b) the following constraint should be observed:

– no service invocation should be made on this association.

4 After reception of the Conclude.Cnf(-) primitive:

a) the following actions should be performed:

– pass the Sub-MMS environment to the "Sub-MMS Environment" state,
– if necessary, continue to invoke the service primitives.

Called user procedure

1 Following reception of the Conclude.Indication primitive:

a) the following action should be performed:

- pass the Sub-MMS environment to the "Relinquishing Sub-MMS Environment" (Responder)state,

b) the following constraints should be observed:

- answer in priority to the Conclude.Ind primitive.
- no service request can be invoked except Abort.

2 Invoke the Conclude.Response(+) primitive if the following constraints are observed:

– no request is waiting for a response from its correspondent,
– no request made by its correspondent is waiting for a response,
– no domain loading is in progress.
– no saving of a domain is in progress.

a) The following action should be performed:

- switch the Sub-MMS environment to the "No Sub-MMS Environment" state,
- continue, if necessary, to invoke the primitive services.

b) the following constraint should be observed:

- no service invocation should be made on this association.

3 Invoke the Conclude.Response(-) primitive if one of the following constraints is not respected:

– at least one request is waiting for a response of its correspondent,
– at least one request by its correspondent is waiting for a response,
– at least one domain loading is in progress,
– at least one domain saving is in progress.

a) the following actions should be performed:

- pass the Sub-MMS environment to the "Sub-MMS Environment" state,
- if necessary, continue to invoke the service primitives.

NOTE We recommend reserving for the calling user the role of conclude service initiator.

6.2.2.4.3 Unconfirmed abort service

6.2.2.4.3.1 Functionality

The Abort service should be used to quit the Sub-MMS environment without negotiation. The Sub-MMS user should invoke the Abort request primitive to indicate that it wishes to stop the communications on the association immediately and without negotiation. The Sub-MMS Abort service comes from and uses the MCS A_ABORT service. (See projection of the Sub-MMS PDU on the Type 7 MCS services of IEC 61158-6).

NOTE The Abort indication service primitive can also be generated by the supplier of the Sub-MMS service.

6.2.2.4.3.2 Service primitives

The structure of the service is shown in Table 38.

Table 38 – Unconfirmed abort service parameters

Parameter Name	Req	Ind
Argument		
Locally Generated		M
User Information	U	U

Argument

The argument should transport the specific parameters of the Abort service.

Locally Generated

This parameter should indicate if the Abort request has been generated locally by the supplier of the Sub-MMS services, or if the Abort request has been received. This parameter should be filled in by the Sub-MMS supplier.

User Information

This parameter, when present, should contain additional information concerning the reasons for this Abort.

6.2.2.4.3.3 Service procedure

In the case of an Abort initiated by the Sub-MMS user, the correspondent should be informed of this Abort by the reception of an Abort service indication primitive and the Sub-MMS environment should be deleted.

In the case of an Abort initiated by the Sub-MMS supplier, the two correspondents should be informed of this Abort by the reception of Abort Service indication primitives (if this is possible) and the Sub-MMS environment should be deleted.

After destruction of the Sub-MMS environment, all the objects with a specific link with the Sub-MMS environment in question are deleted.

6.2.2.4.4 Unconfirmed reject service

6.2.2.4.4.1 Functionality

The Reject service is a service initialized by the supplier following a protocol error.

The protocol errors of a unconfirmed service or a confirmed service response does not result in the issue of a Reject PDU.

6.2.2.4.4.2 Service primitives

The structure of the service is shown in Table 39.

Table 39 – Unconfirmed reject service parameters

Parameter Name	Ind
Argument	
Detected here	M
Service instance	M
Reject PDU type	M
Reject Code	M

Argument

This argument transports the specific parameters of the Reject service.

Detected here

This parameter, of the Boolean type, informs the user if the protocol error which resulted in the rejection has been detected by the local or remote Sub-MMS supplier. The true value signifies that the protocol error has been detected locally.

Service instance

This parameter should indicate the service instance for which an error has been detected. This parameter is not significant if the reject concerns a ConcludeReqPDU.

Reject PDU type

This parameter should indicate the type of PDU which has caused the protocol error. The PDU-ERROR value should be used when the PDU is not a valid Sub-MMS PDU. The possible values for a PDU-ERROR are a sub-assembly of those defined in the MMS.

The values of the Reject PDU Type selected are:

- CONFIRMED-REQUESTPDU,

- PDU-ERROR,

- CONCLUDE-REQUESTPDU.

Reject code

This parameter should indicate the reason for which the Reject has been issued as a function of the Reject PDU Type parameter values. The possible values for the Reject Code are a sub-set of those defined in MMS.

The Reject Code parameter values selected are

1- For CONFIRMED-REQUESTPDU:

- OTHER

  This code should be used for errors other than those defined in the Sub-MMS standard;

- UNRECOGNIZED-SERVICE

  This code should be used when the service is not supported or is not recognized.

- INVALID-INVOKE-ID

This code should be used when an invocation number does not follow the recommendations of this standard.

- INVALID-ARGUMENT

  This code should be used when an argument of a service does not follow the recommendations of this standard;

- MAX-SERV-OUTSTANDING-EXCEEDED

  This code should be used when the maximum number of confirmed negotiated services which can be waiting is exceeded on receiving a confirmed service request:

- MAX-RECURSION-EXCEEDED

  This code should be used when the received PDU, in the sense of overlapping of the data structures, exceeds that which has been negotiated.

- VALUE-OUT-OF-RANGE

  This code should be used when the received PDU contains one or more parameters whose values exceed those authorized by this standard.

2- For PDU-ERROR:

- UNKNOWN-PDU-TYPE

  This code should be used when the type of PDU received is not recognized or is not supported;

- INVALID-PDU

  This code should be used when the received PDU is syntaxically incorrect and a more detailed processing is impossible because of the seriousness of the error.

- ILLEGAL-MAPPING

  This code should be used when the an Initiate.Request is received via an existing association.

3- For CONCLUDE-REQUESTPDU:

- OTHER

  This code should be used for errors other than those defined in the Sub-MMS standard;

- INVALID-ARGUMENT

  This code should be used when a service argument does not follow the recommendations of this standard.

6.2.2.4.4.3 Service procedure

If a Sub-MMS supplier receives a RejectPDU, it should be shown by an indication of the Reject service to the Sub-MMS user. He can then use the Abort service to end the Sub-MMS environment abruptly.

A supplier of the Sub-MMS should be capable of transmitting a RejectPDU if it receives a PDU which generates a protocol error.

6.2.2.4.5 Confirmed status service

6.2.2.4.5.1 Service primitives

The structure of the service is shown in Table 40.

Table 40 – Confirmed status service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
extended derivation	M	M (=)		
Result(+) (Comp)			S	S (=)
vmd logical status			M	M (=)
vmd physical status			M	M (=)
local detail			U	U (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Extended derivation:

This parameter indicates the method to be applied to provide the response to the Status request. Two distinct methods can be activated. Their definition is a local issue.

Result(+)

VMD logical status:

This parameter provides the VMD Logical Status attribute value.

VMD physical status:

This parameter provides the VMD Physical Status attribute value.

Local detail:

This parameter can contain the additional information on the VMD status specific to a vendor.

Result(-)

The execution of the service ended in failure. The Error type parameter indicates the cause of the failure.

6.2.2.4.5.2 Service procedure

The procedures necessary for the elaboration of different Status are carried out, and a valid response is built.

6.2.2.4.6 Unconfirmed unsolicited status service

6.2.2.4.6.1 Service primitives

The structure of the service is shown in Table 41.

Table 41 – Unconfirmed unsollicited status service parameter

Parameter Name	Req	Ind
Argument (Comp)		
vmd logical status	M	M (=)
vmd physical status	M	M (=)
local detail	U	U (=)

Argument

VMD logical status:

This parameter provides the VMD Logical Status attribute value.

VMD physical status:

This parameter provides the VMD Physical Status attribute value.

Local detail:

This parameter can contain the additional information specific to a vendor concerning the VMD status.

6.2.2.4.6.2 Service procedure

A SUB-MMS user capable of detecting a change of his status, can take the initiative to transmit the new values of his Status without receiving a request.

6.2.2.4.7 Confirmed identify service

6.2.2.4.7.1 Service primitives

The structure of the service is shown in Table 42.

Table 42 – Confirmed identify service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Result(+) (Comp)			S	S (=)
vendor name			M	M (=)
model name			M	M (=)
revision			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

No specific Parameter in the request.

Result(+)

Vendor name:

This parameter provides the VMD object Vendor Name attribute value.

Model name:

This parameter provides the VMD object Model Name attribute value.

Revision:

This parameter provides the VMD object Revision attribute value.

Result(-)

The service execution ended in a failure. The Error type parameter indicates the cause of the failure.

6.2.2.4.7.2 Service procedure

The information necessary for the construction of the positive response are provided by a VMD object.

6.2.2.4.8 Confirmed get name list service

6.2.2.4.8.1 Service primitives

The structure of the service is shown in Table 43.

Table 43 – Confirmed get name list service paramaters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Object class	M	M (=)		
Continue after	M	M (=)		
Result(+) (Comp)			S	S (=)
List of Identification			C	C (=)
List of Description			C	C (=)
More follows			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Object class

The Object class parameter defines the class of the object. The following values can be specified: Null, Domain, Program Invocation, Variable, Variable list, event and the classes of objects defined by the CS.

Continue after

This parameter gives the identification of the object from which the search should be done.

Result(+)

This selection indicates the successful accomplishment of the service.

List of identification:

This parameter is present if the value of the parameter object class is not null.

This parameter gives a list of object identifications belonging to a specified class in the request.

NOTE If an object supports the double identification (name and index), only the index should be restored.

List of object description:

This parameter is present if the value of the parameter class = null.

This parameter gives the description of each object read.

More follows:

This parameter indicates if there are other objects to be identified.

Result(-)

This selection indicates the failure of the service

Error type

This parameter indicates the cause of the failure

6.2.2.4.8.2 Service procedure

If all the operations are carried out successfully, the service provides, in its positive response, a list of object identifications that belong to the required class. If the class is not indicated (null) and if a common object identification space exists, the server then provides the description for each oject. The first identification begins just after the required identification.

In case of failure of any operation the server provides the reason for the failure in a negative response.

Whatever may be the quality of the channel service via which this service is directed, no access restriction should be applied by the object access protection.

6.2.3 Domain ASE

6.2.3.1 Overview

Sub-MMS defines a Domain object which can pre-exist or be created by a Sub-MMS service. The data or the data complement of a Domain object can be loaded or saved by sub-MMS services.

The domain management services are the following:

1 - Delete Domain

2 - Initiate Download Sequence

3 - Download Segment

4 - Terminate Download Sequence

5 - Initiate Upload Sequence

6 - Upload Segment

7 - Terminate Upload Sequence

8 - Get Domain Attribute

NOTE 1 The Delete Domain service can be locally executed.

NOTE 2 An already existing domain is spontaneously created either with all its data or with a part of its data.

6.2.3.2 Domain class specification

6.2.3.2.1 Domain class model

FAL ASE:	**Domain ASE**
CLASS:	Domain
CLASS ID:	not used
PARENT CLASS:	not used
Object: Domain	
(m) Key Attribute:	Domain name
(m) Key Attribute:	Domain index
(m) Attribute:	List of capabilities
(m) Attribute:	State (LOADING, COMPLETE, INCOMPLETE, READY, IN USE)
(m) Attribute:	Predefined (TRUE, FALSE)
(m) Attribute:	Sharable (TRUE, FALSE)
(m) Attribute:	List Of Program Invocation Identification
(m) Attribute:	Upload In Progress
(o) Attribute:	Domain Access Protection
(m) Attribute:	Password
(m) Attribute:	Access Groups
(m) Attribute:	Access Rights
(o) Attribute: Extension	

6.2.3.2.2 Attributes

Domain name, index:

These attributes allow identifying in an unique way the object domain. The types of identifier supported are either the name or the index or both.

State:

This attribute specifies the state of the Domain object in compliance with the state chart described below.

Predefined:

This attribute can take the values TRUE or FALSE. The FALSE value authorises the service Delete Domain to delete the object. In a pre-existent Domain Object this attribute is initialized at TRUE.

Sharable:

This attribute takes the value TRUE if the Domain object can be used in several program invocations simultaneously.

List of program identifications:

This attribute specifies the list of program invocations which use this Domain object. The list contains only a single identification of PI if the Sharable attribute is at FALSE.

Upload In progress:

This attribute indicates the number of uploads being executed on this domain.

Domain access protection:

This attribute indicates if the object supports an access protection.

Password:

This attribute specifies the value of the password accepted for the access rights.

Access groups:

This attribute specifies if the object belongs to a group of users, as shown in Table 44. If one of the bits is set to 1 it indicates the number of the group to which the object belongs.

Table 44 – Access group attribute description for domain object

Bit name	Access group number
G0	Access group 8
G1	Access group 7
G2	Access group 6
G3	Access group 5
G4	Access group 4
G5	Access group 3
G6	Access group 2
G7	Access group 1

Access Rights:

This attribute specifies the access rights associated with the Domain object, as shown in Table 45. Each bit, positioned to 1 indicates the acceptance conditions of the loading, saving or utilization services in a program invocation.

Table 45 – Access rights attribute description for domain object

Name	Significance
R	UPLOAD authorized to clients who have provided a password identical to the Password attribute of the object.
W	DOWNLOAD, Deleting authorized to clients who have provided a password identical to the Password attribute of the object
U	Utilization in a PI authorized to clients who have provided a password identical to the Password attribute of the object
Rg	Upload authorized to clients belonging to one of the groups specified in the Access Rights attribute of the object.
Wg	Download, Deleting authorized to clients belonging to one of the groups specified in the Access Rights attribute of the object
Ug	Utilization in a PI authorized to clients belonging to one of the groups specified in the Access Rights attribute of the object
Ra	Upload authorized to all the clients
wa	Download, Deleting authorized to all the clients
Ua	Utilization in a PI authorized to all the clients

Extension:

This attribute specifies additional information.

6.2.3.3 Services

6.2.3.3.1 Confirmed delete domain service

6.2.3.3.1.1 Functionality

This service allows a client, under certain conditions, to delete an existing domain.

6.2.3.3.1.2 Service primitives

The structure of the service is shown in Table 46.

Table 46 – Confirmed delete domain service parameters

Parameter name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Domain identification:

This parameter specifies the identification by name or by index of a Domain object.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.3.3.1.3 Service procedure

The VMD should perform the following actions:

– check that there is an existing domain with the same identification,
– check that the predefined attribute is set to false,
– check that the Domain is in the ready state and that there is no uploading in progress,
– if the request is transmitted via a channel with the service quality 2, check the compatibility of the access rights of the channel with the password attributes, access group and access rights of the object,
– delete the object Domain in question.

If all the actions are executed with success, a positive report is transmitted, otherwise a negative report is transmitted explaining the reasons for the failure.

6.2.3.3.2 Confirmed initiate download sequence service

6.2.3.3.2.1 Functionality

There are two types of domains, those which are created dynamically by the Initiate Download Sequence service and those which are born partially or completely loaded at power up. In the latter case, the domain is said to be pre-existent.

The Initiate Download Sequence service allows a client to:

1 - initialize the loading of a pre-existent domain if it is in the "predefined" state,

2 - create the domain object then initialize the loading if the domain is inexistent.

6.2.3.3.2.2 Service primitives

The structure of the service is shown in Table 47.

Table 47 – Confirmed initate download sequence service parameters

Parameter name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain Identification	M	M (=)		
List of capabilities	M	M (=)		
Sharable	M	M (=)		
Domain Access Protection	C	C (=)		
Password	M	M (=)		
Access Group	M	M (=)		
Access Right	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Domain identification:

This parameter specifies the identification by name or by index of the domain to be downloaded.

List of Capabilities:

This parameter generally contains specific information concerning limitations of implementation. Its content can be empty.

Sharable:

The "sharable" parameter is a Boolean; if its value is true, the Domain can be divided by several PIs.

Domain Access Protection:

Its presence is compulsory if the service is transmitted via a channel with the quality of service (2).

This parameter specifies the value to be assigned to the Password, Access Groups, Access Rights attributes of the object domain created. If the Domain is of the pre-existent type, this parameter is overlooked.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or is not accepted by the VMD. An error code is provided.

6.2.3.3.2.3 Service procedure

The VMD should

- initialize the loading if the domain is Pre-existent on condition that its status has the "predefined" value,
- create an object domain then initialize the loading if the domain is inexistent,
- check the presence of the Domain Access Protection parameter if the request is transmitted via a channel having service quality 2,
- initialize the attributes of the domain as indicated below:
- initialize the attribute identification with the Name given in parameter or the value of the index if the object domain is created,
- initialize the "status" attribute at the "Loading" value,
- the predefined attribute is initialized at "true" if the domain is preexistent. Otherwise it takes the value "false",
- initialize the "Sharable" attribute in compliance with the sharable parameter,
- initialize the Password, Access Group and Access Right attributes of the created domain in compliance with the Domain Access Protection parameter if it is present in the request. If the domain is of the pre-existent type, its Password, Access Group and Access Right attributes remain unchanged.

If all the actions have been executed successfully, a positive report is transmitted. Otherwise a negative report should be transmitted mentioning the reasons for the failure.

6.2.3.3.3 Confirmed download segment service

6.2.3.3.3.1 Functionality

This service allows the Server to ask the Client for a segment of data of the domain.

6.2.3.3.3.2 Service primitives

The structure of the service is shown in Table 48.

Table 48 – Confirmed download segment service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Load Data			M	M (=)
More Follow			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Domain identification:

This parameter specifies the identification by name or by index of an object Domain.

Result(+)

Load data:

This parameter, of the OCTETSTRING type, specifies the data to be loaded.

More follow:

This parameter of the Boolean type, if "true" informs the VMD that data remains to be loaded.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.3.3.3.3 Service procedure

The Client should perform the following actions:

– prepare a segment of data of the domain for the "Load data" parameter; the segmentation of the data is a local issue,

– correctly position the value of the "more follow" parameter.

If all the actions are successfully executed, a positive report including the "Load data" and "more follow" parameters is transmitted. If not a negative report should be transmitted explaining the reasons for the failure.

6.2.3.3.4 Confirmed terminate download sequence service

6.2.3.3.4.1 Functionality

This service allows the Server:

1 to inform the Client that it is authoritatively stopping the loading because the received data are not consistent,

2 to inform the Client that it has received all the data of the domain and that it has checked their consistency.

6.2.3.3.4.2 Service primitives

The structure of the service is shown in Table 49.

Table 49 – Confirmed terminate download sequence service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain Identification	M	M (=)		
Discard	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Domain identification:

This parameter specifies the identification by name or by index of the Domain.

Discard:

This parameter informs the Client if the loading and consistency of all the data of the domain have been successful, otherwise it indicates the reasons for the failure.

Result(+)

The service is valid and has been correctly executed by the Client.

Result(-)

The service is invalid or has not been accepted by the Client. An error code is provided.

6.2.3.3.4.3 Service procedure

The Server should perform the following actions:

- check that all the data of the domain have been correctly received,
- check the consistency of the data of the domain.

If all the actions have been successfully executed, a request including the parameters "Discard = empty" is transmitted, otherwise a request should be transmitted including the parameter "Discard = reasons for the failure".

In spite of the success of the loading, if the Client answers negatively, the Server should force the status of the domain to the "predefined" value if the latter is of the "pre-existent domain" type. Otherwise it should delete the domain object.

6.2.3.3.5 Confirmed initiate upload sequence service

6.2.3.3.5.1 Functionality

This service allows a Client to upload the data of a domain belonging to a server. This uploading is carried out through an upload object (ULSM) created for this purpose.

6.2.3.3.5.2 Service primitives

The structure of the service is shown in Table 50.

Table 50 – Confirmed initiate upload sequence service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
ULSM Index			M	M (=)
List Of Capabilities			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Domain identification:

This parameter specifies the identification by name or by index of the domain to be saved.

Result(+)

ULSM Index:

This parameter informs the Client of the identification under which the domain saving should take place.

A non-significant value can be transmitted in this parameter to signify that the saving procedure should be performed with identification of the domain.

List of Capabilities:

This parameter generally contains specific information concerning the limitations of implementation. Its content can be empty.

Result(-)

The service is invalid or is not accepted by the VMD. An error code is supplied.

6.2.3.3.5.3 Service procedure

The VMD should perform the following actions:

- check the existence of the domain,
- check that its status has for value "Ready" or "In-Use",
- create an ULSM object and assigning it an identifier called "ULSM index". If the value of the ULSM index is not significant, the continuation of the upload should be done with the identifier forming part of the request.
- prepare the content of the "ULSM index" and "List of capabilities" parameters,
- increment the Upload in Progress attribute of the Domain object.

If all the actions have been executed with success, a positive report including the "ULSM index" and "List of capabilities" parameters is transmitted. Otherwise a negative report should be transmitted including the reasons for the failure.

6.2.3.3.6 Confirmed upload segment service

6.2.3.3.6.1 Functionality

This service allows a client to obtain the content of a Domain.

6.2.3.3.6.2 Service primitives

The structure of the service is shown in Table 51.

Table 51 – Confirmed upload segment service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Upload Identification	M	M (=)		
ULSM Index	S	S		
Domain Identification	S	S		
Result(+) (Comp)			S	S (=)
Load Data			M	M (=)
More Follow			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Upload identification:

This parameter indicates either the identification of the ULSM object of the upload created in the initialization phase or the identification (name or index) of the domain object to be uploaded.

Result(+)

Load Data:

This parameter specifies the data transmitted by the server.

More Follows:

This parameter of the Boolean type has the value "True" if the uploading operation should continue.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.3.3.6.3 Service procedure

The Sub-MMS Server provides in the response the content of a data segment to be uploaded. The More Follow parameter is initialized at FALSE if there is no more information to be transferred.

6.2.3.3.7 Confirmed terminate upload sequence service

6.2.3.3.7.1 Functionality

This service terminates an uploading sequence.

6.2.3.3.7.2 Service primitives

The structure of the service is shown in Table 52.

Table 52 – Confirmed terminate upload sequence service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Upload Identification	M	M (=)		
ULSM index	S	S (=)		
Domain Identification	S	S (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Upload identification:

This parameter indicates either the identification of the upload USLM object created in the initialization phase or the identification (name or index) of the domain object to be uploaded.

Result(+)

The uploading operation is terminated with success.

Result(-)

The service is invalid or has not been accepted by the VMD. An error code is provided.

6.2.3.3.7.3 Service procedure

The Sub-MMS server delets the ULSM upload object dedicated to this operation. It decrements the value of the Upload in Progress attribute.

A negative response is transmitted if the Terminate Upload Request service is received whereas the last segment had been transmitted with the More Follow parameter equal to TRUE.

6.2.3.3.8 Confirmed get domain attribute service

6.2.3.3.8.1 Service primitives

The structure of the service is shown in Table 53.

Table 53 – Confirmed get domain attributes service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Domain Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
List of Identification			M	M (=)
Object Class			M	M (=)
List Of Capabilities			M	M (=)
Domain State			M	M (=)
Predefined			M	M (=)
Sharable			M	M (=)
List Of Program Invocation			M	M (=)
Upload in Progress			M	M (=)
Domain Access Protection			C	C (=)
Password			M	M (=)
Access Group			M	M (=)
Access Right			M	M (=)
Extension			U	U (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Domain identification:

This parameter indicates the identification of a domain object (by name or by index) whose attributes should be retrieved in the response.

Result(+)

This parameter indicates that the attribute retrieval operation has been successfully accomplished.

List of Identification:

This parameter gives the identification of the object

Object class:

This parameter indicates the object class

List Of Capabilities:

This parameter indicates the characteristics of the domain.

Domain State:

This parameter indicates the state of the domain.

Predefined:

This parameter indicates if the domain is predefined.

Sharable:

This parameter indicates if the domain can be shared by several PI objects.

List Of Program Invocation:

This parameter indicates the list of PIs sharing the domain.

Upload in Progress:

This parameter indicates if an upload is in progress.

Domain Access Protection:

This parameter is present if the object supports access protection. In this case it comprises the following information:

Password

This parameter indicates the password for the object.

Access Groups

This parameter indicates the groups to which the object belongs.

Access Rights

This parameter indicates the access rights required to have access to the object.

Extension:

This parameter gives additional information.

Result(-)

The service is invalid or has not been accepted by the VMD. An error code is provided.

6.2.3.3.8.2 Service procedure

The Sub-MMS server performs the following operations:

- to check that there is a domain with the same identification,
- read the attributes of the domain.

If all the operations have taken place correctly, the server provides in its positive response the values of the attributes read.

If one of the operations end in a failure, the server provides in the negative response the reasons for the failure.

Whatever the quality of service of the channel via which this service is routed, no access restriction should be applied via the object access protections.

6.2.3.4 Mechanisms

6.2.3.4.1 State charts

Figure 49 shows the Domain management states and state transitions.

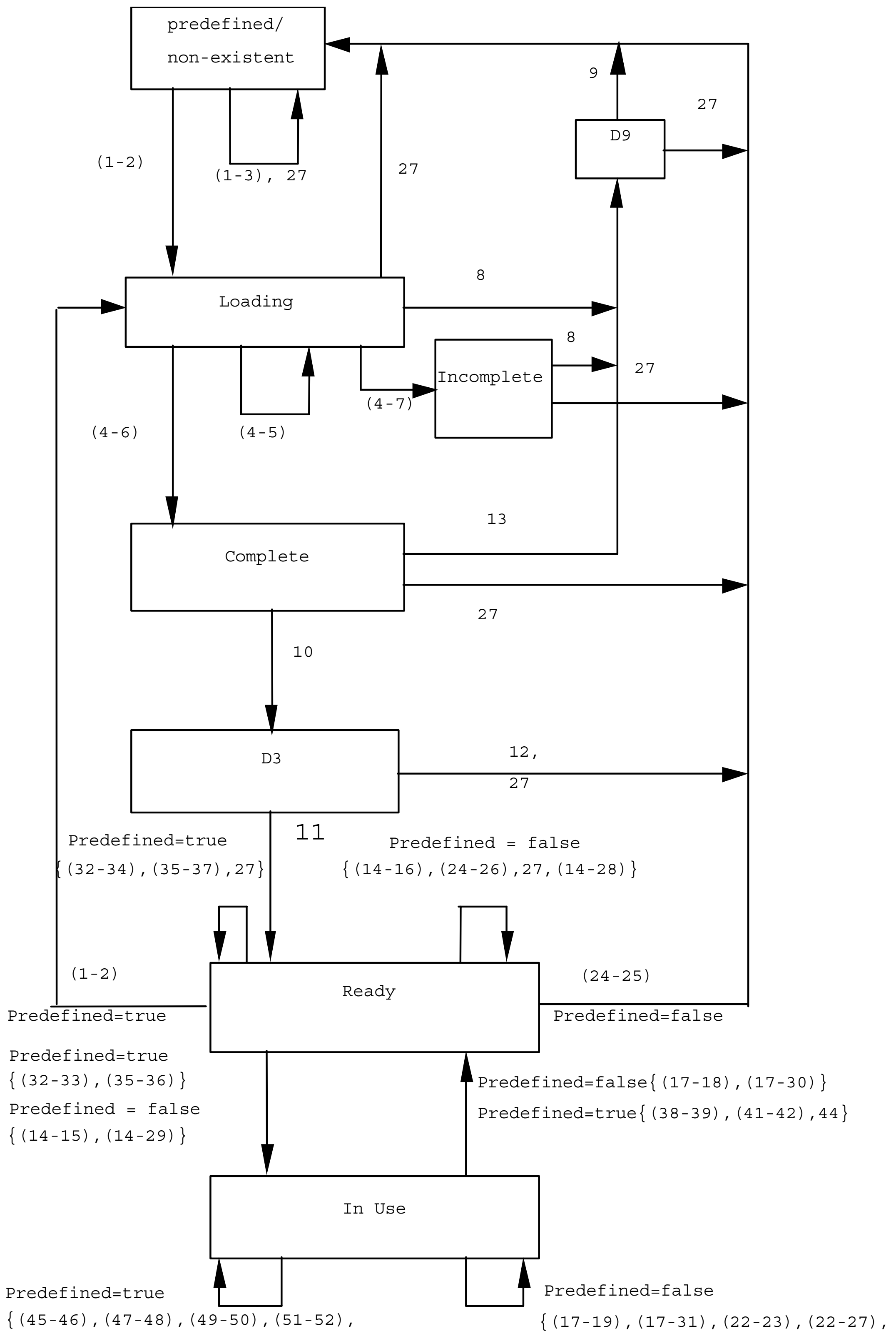


Figure 49 – Domain management state chart

NOTE This state chart is compatible with its MMS and FMS equivalent. The execution of a service indication is done automatically. Consequently only steady states are represented on the diagram. The reading of the attributes of a domain is possible only if the domain is completely loaded. Consequently, only the "ready" or "in-use" states are visible via the network

The transitions are as follows:

1 - Initiate Download Sequence. Indication

2 - Initiate Download Sequence. Response(+)

3 - Initiate Download Sequence. Response(-)

4 - Download Segment. Request

5 - Download Segment. Confirm(+) More follow=true

6 - Download Segment. Confirm(+) More follow=false

7 - Download Segment. Confirm(-)

8 - Terminate Download Sequence. Request Discard present

9 - Terminate Download Sequence. Confirm(+)or (-)

10 - Terminate Download Sequence. Request Discard not present

11 - Terminate Download Sequence. Confirm(+)

12 - Terminate Download Sequence. Confirm(-)

13 - Terminate Download Sequence. Request Discard present

14 - Create Program Invocation. Indication (program count=0)

15 - Create Program Invocation. Response(+)

16 - Create Program Invocation. Response(-)

17 - Delete Program Invocation. Indication (program count=1)

18 - Delete Program Invocation. Response(+)

19 - Delete Program Invocation. Response(-)

20 - Create Program Invocation. Indication (program count> 0)

21 - Create Program Invocation. Response(+) or (-)

22 - Delete Program Invocation. Indication (program count>1)

23 - Delete Program Invocation. Response (+) or (-)

24 - Delete Domain. Indication

25 - Delete Domain. Response(+)

26 - Delete Domain. Response(-)

27 - Abort. Indication

28 - Abort. Indication (program invocation creation failed)

29 - Abort. Indication (program invocation creation succeeded)

30 - Abort. Indication (program invocation deletion succeeded)

31 - Abort. Indication (program invocation deletion failed).

32 - Start.Indication (Program Count = 0)

33 - Start.Response(+)

34 - Start.Response(-)

35 - Resume.Indication (Program Count = 0)

36 - Resume.Response (+)

37 - Resume.Response (-)

38 - Stop.Indication (Program Count = 1)

39 - Stop.Response (+)

40 - Stop.Response (-)

41 - Kill.Indication (Program Count = 1)

42 - Kill.Response (+)

43 - Kill.Response (-)

44 - Program Stopped or End of Program (Program Count = 1)

45 - Start.Indication (Program Count > 0)

46 - Start.Response (+) or (-)

47 - Resume.Indication (Program Count > 0)

48 - Resume.Response (+) or (-)

49 - Stop.Indication (Program Count > 0)

50 - Stop.Response (+) or (-)

51 - Kill.Indication (Program Count > 0)

52 - Kill.Response (+) or (-)

53 - Program Stopped or End of Program (Program Count > 0).

NOTE This flowchart is compatible with its MMS and FMS equivalent. The service indications for the server are executed automatically. Consequently, only the stable states are included in the flowchart.

Figure 50 shows the Domain upload states and state transitions.

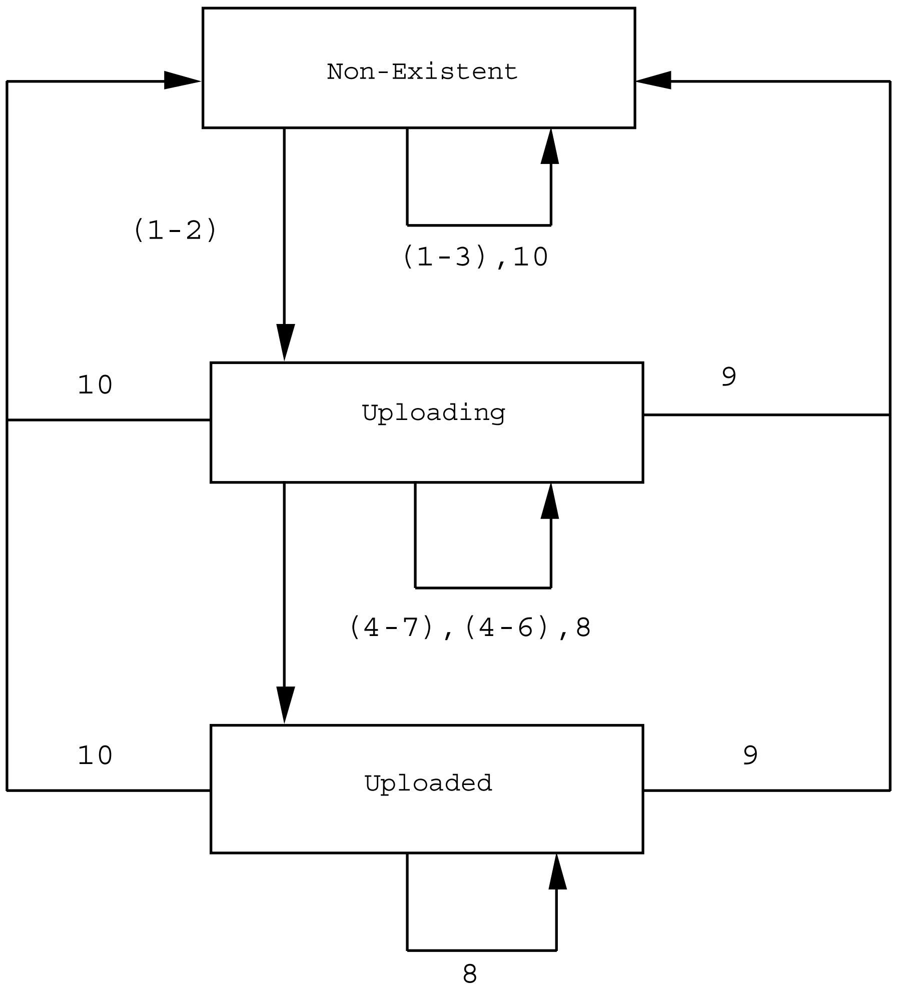


Figure 50 – Domain upload flowchart

Description of the Transitions

1 - Initiate Upload Sequence.Indication

2 - Initiate Upload Sequence.Response(+)

3 - Initiate Upload Sequence.Response(-)

4 - Upload Segment.Indication

5 - Upload Segment.Response(+) more follows = false

6 - Upload Segment.Response(+) more follows = true

7 - Upload Segment.Response(-)

8 - Terminate Upload Sequence.Indication

9 - Terminate Upload Sequence.Response (+) or (-)

10 - Abort.Indication or Abort.Request

6.2.3.4.2 Sequencing of the services

The Initiate Download Sequence, Download Segment and Terminate Download Sequence services should observe the sequence shown in Figure 51.

CLIENT	SERVER
Initiate Download Sequence.Request	----------->
<--------	Initiate Download Sequence.Response
<--------	Download Segment.Request
Download Segment.Response	------------>
••••••••••	••••••••••
••••••••••	••••••••••
<-------	Terminate Download Sequence.Request
Terminate Download Sequence.Response	------------>

Figure 51 – Domain download sequence diagram

The Initiate Upload Sequence, Upload Segment and Terminate Upload Sequence should observe the sequence shown in Figure 52.

CLIENT	SERVER
Initiate Upload Sequence.Request	----------->
<--------	Initiate Upload Sequence.Response
Upload Segment.Request	----------->
<--------	Upload Segment.Response
••••••••••	••••••••••
••••••••••	••••••••••
Terminate Upload Sequence.Request	------------>
<---------	Terminate Upload Sequence.Response

Figure 52 – Domain upload sequence diagram

6.2.4 Program invocation (PI) ASE

6.2.4.1 Overview

Sub-MMS defines an object "Program invocation" which can be created/deleted either by the adequate Sub-MMS services or by a local initiative.

The creation of a PI by the Create PI service and the deleting of a PI by the Delete or Kill services is done atomically (not interruptible by another service)

1 - Create Program Invocation

2 - Delete Program Invocation

3 - Start

4 - Stop

5 - Resume

6 - Reset

7 - Kill

8 - Get Program Invocation Attributes

6.2.4.2 Program invocation class specification

6.2.4.2.1 Program invocation model

FAL ASE:	**Program invocation ASE**
CLASS:	Program invocation
CLASS ID:	not used
PARENT CLASS:	not used
Object: Program Invocation	
(m) Key Attribute:	PI name
(m) key Attribute:	PI index
(m) Attribute:	PI state (IDLE, STARTING, RUNNING, STOPPING, STOPPED, RESUMING, RESETTING, UNRUNNABLE)
(m) Attribute:	List of Domain identification
(m) Attribute:	Sub-MMS Deletable (True, false)
(m) Attribute:	Reusable(true, false)
(m) Attribute:	Execution Argument
(o) Attribute:	PI Access Protection
(m) Attribute:	Password
(m) Attribute:	Access Groups
(m) Attribute:	Access Rights
(o) Attribute:	Extension

6.2.4.2.2 Attributes

PI Name and index:

These attributes allow unique identification of a Program Invocation object. The types of identifier supported are either a name, or an index or both.

PI State:

This attribute specifies the state of the PI object in compliance with the status diagram described below.

List of Domain Identification:

This attribute specifies the list of Domain objects which compose this program invocation.

Sub-MMS Deletable:

The attribute can take the TRUE or FALSE values. The TRUE value authorizes the Delete PI service to delete the object.

Reusable:

This attribute indicates if the program invocation passes after execution in the IDLE or UNRUNNABLE state. The TRUE value signifies a transition towards the IDLE state and the FALSE value a transition towards the UNRUNNABLE state.

Execution Argument:

This attribute specifies information concerning execution of the program.

PI Access Protection:

This attribute indicates if the object supports the access protection.

Password:

This attribute specifies the value of the password accepted for the access rights.

Access Groups:

This attribute specifies if the object belongs to a group of users, as shown in Table 54. If one of the bits is set to 1, it indicates a group number to which the object belongs.

Table 54 – Access group attribute details for program invocation object

Bit name	Access group number
G0	Access group 8
G1	Access group 7
G2	Access group 6
G3	Access group 5
G4	Access group 4
G5	Access group 3
G6	Access group 2
G7	Access group 1

Access Rights:

This attribute specifies the access rights associated with the Program Invocation object, as shown in Table 55. Each bit set to 1 indicates the acceptance conditions for the services starting, stopping or deleting a program invocation.

Table 55 – Access rights attribute details for program invocation object

Bit name	Significance
S	The Start, Resume, Reset operation is authorized for clients who have provided a password identical to the password attribute of the object
H	The STOP operation is authorized for clients who have provided a password identical to the password attribute of the object
D	PI deletion (Kill, Delete PI) is authorized for clients who have provided a password identical to the password attribute of the object
Sg	The Start, Resume, Reset operation is authorized for clients who belong to one of the groups specified in the Access Groups attribute of the object
Hg	The STOP operation is authorized for clients who belong to one of the groups specified in the Access Groups attribute of the object
Dg	Deletion of the PI (Kill, Delete PI) is authorized for clients belonging to one of the groups specified in the Access Groups attribute of the object
Sa	The Start, Resume, Reset operation is authorized for all the clients
Ha	The STOP operation is authorized for all the clients
Da	Destruction of the PI (Kill, Delete PI) is authorized for all the clients

Extension:

This attribute specifies additional information.

The status chart of a PI is identical to its MMS equivalent. However, in order to make the chart more legible, the intermediate states P1, P2, P3 and P4 concerning the KILL service are not included in the chart. We recall that the Create-PI, Delete-Pi and Kill services should be executed automatically (not interruptible by a service). The intermediate states are never visible via the network and their absence does not change the dynamic behaviour or a PI.

6.2.4.3 Services

6.2.4.3.1 Confirmed create program invocation service

6.2.4.3.1.1 Functionality

The purpose of this service is to allow a client to create, in a VMD, a PI object attached to several Domains.

6.2.4.3.1.2 Service primitives

The structure of the service is shown in Table 56.

Table 56 – Confirmed create program invocation service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Proposed PI Identification	M	M (=)		
List Of Domain Identification	M	M (=)		
Reusable	M	M (=)		
PI Access Protection	C	C (=)		
Password	M	M (=)		
Access Groups	M	M (=)		
Access Rights	M	M (=)		
Extension	U	U (=)		
Result(+) (Comp)			S	S (=)
Final PI Index			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Proposed PI identification:

This parameter specifies the identification proposal per name or per index to be assigned by the VMD to the PI object after creation.

List of Domain Identification:

This parameter specifies the identifications by name or by index of the domains to be attached to the created PI object. The limitation of the number (1 to n) of the domains attached to a local issue.

Reusable:

The "Reusable" parameter should be a Boolean; if its value is true, PI can be executed several times.

PI Access Protection:

This parameter specifies the value of the Password, Access Groups, Access Rights attributes to be assigned to the created PI object.

Its presence is mandatory if the service is transmitted via a channel with the quality of service (2).

Extension:

This parameter gives additional information.

Result(+)

Final PI index:

This parameter allows a server to transmit the definitive index value assigned to the created PI object. This index can take a non-significant value to indicate to the client that the identification proposed by name or by index is accepted.

A PI whose proposed identification is a name could always be identified by this name whatever the value of the Final-PI-index parameter.

Result(-)

This service is invalid or not accepted by the VMD. An error code is provided.

6.2.4.3.1.3 Service procedure

The VMD should

- check that there is no PI with the same identification,
- check that all the domains to be attached to the PI exist and satisfy one of the two conditions: READY state, IN USE state, with the sharable attribute set to TRUE,
- if the request is transmitted via a channel with the service 2 quality, check the presence of PI Access Protection parameter and its compatibility with the password attributes, access groups and access rights of the related domains,
- create a PI object and initialize its attributes as indicated below:
- the identification attribute is initialized with the Name given in parameter or the index value selected (proposed or final) or with both,
- the "state" attribute is initialized to the IDLE value,
- the List of Domain identification attribute is initialized in compliance with the List of Domain Identification parameters,
- the Deletable Sub-MMS attribute is initialized to the TRUE value,
- the "reusable" attribute is initialized in compliance with the Reusable parameter,
- the execution attribute argument is initialized at one empty octet chain,
- the attributes Password, Access Groups and Access Rights attributes are initialized in compliance with the PI Access Protection parameter if it is present in the request,
- Initialize to the value IN USE the state of the domains related to the PI whose value is READY.

If all the actions have been executed with success, a positive report including, if necessary, a final PI index, is transmitted. Otherwise a negative report including the reasons for the failure should be transmitted.

6.2.4.3.2 Confirmed delete program invocation service

6.2.4.3.2.1 Functionality

This service allows deletion of an object of the PI type in a VMD.

6.2.4.3.2.2 Service primitives

The structure of the service is shown in Table 57.

Table 57 – Confirmed delete program invocation service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Program Invocation Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.4.3.2.3 Service procedure

The VMD should

- check that there is a PI with the same identification,
- check that the PI is located in one of the following states: IDLE, UNRUNNABLE, STOPPED,
- check that the "Sub-MMS" deletable" attribute is true,
- check the compatibility of the access rights of the channel with the password, access group and access rights attributes of the object if the request is transmitted via a channel with the quality of service 2,
- delete the identification of this PI in the Domain objects composing it,
- delete the PI object in question.

If all the actions are executed successfully, a positive report is transmitted, otherwise a negative report indicating the reasons for the failure should be transmitted.

6.2.4.3.3 Confirmed start service

6.2.4.3.3.1 Functionality

This service allows a Client to activate execution of a PI with a server.

6.2.4.3.3.2 Service primitives

The service structure is shown in Table 58.

Table 58 – Confirmed start service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Program Invocation Identification	M	M (=)		
Execution Argument	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
Program Invocation State			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Execution argument:

The content of the parameter can be empty.The definition of its contents is a local issue.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid and has not been accepted by the VMD. An error code and the state of the PI are provided.

6.2.4.3.3.3 Service procedure

The VMD should

- check that there is a PI with the same identification,
- check that the PI is in the "Idle" state,
- initialize the Execution Argument attribute of the PI object with the Execution Argument parameter value.

If the request is transmitted via a channel with the quality of service 2, check the compatibility of the channel access rights with the password, access groups and access rights attributes of the object.

– Start the execution of the PI object in question.

If all the actions are executed with success, a positive report is transmitted, otherwise a negative report should be transmitted indicating the reasons for the failure.

6.2.4.3.4 Confirmed stop service

6.2.4.3.4.1 Functionality

This service allows a client to stop execution of a PI at a server.

6.2.4.3.4.2 Service primitives

The structure of the service is shown in Table 59.

Table 59 – Confirmed stop service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Program Invocation Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
Program Invocation State			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or has been accepted by the VMD. An error code and the PI state are provided.

6.2.4.3.4.3 Service procedure

The VMD should

– check that there is a PI with the same identification,

– check that the PI is in the RUNNING state, it then transits to the STOPPING state,

– check the compatibility of the access rights of the channel with the password, access groups and access rights attributes of the object if the request is transmitted via a channel having the quality of service 2,

– stop the execution of the PI object in question.

If all the actions are executed with success, a positive report is transmitted and the object PI is placed in the STOPPED state. Otherwise a negative report should be transmitted explaining the reasons for the failure and object PI response to the RUNNING state.

6.2.4.3.5 Confirmed resume service

6.2.4.3.5.1 Functionality

This service allows a Client to resume execution of a PI at a Server from its actual stopping point.

6.2.4.3.5.2 Service primitives

The structure of the service is shown in Table 60.

Table 60 – Confirmed resume service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)		=		
Program Invocation Identification	M	M (=)		
Execution Argument	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
Program Invocation State			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Execution argument:

The content of the parameter can be empty.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or has not been accepted by the VMD. An error code and the PI state are provided.

6.2.4.3.5.3 Service procedure

The VMD should

- check that there is PI with the same identification,
- check that the PI is located in the STOPPED state, it then transits to the RESUMING state,
- check the compatibility of the access rights of the channel with the password attributes, access groups and access rights of the object if the request is transmitted via a channel with the quality of service 2,
- resume execution of the PI object in question.

If all the actions are executed with success, a positive report is transmitted and the object PI takes the RUNNING state, otherwise a negative report should be transmitted explaining the reasons for the failure, the object PI can be placed in the UNRUNNABLE or STOPPED state as required.

6.2.4.3.6 Confirmed reset service

6.2.4.3.6.1 Functionality

This service allows resetting a PI at a server in view of a possible start-up on condition that the "Reusable" attribute has the value "TRUE".

6.2.4.3.6.2 Service primitives

The structure of the service is shown in Table 61.

Table 61 – Confirmed reset service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Program Invocation Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
Program Invocation State			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Result(+)

The service is valid and has been correctly executed by the VMD.

Result(-)

The service is invalid or not accepted by the VMD. An error code and the state of the PI are provided.

6.2.4.3.6.3 Service procedure

The VMD should

- check that there is a PI with the same identification,
- check that the PI is in the STOPPED state, it then transits to the RESETTING state,
- check the compatibility of the access rights of the channel with the password, access groups and access rights attributes of the object if the request is transmitted via a channel with the quality of service 2,
- reset the PI object in question.

If all the actions are executed with success, a positive report is transmitted and the object is placed in the IDLE state. Otherwise a negative report should be transmitted explaining the reasons for the failure. The PI can be placed in the UNRUNNABLE or STOPPED state as required.

6.2.4.3.7 Confirmed kill service

6.2.4.3.7.1 Functionality

This service allows forcing a PI at a server to the "Unrunnable" state in view of deletion.

6.2.4.3.7.2 Service primitives

The structure of the service is shown in Table 62.

Table 62 – Confirmed kill service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Program Invocation Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

PI identification:

This parameter specifies the identification by name or by index of a PI object.

Result(+)

The service is valid and has been executed correctly by the VMD.

Result(-)

The service is invalid or has not been accepted by the VMD. An error code is provided.

6.2.4.3.7.3 Service procedure

The VMD should

- check that there is a PI with the same identification,
- check that the PI is located in one of the following states: IDLE, STARTING, RUNNING, STOPPING, RESUMING, STOPPED, RESETTING,
- check the compatibility of the access rights of the channel with the password, access groups and access rights attributes of the object if the request is transmitted via a channel with the quality of service 2,
- force the PI state to the "Unrunnable" value.

If all the actions are executed with success, a positive report is transmitted, otherwise a negative report should be transmitted indicating the reasons for the failure.

Argument

PI identification:

This parameter specifies the identification by name or by index of an object PI.

Result(+)

This selection indicates that the service has been correctly executed by the VMD.

List of identifications:

This parameter gives the identifiers of the PI object.

Object class:

This parameter indicates the class of the object.

Program Invocation State

This parameter indicates the state of the PI.

List Of Domain Identification

This parameter indicates the list of domains attached to the PI.

Sub-MMS Deletable

This parameter indicates if the PI is deletable.

Reusable

This parameter indicates if the PI is rexecutable.

Execution Argument

This parameter indicates the last value supplied as argument either by the Start service or by the Resume service.

PI Access Protection

This parameter is present if the object supports the access protections. In this case it includes the following information:

Password

This information indicates the password of the object.

Access Groups

This information indicates the groups to which the object belongs.

Access Rights

This information indicates the access rights required to obtain access to the object.

Extension:

This parameter gives additional information.

Result(-)

This selection indicates that the service is invalid or not accepted by the VMD.

Error Type

This parameter indicates the reason for the failure.

6.2.4.3.7.4 Service procedure

The VMD should

- check that there is a PI with the same identification,
- read the PI attributes.

If all the actions are successfully executed, a positive report is transmitted, otherwise a negative report should be transmitted explaining the reasons for the failure.

Whatever the quality of the service on the channel by which this service is conveyed, no access restriction should be applied via the object access protections.

6.2.4.4 Mechanisms

Figure 53 shows the Program invocation states and state transitions.

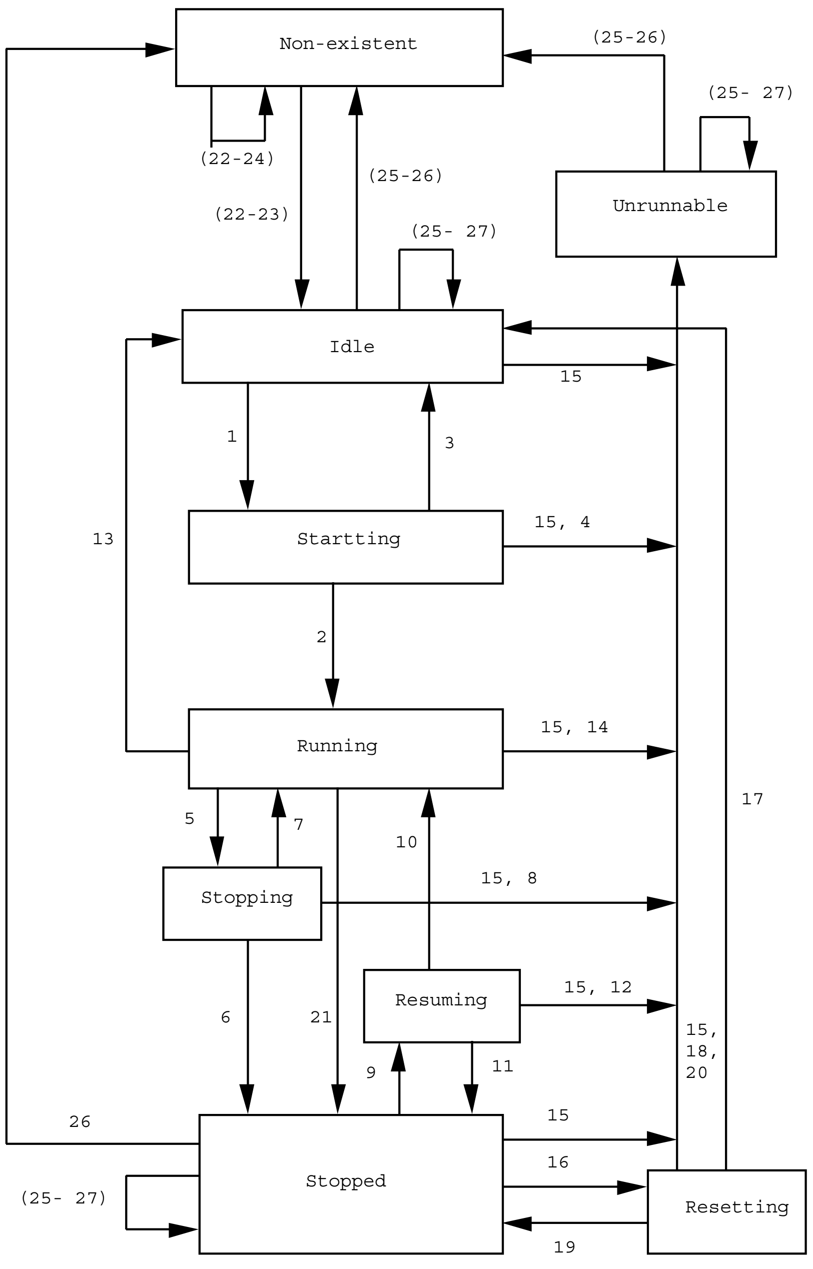


Figure 53 – Program invocation state chart

Description of the transitions:

1 - Start.Indication

2 - Start.Response(+)

3 - Start.Response(-) non-destructive

4 - Start.Response(-) destructive

5 - Stop.Indication

6 - Stop.Response(+)

7 - Stop.Response(-) non-destructive

8 - Stop.Response(-) destructive

9 - Resume.Indication

10 - Resume.Response(+)

11 - Resume.Response(-) non-destructive

12 - Resume.Response(-) destructive

13 - (end of program) & Reusable=true

14 - (end of program) & Reusable=false

15 - Kill.Response(+)

16 - Reset.Indication

17 - Reset.Response(+) Reusable=true

18 - Reset.Response(+) Reusable=false

19 - Reset.Response(-) non-destructive

20 - Reset.Response(-) destructive

21 - (program stopped)

22 - CreateProgramInvocation.Indication

23 - CreateProgramInvocation.Response(+)

24 - CreateProgramInvocation.Response(-)

25 - DeleteProgramInvocation.Indication

26 - DeleteProgramInvocation.Response(+)

27 - DeleteProgramInvocation.Response(-)

6.2.5 Variable ASE

6.2.5.1 Overview

The Sub-MMS defines two classes of objects:

– The Variable object which specifies the access to a simple or structured variable,
– The Variable-List object which specifies access to a series of variable objects.

These two objects can be identified either by name or by index or by both.

Five Sub-MMS services enable manipulating these objects. Total access and partial access are authorized on a Variable object.

The CS can introduce other objects.

The variable management services are as follows:

1 - Read (list of variables or a variable-list)

2 - Write (list of variables or a variable-list)

3 - Information Report (list of variables or a variable-list)

4 - Define Variable-List (a variable-list)

5 - Delete Variable-List (a variable-list)

6 - Get Variable Access Attributes

7 - Get Variable List Attributes

6.2.5.2 Variable class specification

6.2.5.2.1 Variable class model

A variable object is never created or deleted by Sub-MMS services. These operations are local issues.

FAL ASE:	**Variable ASE**
CLASS:	**Variable**
CLASS ID:	not used
PARENT CLASS:	not used
Object: Variable-	
(m) Key Attribute:	Variable Name
(m) key Attribute:	Variable Index
(m) Attribute:	Type Description
(o) Attribute:	Variable Access Protection
(m) Attribute:	Password
(m) Attribute:	Access groups
(m) Attribute:	Access rights
(o) Attribute:	Extension

6.2.5.2.2 Attributes

Variable name et index:

These attributes allow a unique identification of variable object. The types of identifier supported are either name, or index or both.

Type Description:

This attribute specifies the abstract type of the variable. The authorized types are those defined by "Type Data Specification" (except the Error Type) (See 6.2.5.2).

Variable Access Protection:

This attribute specifies if the object supports the access protection.

Password:

This attribute specifies the value of the password accepted for the access rights.

Access Groups:

This attribute specifies if the object belongs to a group of users, as shown in Table 63. If one of the bits is set to 1, it indicates the number of a related group.

Table 63 – Access group attribute details for variable object

Bit name	access group number
G0	access group 8
G1	access group 7
G2	access group 6
G3	access group 5
G4	access group 4
G5	access group 3
G6	access group 2
G7	access group 1

Access Rights:

This attribute specifies the access rights associated with the variable object, as shown in Table 64. Each bit set to 1 indicates the acceptable conditions of a read or write service.

Table 64 – Access rights attribute details for variable object

Bit name	Significance
R	Reading authorized to clients who have provided a password identical to the Password attribute of the object
W	Writing authorized to clients who have provided a password identical to the Password attribute of the object.
Rg	Reading authorized to clients belonging to one of the groups specified in the Access Groups attribute of the object.
Wg	Writing authorized to the clients belonging to one of the groups specified in the Access Groups attribute of the object
Ra	Reading authorized for all the clients
wa	Writing authorized for all the clients

Extension:

This attribute specifies additional information.

6.2.5.2.3 Variable-list class specification

A Variable-List object allows access to a list of objects of the Variable class. Each element of the list is a variable which can be identified either by a name or by an index. The partial access to a variable is not authorized in the definition of an object of the Variable list class.

FAL ASE:	**Variable ASE**
CLASS:	Variable list
CLASS ID:	not used
PARENT CLASS:	not used
(m) Key Attribute:	Variable-List Name
(m) Key attribute:	Variable-List index
(m) Attribute:	Sub-MMS Deletable (True,false)
(m) Attribute:	List of Variable identification
(o) Attribute:	Variable-List Access Protection
(m) Attribute:	Password
(m) Attribute:	Access groups
(m) Attribute:	Access rights
(o) Attribute:	Extension

6.2.5.2.4 Attributes

Variable list Name and index:

These attributes allow unique identification of a variable-list object by using either a name or an index, or both.

Sub-MMS Deletable:

This attribute can take true or false values. The true value authorizes the Delete Variable-List service to delete the object.

List of Variable Identification:

This attribute identifies all the variable objects which compose the object Variable-List. Each object can be identified either by a name or by an index or both.

Variable-List Access Protection

This attribute specifies if the object supports the access protection.

Password:

This attribute specifies the value of the password accepted for the access rights.

Access Groups:

This attribute specifies if the object belongs to a group of users, as shown in Table 65. If one of the bits is set to 1, it indicates the number of group to which it belongs.

Table 65 – Access group attribute details for variable list object

Bit name	access group number
G0	access group 8
G1	access group 7
G2	access group 6
G3	access group 5
G4	access group 4
G5	access group 3
G6	access group 2
G7	access group 1

Access Rights:

This attribute specifies the access rights associated with the variable-list object, as shown in Table 66. Each bit set to 1 indicates the acceptance condition of a read, write or delete service of a variable-list object.

Table 66 – Access right attribute details for variable list objects

Bit name	Significance
R	Reading authorized for clients who have provided a password identical to the Password attribute of the object
W	Writing authorized for clients who have provided a password identical to the Password attribute of the object
D	Deletion authorized for clients who have provided a password identical to the Password attribute of the object
Rg	Reading authorized for clients belonging to one of the groups specified in the Access Groups attribute of the object.
Wg	Writing authorized for clients belonging to one of the groups specified in the Access Groups attribute of the object
Dg	Deletion authorized for clients belonging to one of the groups specified in the Access Groups attribute of the object
Ra	Reading authorized for all the clients
wa	Writing authorized for all the clients
Da	Deletion authorized for all the clients

Extension:

This attribute specifies additional information.

6.2.5.3 Services

6.2.5.3.1 Confirmed read service

6.2.5.3.1.1 Functionality

This service is used by a client to request from a VMD either the global/partial reading of one or several variables or the reading of a variable-list.

The limitation by the server of the number of variables to be read in one service invocation (1 to n) is a local issue.

6.2.5.3.1.2 Service primitives

The structure of the service is shown in Table 67.

Table 67 – Confirmed read service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Type With result	M	M (=)		
Variable Access Specification	M	M (=)		
Result(+) (Comp)			S	S (=)
List Of Access Result			M	M (=)
List Of Type Data Specification			C	C (=)
List Of Data Value			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Type With result:

This parameter indicates if the types of variables read should be supplied in the positive response.

Variable Access Specification:

This parameter describes the identification of several variables, elements of variables or of one variable-list to be accessed.

Result(+)

This selection specifies that at least one reading of variable has been carried out with success.

list of Access Results

The list of access results parameter specifies the lists of failures/successes of all the variables read, observing the order given by the Variable Access Specification Parameter. In case of reading of a variable list object, the order of the results is consistent with the description of that object.

List of Type Data Specification:

The content of this parameter is empty if the parameter Type With result of the request is equal to false.

The parameter List of Type Data Specification specifies the descriptors of the type of variables read with success or the descriptor of the ErrorType for the variables read with failure. This information is supplied observing the order given in the Variable Access Specification parameter. In case the variables are of the same type, the list can be reduced to a single description. The authorized types are thus those defined by "Type Data Specification" (See 6.2.5.2).

List Of Data Values:

The List of Data Values parameter specifies the data corresponding to the values of the variables read with success and the error data of the ErrorType for the variables read with failure. This information is supplied according to the order in the Variable Access Specification parameter or in the description of the Variable-List object. (See 6.2.5.2.3 for the authorized variable values).

Result(-)

The service is invalid or not accepted by the VMD. An error code is formed.

6.2.5.3.1.3 Service procedure

For each variable read, the VMD provides a data and a report of the operation, observing the order indicated in the request. It analyses the value of the parameter Type With Result to determine whether it should provide in the response, the description of the type of each variable read.

For a reading operation performed on a channel using access protections (quality of service 2) the VMD should check before each operation of elementary reading, the consistency of the access rights.

For each variable read with success, the VMD provides a positive indicator in the List of Access result, its descriptor type, if necessary, in List of Type data Specification and its value in List of Data Values.

For each variable read unsuccessfully, the VMD provides an error indicator in the List of Access Results, the descriptor of the Error Type in the List of Type data Specification and the value of the error in the list of data values.

6.2.5.3.2 Confirmed write service

6.2.5.3.2.1 Functionality

This service is used by a client to write the global or partial value of one or several variables or the value of a Variable List object.

The limitation by the server of the variable numbers (1 to n) to be written in a service invocation is a local issue.

6.2.5.3.2.2 Service primitives

The structure of the service is shown in Table 68.

Table 68 – Confirmed write service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Variable Access Specification	M	M (=)		
List Of Type Data Specification	U	U (=)		
List Of Data Value	M	M (=)		
Result(+) (Comp)			S	S (=)
List Of Access Result			M	M (=)
List of Error Type			C	C (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Variable Access Specification:

This parameter describes the identification of several variables, elements of variables or of a Variable-List object to be written.

List Of Data specifications:

The parameter List of Data Specification specifies the descriptors of the type of variables to be written, observing the order in the Variable Access Specification parameter. Its content can be empty when the variables are implicitly known. In case the variables are of the same type, the list can be reduced to a single description. The authorized types are those defined by "Type Data Specification" (except the Error Type) (See 6.2.5.2).

List Of Data Values:

The List of Data Value parameters specifies the values of the variables to be written, observing the order in the Variable Access Specification parameter or in the description of the variable list object. The authorized values are those defined by "Data Value" (See 6.2.5.2.3).

Result(+)

This selection specifies that at least one writing has been carried out with success.

List Of Access Result:

The List of Access Result parameter specifies the write operation reports of the variables, observing the order indicated in the Variable Access Specification parameter.

List Of Error Type:

The parameter List Of Error Type specifies a value of the Error type for each writing of variable ending in a failure, observing the order indicated in the Variable Access Specification parameter.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.5.3.2.3 Service procedure

The VMD checks the consistency between the variables described in the Variable Access specification and the List of Type Data Specification parameter, if it is provided. In case of inconsistency on the type or the number of variables, a negative result is returned. If there is consistency, the VMD writes the values in each specified variable.

On a channel using the access protections, the VMD should check before each elementary write operation the consistency of the access rights.

A report of the operation is provided in the List of Access Result parameter for each elementary write operation. An error code is given necessarily in the List of Error type parameter for each write failure or insufficiency of access rights.

6.2.5.3.3 Unconfirmed information report service

6.2.5.3.3.1 Functionality

This service is used by a Sub-MMS server to transmit either the global/partial values of one or several variables or the values of a Variable-List object.

The limitation by the server of the number of variables (1 to n) to be transmitted in one service invocation is a local issue.

This service is not confirmed.

6.2.5.3.3.2 Service primitives

The structure of the service is shown in Table 69.

Table 69 – Unconfirmed information report service parameters

Parameter Name	Req	Ind
Argument (comp)		
Local Detail	U	U (=)
Variable Access Specification	M	M (=)
List Of Type Data Specification	U	U (=)
List Of Data Value	M	M (=)

Argument

Local Detail:

This parameter of the OctetString type can contain information dependent on implementations. It can be used to transport a priority level.

Its content can be empty if no specific information is transmitted.

Variable Access Specification:

This parameter describes the identification of the variables, elements of variables or Variable-list object whose values are transmitted.

List of Type Data Specification:

This parameter specifies the descriptors of the types of variables respecting the order given in the Variable Access Specification parameter. Its content can be empty when the variables are implicitly known. In case the variables are of the same type, the list can be reduced to a single description. The authorized types are those defined by "Type Data Specification" (except that of "Error Type") (See 6.2.5.2).

List Of Data Value:

This parameter specifies the values of the variables, observing the order of the variables included in the Variable Access Specification parameter. The authorized values are those defined by "Data Value" (See 6.2.5.2.3).

6.2.5.3.3.3 Service procedure

No service procedure is specified by Sub-MMS.

6.2.5.3.4 Confirmed define variable list service

6.2.5.3.4.1 Functionality

The purpose of this service is to allow a client to create in a VMD a Variable-List object and attach to it a list of variable class objects.

Partial access to the attached variables is not possible.

The limitation by the server of the number of variables to be attached (1 to n) to a Variable-List class object is a local issue.

6.2.5.3.4.2 Service primitives

The structure of the service is shown in Table 70.

Table 70 – Confirmed define variable-list service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Proposed Variable-list Identification	M	M (=)		
List of Variable Identification	M	M (=)		
Variable-list Access protection	C	C (=)		
Password	M	M		
Access Groups	M	M		
Access Rights	M	M		
Extension	U	U (=)		
Result(+) (Comp)			S	S (=)
Final Variable-list Index			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Proposed Variable List identification:

This parameter specifies the proposal for identification by name or by index to be assigned by the VMD to the object variable-list after creation.

List of variable Identification:

This parameter specifies the identifications by name or by index of the variables linked to the object variable-list created. It also fixes the order of the variables composing the list.

Variable List Access Protection:

This parameter specifies the value of the Password, Access Groups, Access Rights attributes to be assigned to the object variable-list created.

It is compulsory if the service is performed on a channel with the quality of service (2). Otherwise it is empty.

Extension:

This parameter gives additional information.

Result(+)

Final Variable-List index:

This parameter allows the server to transmit the value of the final index assigned to the created variable-list object. This index can take a non-significant value to inform the client that the identification proposed by name or by index is accepted.

A variable whose proposed identification is a name, could always be identified by this name whatever the value of the Final-VL-index parameter.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.5.3.4.3 Service procedure

If the parameters of the request are acceptable, an object variable-list is created and initialized.

The identification attribute is initialized with the Name given in parameter, or the index value selected (proposed or final) or with both.

The Sub-MMS Deletable attribute is assigned to the True value.

The values of the identifications of the variables composing the list are initialized from the List of Variable specification parameter.

On a channel using the quality of service 2, the Password, Access Rights and Access Group attributes are initialized with the value of the parameters.

After this initialization, a positive report is transmitted;

In a context using the quality of service with access protection, the absence of the Password parameters, access rights and access groups results in transmission of a negative result. Besides, the creation of the variable-List object is conditioned by the values of the access rights of each of the list variables which should be compatible with the access rights proposed by the service.

6.2.5.3.5 Confirmed delete variable-list service

6.2.5.3.5.1 Functionality

This service allow deletion in a VMD of a single object of the variable-list type.

6.2.5.3.5.2 Service primitives

The structure of the service is shown in Table 71.

Table 71 – Confirmed delete variable-list service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Variable-list Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Variable-list identification:

This parameter specifies the identification by name or by index of a Variable-list object to be deleted.

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

Result(+)

The service is valid and has been correctly executed by the VMD.

6.2.5.3.5.3 Service procedure

If the identification of the Variable-list object corresponds to an existing Variable-list object and the Sub-MMS deletable attribute is true, the delete operation is performed and a positive response is transmitted.

On a channel with access protection, the access protection parameters provided during the opening of the association (negotiated or prenegotiated) are analyzed with respect to the values of the password, access rights and Access groups attributes of the object. If there is inconsistency, the operation is not performed and a negative report is transmitted.

6.2.5.3.6 Confirmed get variable access attributes service

6.2.5.3.6.1 Functionality

This service allows a client to read, in a VMD, the attributes of a Variable object.

6.2.5.3.6.2 Service primitives

The structure of the service is shown in Table 72.

Table 72 – Confirmed get variable access attributes service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Variable Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
List of identifications			M	M (=)
Object class			M	M (=)
Sub-MMS deletable			M	M (=)
Type description			M	M (=)
Variable Access Protection			C	C (=)
Password			M	M (=)
Access Groups			M	M (=)
Access Rights			M	M (=)
Extension			U	U (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Variable Identification:

This parameter specifies the identification of the object whose attributes are to be restored in the response.

Result(+)

This selection indicates that the service was correctly executed.

List of identification:

This parameter gives the identifiers of the variable object.

Object class:

This parameter indicates the class of the object.

Sub-MMS deletable

This parameter indicates if the object is deletable.

Type Description

This parameter indicates the type of variable. The types permitted are those defined by "Type Data Specification" (except Error Type) (See 6.2.5.2).

Variable Access Protection

This parameter is present if the object supports the access protections. In this case it includes the following information:

Password

This information indicates the object password.

Access Groups

This information indicates the groups to which the object belongs.

Access Rights

This information indicates the access rights required for access to the object.

Extension:

This parameter gives additional information

Result(-)

The service is invalid or not accepted by the VMD. An error code is supplied.

6.2.5.3.6.3 Service procedure

The server should perform the following actions:

- check that there is a Variable object,
- read the object attributes.

If all the actions are performed correctly, a positive response is transmitted.

If one of the actions is unsuccessful, a positive response is transmitted.

Whatever the quality of service of the channel via which this service is transmitted, no access restriction will be applied by means of object access protection.

6.2.5.3.7 Confirmed get variable-list attributes service

6.2.5.3.7.1 Functionality

This service allows a client to read in a VMD the attributes of a variable-List object.

6.2.5.3.7.2 Service primitives

The structure of the service is shown in Table 73.

Table 73 – Confirmed get variable-list attributes service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Variable-list Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
List of identification			M	M (=)
Object class			M	M (=)
Sub-MMS deletable			M	M (=)
List of Variable Identification			M	M (=)
Variable List Access Protection			C	C (=)
Password			M	M (=)
Access Group			M	M (=)
Access Rights			M	M (=)
Extension			U	U (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Variable-list identification:

This parameter indicates the variable-list object whose attributes are to be retrieved.

Result(-)

The service is invalid or not accepted by the VMD. An error code is supplied.

Result(+)

The service is valid and has been correctly executed by the VMD.

List of identification:

This parameter ives the identifiers of the variable list object.

Object class:

This parameter indicates the class of the object.

Sub-MMS deletable

This parameter indicates if it is true that the object is destructible.

List of Variable Identification

This parameter indicates the variables attached to the Variable-List object.

Variable-List Access Protection

This parameter is present if the object supports the access protections. In this case it includes the following information:

Password

This information indicates the password of the object.

Access Groups

This information indicates the groups to which the object belongs.

Access Rights

This information indicates the access rights required for access to the object.

Extension:

This parameter gives additional information.

6.2.5.3.7.3 Service procedure

The server should perform the following action:

– check that there is a variable-list object,

– read the attributes of the object.

If all the actions have been correctly executed, a positive response is sent.

If one of the actions is unsuccessful, a negative response is sent.

Whatever the quality of the service of the channel via which this service is conveyed, no access restriction should be applied through the object access protection.

6.2.5.4 Additional concepts

6.2.5.4.1 Definition of the data specification type

The various descriptors of the type of data for variables are given by the above list. The CS and the sub-MMS users can define other types. See Table 74.

Table 74 – Data type specification

Parameter name	Req	Ind	CBB
Type Data Specification	M	M (=)	
Array type	S	S (=)	arr
Number Of element	M	M (=)	
Type Data Specification	M	M (=)	
Structure type	S	S (=)	str
List Of Type Data	M	M (=)	
Specification	S	S (=)	
Simple Boolean type	M	M (=)	
Boolean length	S	S (=)	
Simple Integer type	M	M (=)	
Integer length	S	S (=)	
Simple Unsigned type	M	M (=)	
Unsigned length	S	S (=)	
Simple Bitstring type	M	M (=)	
Bitstring length	S	S (=)	
Simple Boolean array type	M	M (=)	
Boolean Array length	S	S (=)	
Simple Visible type	M	M (=)	
Visible string length	S	S (=)	
Simple Octet String type	M	M (=)	
Octetstring length	S	S (=)	
Simple Time difference type	M	M (=)	
Time difference length	S	S (=)	
Simple Time of day type	M	M (=)	
Time of day length	S	S (=)	
Simple single floating type	M	M (=)	
Single floating length	S	S (=)	
Simple Double floating type	M	M (=)	
Double floating length	S	S (=)	
Simple BCD type	M	M (=)	
BCD length	S	S (=)	
Simple Error type	M	M (=)	
Error length			

The CBB (Conformance Building Block) parameter shows which are the types of variables negotiable at the opening of an association.

1 - Array type is the description of the type of a table of elements of the same type.

2 - Structure type is the description of the type of a structure of which each field can be of a distinct type.

3 - Boolean type is the description of the type of a Boolean.

4 - Integer type is the description of a type of an Integer.

5 - Unsigned type is the description of the type of an integer whose values are positive.

6 - Bitstring type is the description of the type of bit string. The first bit of the string is positioned at bit 2**7 of the first octet. The second bit is position at bit 2**6 of the first octet, and so on.

7 - Boolean Array is the description of a table of bits. The first element of the table is positioned at bit 2**0 of the first octet. The second is positioned at bit 2**1 of the first octet, and so on.

8 - Visiblestring type is the description of the type of a string of octets whose value is an ASCII character to be taken from {"A" to "Z", "a" to "z", "0" to "9", ".", "_"}.

9 - Octetstring type is the description of the type of a string of octets.

10 - Time difference type is the description of the Time difference type(Unsigned-32 expressing in milliseconds the time elapsed since midnight).

11 - Time of day type is la description of the Time Of Day type

12 - Single floating type is the description of the Single floating point (format IEC 60559).

13 - Double floating type is the description of the Double floating point (format IEC 60559).

14 - BCD type is the description of the type in digit string.

15 - Error type is the description of the Error type.

6.2.5.4.2 Definition of the list of access results

The access result list is a series of indicators indicating the series of successes/failures relative to the access of several variables. This parameter should be a BITSTRING. A bit set to TRUE (value 1) signifies access with success.

6.2.5.4.3 Variable access specification

6.2.5.4.3.1 Variable access specification parameter

The structure of the Variable Access Specification parameter is given in Table 75.

Table 75 – Variable access specification

Parameter name: **Variable Access Specification**	**Req** **Rsp**	**Ind** **Cnf**
Kind of Variable	M	M (=)
Variable-List	S	S (=)
Identification	M	M (=)
List Of Variable	S	S (=)
variable Access description	M	M (=)

Kind of variable:

This parameter specifies an access to a series of objects of the Variable class with the possibility of obtaining partial access or access to a single object of the Variable-List class previously defined.

Variable List:

This parameter specifies the identification by name or by index of an object variable list.

List Of variables:

This parameter gives an enumeration of the access descriptions to variable class objects.

6.2.5.4.3.2 Variable access description parameter

The structure of the Variable Access description parameter is given in Table 76.

Table 76 – Variable access description attribute details

Parameter name: **Variable Access description**	**Req** **Rsp**	**Ind** **Cnf**
Kind of Access	M	M (=)
Global Access	S	S (=)
Identification	M	M (=)
Partial Access	S	S (=)
Identification	M	M (=)
Path Selection	M	M (=)

Kind of Access:

This parameter indicates if the variable is accessed globally or partially.

Global Access:

This parameter exclusively specifies the name or the index of the variable to be accessed globally.

Partial Access:

This parameter describes the identification of the variable object to be accessed partially followed by the description of the path to be followed to reach one or several elements of the variable.

6.2.5.4.3.3 Path selection parameter

The structure of the path selection parameter is given in Table 77.

Table 77 – Path selection parameters

Parameter name: Path Selection	Req Rsp	Ind Cnf	CBB
Kind of selection	M	M (=)	
Select Access	S	S (=)	
Kind of access	M	M (=)	
(1)st level nesting access	S	S (=)	
Access selection	M	M (=)	
Component index	S	S (=)	Str
Element index	S	S (=)	Arr
(n≥1)th level nesting access	S	S (=)	
Access selection	M	M (=)	
List of components	S	S (=)	Str
Component index	M	M (=)	
List of Elements	S	S (=)	Arr
Element index	M	M (=)	
Range elements	S	S (=)	Arr
start element index	M	M (=)	
Number of elements	M	M (=)	
Select Alternate Access	S	S (=)	
Access selection	M	M (=)	
Component index	S	S (=)	Str
Element index	S	S (=)	Arr
Path selection	M	M (=)	

6.2.6 Event ASE

6.2.6.1 Overview

The objects, the services and the mechanisms of events should be capable of adapting themselves to the modest needs of sensors/actuators as well as to the greater demands of programmable controllers/work stations.

1- Sub-MMS standardizes the following actions:

a) Acknowledging an event resulting from a particular event object; this action uses the Acknowledge Event Notification service. The acknowledgement only has a sense for an event previously notified by the Event Notification service.

b) Validating/invalidating an event object; this action makes use of the Alter Event Condition Monitoring service. A valid object can generate events to be notified. An invalid object cannot generate events. The notification of events (resulting from several Event objects of the same type) uses the Event Notification service.

2- Sub-MMS authorizes the definition of specific actions by the users of Sub-MMS and/or by the Companion Standards. These actions use the Alter Event Condition Monitoring service.

3- Sub-MMS introduces the notion of the event detection mechanism common to several objects.

This detection takes place periodically during a period of time sufficiently short to consider that all these events have been detected at the same instant.

In this case a value which we should call "Common Occurrence ID" is assigned to the "Event Occurrence ID" attribute (if supported) for all the objects for which an event was detected during this time interval.

The events thus detected resulting from objects of the same type are notified to clients in the same invocation of the "Event Notification" service with the value of the "Event Transaction Occurrence ID" parameter equal to "Common Occurrence ID". To save space, each of these events should be represented by the truncated "Event Message" attribute of the "Event Occurrence ID" attribute (if it is supported) since its value is identical to the value of the Event Transaction Occurrence ID.

To meet the requirements of more or less complex event objects, Sub-MMS defines a configurable event object.

This configuration allows the creation of the following types of event objects:

1- Object not supporting any standard action or action specific to the user/C.S. In this case, the "Event Message" attribute is a structure with only one "Event Data" attribute. This object can collaborate in the detection of events common to several objects.

2- Object only supporting the acknowledgement action. In this case the "Event Message" attribute is a structure including three attributes: "Event State", "Event Occurrence ID" and "Event Data". This object can collaborate in the detection of events common to several objects.

3- Object only supporting the validation/invalidation action. In this case, the "Event Message" attribute is a structure with two attributes, "Event State" and "Event Data". This object can collaborate in the detection of events common to several objects.

4- Object supporting the acknowledgement and the validation/invalidation. In this case the "Event Message" attribute is a structure with three attributes, "Event State", "Event Occurrence ID" and "Event Data".

6.2.6.2 Event class specification

6.2.6.2.1 Event class model

FAL ASE:		**Event ASE**	
CLASS:		Event	
CLASS ID:		not used	
PARENT CLASS:		not used	
Object: Event			
(m)	Key Attribute:	Name	
(m)	Key Attribute:	Index	
(m)	Attribute:	Event type	
	(m)	Attribute:	Common event detection support(true, false)

	(m)	Attribute:	Acknowledge action support(true, false)
	(m)	Attribute:	Enable action support(true, false)
	(o)	Attribute:	Extension action support
(m)	Attribute:	Event_Message	
	(c)	Attribute:	Event State
		(m) Attribute:	ack action state(acknowledged, not acknowledged)
		(m) Attribute:	enable action state(validated invalidated)
		(o) Attribute:	extension actions states
	(c)	Attribute:	Event Occurrence ID
	(m)	Attribute:	Event data
(o)	Attribute:	Event Access Protection Support	
	(m)	Attribute:	Password
	(m)	Attribute:	Access Group
	(m)	Attribute:	Access Rights
(o)	Attribute:	Extension	

6.2.6.2.2 Attributes

Key attributes

These attributes indicate if the object supports the identification by Name, Index, or Name and Index at the same time.

Event type

This attribute, of the BITSTRING-16 type, characterizes the object type. It indicates if the object collaborates with other Event-Objects with a common event detection mechanism. It also indicates if the object supports specific actions affecting the "Event State" attribute:

Common event detection support:

It indicates if it is true that the object collaborates with other objects for the same event detection mechanism.

Acknowledge action support:

This attribute indicates if the object supports the action of acknowledgement by using the Acknowledge Event Notification service.

Enable action support:

This attribute indicates if the object supports the "validation/invalidation" action using the Alter Event Condition Monitoring service.

Extension action support:

This attribute indicates if the object supports the specific actions, which are carried out by the Alter Event Condition Monitoring service. These actions could be in conformity with the C.S as well as specific to a user.

Event message

This attribute specifies the dynamic information of the object.

Event state

This attribute, of the BITSTRING-16 type, is present if the object supports the actions. It indicates the last remote actions having acted on this object by the acknowledgement of the Acknowledge Event Notification and/or Alter Event Condition Monitoring services:

a) the "Acknowledge action state" attribute stores the acknowledgement,
b) the "Enable action state" attribute stores the action "validation/invalidation",
c) the "Extension actions states" attribute stores the eventual extension actions.

Event occurrence ID

This attribute indicates the identification of the occurrence of an event specific to the object. The attribute is present if the acknowledgement is supported by the object.

The OCTETSTRING-2 type is permitted; the semantic of its contents should be described in the PICS.

Event data

This attribute indicates the value associated to the object Event. The types permitted are those defined by "Data Value" (See 6.2.5.2.3).

Event access protection support

This attribute if present specifies the information relative to the protection of the object.

Password

This attribute specifies the value of the accepted password for the access rights.

Access group

This attribute specifies if the object belongs to a group of users, as shown in Table 78. If one of the bits is positioned at 1, it indicates an access group number.

Table 78 – Access group attribute detail for event object

bit name	number of access group
G0	Access group 8
G1	Access group 7
G2	Access group 6
G3	Access group 5
G4	Access group 4
G5	Access group 3
G6	Access group 2
G7	Access group 1

Access rights

This attribute specifies the access rights associated with the Event object, as shown in Table 79. Each bit positioned at 1 indicates the acceptance conditions of the Acknowledge Event Notification (acknowledgement) and Alter Event Condition Monitoring (validation/invalidation) services.

Table 79 – Access rights attribute details for event object

bit name	Signification
W	Acknowledgement and event reading (by the Acknowledge Event Notification, Get Alarm Summary services) are permitted to the clients having provided a password identical to the object Password attribute
D	Validation/Invalidation and event reading (by the Alter Event Condition Monitoring, Get Alarm Summary services) are permitted to clients having provided a password identical to the object Password attribute
Wg	Acknowledgement and event reading (by the Acknowledge Event Notification, Get Alarm Summary services) are permitted to clients belonging to one of the specified groups in the object Access Groups attribute
Dg	Validation/Invalidation and event reading (by the Alter Event Condition Monitoring, Get Alarm Summary services) are permitted to clients belonging to one of the specified groups in the object Access Groups attribute
Wa	Acknowledgement and event reading (by the Acknowledge Event Notification, Get Alarm Summary services) are permitted to all the clients
Da	Validation/Invalidation and event reading (by the Alter Event Condition Monitoring, Get Alarm Summary services) permitted to all the clients

Extension:

This attribute specifies additional information.

The event management services are

1 - Event Notification; this service enables notifying the events.

2 - Acknowledge Event Notification; this service enables event acknowledgement.

2 - Alter Event Condition Monitoring; this service enables altering the event status.

3 - Get Alarm Summary; this service enables reading the information associated with one or more events.

4 - Get Event Condition Attribute: this service enables obtaining the values of certain attributes of an object Event.

6.2.6.3 Services

6.2.6.3.1 Unconfirmed event notification service

6.2.6.3.1.1 Functionality

This service allows the server to notify one or more events. Each even is represented by the Event_Message attribute of an object.

The limitation by the server of the number of events to be notified (0 to n) in one service invocation is a local issue.

When and how this service is used is a local issue.

6.2.6.3.1.2 Service primitives

The structure of the service is shown in Table 80 and Table 81.

Table 80 – Unconfirmed event notification service parameters

Parameter name	Req	Ind
Argument (Comp)		
Common Information	M	M (=)
Event Type	M	M (=)
Event Transaction Occurrence ID	M	M (=)
User Extension	U	U (=)
List of Event Identification	M	M (=)
List of Event_Message Type description	U	U (=)
Event State type description	C	C (=)
Event Occurrence ID type description	C	C (=)
Event Data type description	M	M (=)
List of Event_Message value	M	M (=)
Event State value	C	C (=)
Event Occurrence ID value	C	C (=)
Event Data value	M	M (=)

Table 81 – Event type parameter details

Parameter name: Event Type	Req	Ind
Common event detection support	M	M (=)
Acknowledge action support	M	M (=)
Enable action support	M	M (=)
Extension action support	U	U (=)

Argument

Common Information

This parameter, of the OCTETSTRING type, specifies the information relative to the objects in the indicated order:

a) "Event Type" indicates a type common to all the object events. This type is characterized by the following information:
   - "Commun event detection support",
   - "Acknowledge action support",
   - "Enable action support",
   - "Extension action support".

b) "Event Transaction Occurrence ID" of OCTETSTRING-16 type, indicates the identification of the transaction occurrence.

c) User-Extension specifies the information known to the user.

List Of Event Identification

This parameter gives the object list where an Event_Message appears in the service.

List Of Event_Message Type Description

The content of this parameter can be empty.

This optional parameter, when not empty, specifies the descriptor of the Event_Message type for each object identified in the service. It is possible to reduce the list of descriptors to a single descriptor when they are identical. Each descriptor of the structure type specifies the following information in the indicated order:

– the first item of information indicates the "Event State" type; this information is present only if the object supports actions;

– the second item of information indicates the "Event Occurrence ID" type; this event is present only if the "Common event detection support" parameter is false and the "Acknowledge action support" is true (objects supporting acknowledgement but not collaborating with a common event detection mechanism);

– the third item of information indicates the "Event Data" type; this information is always present.

The types permitted are those defined by the type Data Specification (except Error Type). (See 6.2.5.2).

List Of Event Message Value

This parameter specifies the Event_Message value of each object identified in the service. Each value of the structure type specifies the following information in the indicated order:

– the first item of information indicates the "Event State" value; this information is present only if the object supports actions;

– the second item of information indicates the "Event Occurrence ID" value; this information is present only if the "common event detection support" parameter is false and the "Acknowledge action support" parameter is true (objects supporting acknowledgement but not collaborating with a common event detection mechanism);

– the third item of information indicates the "Event Data" value; this information is always present.

(See 6.2.5.2.3 for the permitted data values).

6.2.6.3.1.3 Service procedure

The VMD having to indicate events concerning certain event class objects, should carry out the following operations:

1 - Initialize the "Event Occurrence ID" attribute (if present) of these objects either at a transaction identifying value if the "Common Event Detection Support" attribute has the real value, or at a value specific to event occurrence.

2 - Transmission, in an invocation of the Event Notification service, of the detected events whose "Event-Type" attributes of the objects concerned are identical.

The event Objects whose "Acknowledge Action Support" attributes have the Real value should be acknowledged by the Acknowledge Event Notification service if at least one event occurrence has been transmitted.

6.2.6.3.2 Confirmed acknowledge event notification service

6.2.6.3.2.1 Functionality

This service enable a Client to acknowledge several event occurrences. Each occurrence originates from an event object supporting the acknowledgement.

The limitation by the server of the number of objects to be acknowledged in a service invocation (1 to n) is a local issue.

6.2.6.3.2.2 Service primitives

The structure of the service is shown in Table 82.

Table 82 – Confirmed acknowledged event notification service parameter

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
List Of Event Identification	M	M (=)		
List Of Event Occurrence ID Type Description	U	U (=)		
List Of Event Occurrence ID Values	M	M (=)		
Result(+) (Comp)			S	S (=)
List of Access Result			M	M (=)
List Error Type			C	C (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

List Of Event Identification

This parameter gives the list of Event objects to be acknowledged.

List Of Event Occurrence Id Type Description

The content of this parameter can be empty.

This parameter, when not empty, specifies for each of the objects to be acknowledged, the descriptor of the type of event occurrence. Since all the descriptors are identical, it is possible to reduce the list of descriptors to a single descriptor.

The types permitted are those defined by Type Data Specification (except Error Type). (See 6.2.5.2).

List Of Event Occurrence ID Values

This parameter specifies the value of the event occurences for each of the objects to be acknowledged. (See 6.2.5.2.3 for the permitted data values).

Result(+)

This selection informs the client that the server was able to successfully acknowledge at least one event object among those appearing in the request.

List Of Access Result

This parameter lists the event objects whose acknowledgement was not successful.

List Of Error Type

This parameter indicates the reason for failure for each acknowledgement that ended unsuccessfully.

Result(-)

This selection informs the client that the server was not able to execute the service successfully.

6.2.6.3.2.3 Service procedure

The VMD verifies the coherence between the Event objects described in the List of Event Identification and the List of Event Occurrence ID Type Description parameter, if it is provided. In case of incoherence of type or number a negative result is returned. If there is coherence, the VMD can use the Event Occurrence ID parameter to select the event occurrence(s) to be acknowledged from each of the objects identified by the List of Event Identification parameter.

On a channel using the access protections, the VMD should verify the coherence of access rights before each acknowledgement operation.

An operation report is supplied in the List of access result parameters for each acknowledgement operation. An error code is obligatorily given in the List of Error type parameters for each acknowledgement failure or insufficiency of access rights.

6.2.6.3.3 Confirmed alter event condition monitoring service

6.2.6.3.3.1 Functionality

This service enables modifying the "Event State" attribute of several Event objects.

The limitation by the server of the number of objects to be modified (1 to n) in a service invocation is a local issue.

6.2.6.3.3.2 Service primitives

The structure of the service is shown in Table 83.

Table 83 – Confirmed alter event condition monitoring service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
List of Event State Action ID	M	M (=)		
Event Identification	M	M (=)		
Event State action selection	M	M (=)		
List Of Event State Type description	U	U (=)		
List Of Event State Value	M	M (=)		
Result(+) (Comp)			S	S (=)
List of Access Result			M	M (=)
List Error Type			C	C (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

List Of Event State Action ID

This parameter gives the event object list to be modified. Each modification is identified with the help of the two parameters mentioned above:

Event Identification

This parameter gives the identification of Event object.

Event State Action Selection

This parameter gives the identification of the chosen action.

List Of Event State Type Description

The content of this parameter can be empty.

This parameter, when not empty, specifies the descriptors of the "Event State" type listed in this service. Since all the descriptors are identical, it is possible to reduce the list of descriptors to a single descriptor.

The types permitted are those defined by type Data Specification (except Error Type). (See 6.2.5.2).

List Of Event State Value

This parameter specifies the "Event State" values listed in this service.

(See 6.2.5.2.3 for the permitted data values).

Result(+)

This selection indicates to the client that the server was able to modify successfully at least one element of the Event state attributes of the objets appearing in the request.

List Of Access Results

This parameter lists the "Event State" modifications which were not successfully carried out.

List Of Error Types

This parameter indicates the reason for failure for each unsuccessful modification.

Result(-)

This selection indicates to the client that the server was not able to carry out the service successfully.

6.2.6.3.3.3 Service procedure

The VMD checks the coherence between the Event objects described in the List of Event State Action ID and the List of Event State Type Description parameter, if it is provided. In case of incoherence on the type or number a negative result is returned. If there is coherence, the VMD carries out the modification of the "Event State" attributes.

On a channel using the access protection, the VMD should check the access right coherence before each modification operation.

An operation report is supplied in the List of access result parameter for each modification operation. An error code is mandatorily given in the List of Error type parameter for each modification failure or insufficiency of access rights.

6.2.6.3.4 Confirmed get alarm summary service

6.2.6.3.4.1 Functionality

This service enables reading the Event_Message attribute of several Event objects The limitation by the server of the number of objects (1 to n) to be read in a service invocation, is a local issue.

6.2.6.3.4.2 Service primitives

The structure of the service is shown in Table 84.

Table 84 – Confirmed get alarm summary service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Type with result	M	M (=)		
List of event Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
List of access result			M	M (=)
List of Event_Message Type Description			C	C (=)
Event State Type Description			C	C (=)
Event Occurrence ID Type Description			C	C (=)
Event Data type Description			M	M (=)
List of Event_Message Value			M	M (=)
Event State Value			C	C (=)
Event Occurrence ID value			C	C (=)
Event Data Value			M	M (=)
Result(-)			S	S (=)
Error Type			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Argument

Type with result

This parameter indicates if the Event_Message type attributes read should be supplied in the positive response.

List Of Event Identification

This parameter describes the identification of many Event objects to be accessed.

Result(+)

This selection indicates that at least one "Event_Message" attribute object has been read successfully.

List Of access Results

The List of Access Result parameter specifies the failure/success result of all the Event objects read, respecting the order of appearance in the List of Event Identification parameter.

List Of Event Message Type Descriptions

The content of this parameter is empty if the parameter Type With Result of the request is equal to false.

This parameter, when it is not empty, specifies the descriptor type of Event_Messge attribute of objets read successfully or the ErrorType descriptor for objects read unsuccessfully. This information is provided respecting the order appearing in the List Of Event Identification parameter. In case the "Event_Message" descriptor attributes of the object read are of the same type, the list can be reduced to the description of a single Event_Message.

Each Event_Message descriptor of the structure type includes in the indicated order, the descriptor of the Event State attribute if it is present, the descriptor of the Event Occurrence ID attribute if it is present and the descriptor of the Event Data attribute. The types permitted are those defined by Type Data Specification (except the Error Type). (See 6.2.5.2).

List Of Event Message Values

The List of Event_Message Values parameter specifies the Event_Message attribute value of the objects read successfully and the ErrorType value for objects read unsuccessfully. This information is provided respecting the order in which it appears in the List Of Event Identification parameter.

Each Event_Message value in the indicated order consists of the Event State attribute value if it is present, the Event Occurrence ID attribute value if it is present and the Event Data attribute value. (See 6.2.5.2.3 for the permitted data values).

Result(-)

The service is invalid or not accepted by the VMD. An error code is provided.

6.2.6.3.4.3 Service procedure

The VMD provides each accessed object with a data and an operation report respecting the order indicated in the request. It analyses the value of the Type With Result parameter to determine if it should provide in the response the type description of each Event_Message attribute read.

In case of a read operation carried out on a channel using access protection (service 2 quality), the VMD should check the coherence of access rights before each reading operation.

For each Event_Message attribute read successfully, the VMD provides a positive indicator in the List of Access result, its descriptor type, if necessary, in the List of Event_Message Type Description and its value in List of Event_Message Value.

For each unsuccessful Event_Message attribute read unsuccessfully, the VMD provides an error indicator in the List of Access Result, the ErrorType descriptor in the List of Event_Message Type Description and the error value in the List of Event_Message value.

6.2.6.3.5 Confirmed get event condition attribute service

6.2.6.3.5.1 Functionality

This service allows reading the attributes of an Event object

6.2.6.3.5.2 Service primitives

The structure of the service is shown in Table 85.

Table 85 – Confirmed get event condition attributes service parameters

Parameter Name	Req	Ind	Rsp	Cnf
Argument (Comp)				
Event Identification	M	M (=)		
Result(+) (Comp)			S	S (=)
List of identification			M	M (=)
Object Class			M	M (=)
Event Type			M	M (=)
Event Message type description			M	M (=)
Event Access Protection			C	C (=)
Password			M	M (=)
Access Groups			M	M (=)
Access Rights			M	M (=)
Extension			U	U (=)
Result(-)			S	S (=)
Error Type			M	M (=)

NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.

Argument

Event Identification:

This parameter indicates the object whose attributes are to be retrieved.

Result(+)

List of identification:

This parameter indicates the object identifiers.

Object class:

This parameter indicates the class of the object.

Event Type:

This parameter indicates the event object type

Event Message type description:

This parameter indicates the type of Event-Message attribute of the Event object.

Event Access Protection:

This parameter specifies three items of information if the object is protected.

Password:

This parameter indicates the password of the object.

Access Groups:

This parameter indicates the groups to which the object belong.

Access Rights:

This parameter indicates the protections of the object.

Extension:

This parameter gives additional information

Result(-)

The service is invalid or not accepted by VMD. An error code is provided.

6.2.6.3.5.3 Service procedure

The server carries out the following actions:

- check the existence of the object in question.
- read the object attributes.

If all the actions were performed correctly, the server transmits a positive response.

If an action ends in a failure, the server transmits a negative response.

Whatever the service quality of the channel via which this service is routed no access restriction should be applied through the object access protection.

6.2.7 Directory ASE

To be completed later

6.3 ARs

6.3.1 Messaging common service (MCS) AR ASE

This subclause details a Messaging Common Service Element used in the AL environment for monitoring application associations (its role being equivalent to that of ACSE in the ISO environment), and to enable transfer of data units from the application layer in the associated and non-associated modes.

6.3.1.1 Overview

This application service element is intended for use in the AL environment application layer structure.

This common element has necessarily be integrated with the specific element or elements in the context of an application entity. The MCSE is, indeed, directly projected onto the DLL and provides a user interface for receiving a specific service element such as the SubMMS described.

The services offered by this element feature two additional possibilities constituted by transmission in the associated mode and the non-associated mode.

6.3.1.2 Concepts

6.3.1.2.1 Associated mode transmission

Associated mode transmission–establishment of an application association,

- transfer of data,
- termination of an application association.

In addition to these three stages, which correspond to the phases of its life, an application association has the following characteristics:

– it necessitates establishing and maintaining an agreement concerning the transfer of data between the two application entities communicating and the data link layer on which they are based,
– it enables negotiation, between the two application entities, of the user options and parameters which affect the transmission of data,
– it supplies a context to which the successive data units transmitted are logically related,
– it guarantees transfer by reserving resources and ensuring reliable transmission of the data units exchanged,
– it makes it possible to identify the communicating entities, thus avoiding transmitting their designations at each data transfer.

Associated mode transmissions thus more closely meet the requirements of the applications for long communications with a given interaction traffic, such as, for instance, the remote configuring of an item of equipment, and exchanges of control data between equipment in a distributed application. In such cases, the entities involved agree on the nature of the interactions and resources reserved before proceeding with exchanges of data units.

This agreement is obtained by:

– configuring the two entities involved in the association, in the case of a pre-negotiated association,
– negotiation exchanges between the two entities involved in the association, in the case of a negotiated association.

6.3.1.2.2 Non-associated mode transmission

Non-associated mode transmissions between application entities take place in a single data transmission phase, from the source entity to one or more recipient entities, without establishing an association.

This type of transmission, the lifetime of which is limited to that of the exchange of a data unit, has the following properties:

– it is necessary to attach to the data to be transmitted all the necessary information for relaying and interpreting it, such as, for instance, identification of the expected communicating entities, the quality of service desired, the application context to which the data units logically relate, etc.,
– it makes no presumptions concerning the quality of the service and the contexts which may be applied, for one or more successive invocations of a service, between a pair or a set of entities.

Non-associated mode transmissions most closely meet the requirements of application for occasional spontaneous exchanges, without establishing, maintaining and terminating an association. For instance, for observing variables of an application by equipment randomly connected to the bus.

In such a case, the source entities involved need to have prior knowledge of the recipient entities to which they wish to address themselves, for the transfer of data to take place correctly.

6.3.1.2.3 Quality of service

6.3.1.2.3.1 Quality of service definition

The term quality of service relates to certain observable properties of a transmission, as described by different quality of service parameters.

Some of the quality of service parameters specifically relate to associated mode services and others to non-associated mode services, as shown in Table 86.

Table 86 – Classification of service quality parameters

Mode	Phase	Parameter
Associated	• Establishment • Transfer • Termination	• Establishment duration • PDU size • Transfer rate • Number of retries • Anticipation factor • SDU size • Termination duration
Non-associated	• Data transfer	• Priority

In the associated mode, the quality of service offered for the transfer of data results from the negotiation carried out during the establishment phase of the association.

The negotiation may result in reduction of the quality of service proposed by the user. The reduction in quality of service consists in acting on all or part of its parameters. The semantics of these actions are specific to each parameter, and specified in their definitions.

In the non-associated mode, the quality of service offered for the transfer of data is proposed by the source entity and is complied with by the service provider insofar as possible.

The quality of service parameters relating to the associated mode, whose values can be negotiated at the time of opening and association, are the following and are downgraded as indicated:

– PDU size becomes smaller,
– transfer rate becomes smaller,
– the number of retries becomes smaller,
– anticipation factor becomes smaller,
– SDU size becomes smaller.

Some of these negotiable parameters can effectively be negotiated for a specific association.

However, in the case of a specific association, the unnegotiated parameters will include the unnegotiable ones, the negotiable ones not supported and possibly some negotiable ones whose values are known implicitly by the correspondents.

Finally, in the case of a multipoint association which is necessarily pre-negotiated, only the PDU size and transfer rate parameters are supported.

NOTE In the context of a pre-negotiated association, the service quality parameters should be assigned values consistent with the properties of the devices participating in the association.

6.3.1.2.3.2 Duration of the establishment

The duration of the establishment is the maximum time interval between the association opening demand and confirmation of opening. This time interval includes the time taken for turning round the MCS user called from the correspondent, as well as the time taken for transfer of the request and opening response.

The turn-around time is an intrinsic property of the device, the value of which is utilised by the association opening monitoring mechanism.

NOTE The value of this duration of establishment, which is not proposed by the user, is obtained via network management functions.

6.3.1.2.3.3 PDU size

The size of the data units is the maximum size, as a number of octets, of the protocol data units (MCS-APDU) of the application layer encoded which can be exchanged on an association.

The value of this parameter is negotiated on the basis of the intrinsic properties of the two devices participating in an association.

Indeed, each device globally offers, to all the associations it supports, an application layer protocol data unit maximum size possibility. The maximum size taken in an association is the least of the maximum sizes offered by the two devices participating in it.

The value of this quality of service parameter is thus accounted for by the association monitoring mechanism, which guarantees that all the application data units are smaller than this size.

6.3.1.2.3.4 Transfer rate

The transfer rate is determined, for both directions of transfer of an association, in terms of the guaranteed minimum number of data units of the application layer protocol which it is possible to transmit per unit time.

This transfer rate corresponds to that part of the total rate available in a device for association purposes.

NOTE The allocation of a transfer rate to an association at device level needs to be consistent with the total capacities and rates already allocated.

For reference, the definition of the total rate available in a device at the data link layer is given below. The abbreviations are defined as follows:

Φ equip = Messaging flow available at the equipment level

Φ cyc = messaging flow dependent on the cyclic messaging service available in a device

Φ aper = messaging flow dependent on the aperiodic messaging service available in a device

φ mac = messaging flow reserved by the microcycle in the various messaging windows. This flow is that which is shared between all system devices for aperiodic messaging.

φ dem = message exchange request flow, for a given device. This corresponds to the sum of the flows offered by the various periodic identifiers supporting a message request in a device.

Definitions

Φ equip = Φ cyc + Φ aper

Φ cyc = $\sum_i [1/T_i]$

i = each F_MSGcyc queue of the device,

Ti = period of teh ID_MSG associated to the queue

Φ aper = $((\varphi \text{ dem})*(1/ \sum_j \varphi \text{ dem}(j)))*(\varphi \text{ mac})$

j = each system device

φ dem = request flow of the device in question

It should be noted that

– the cyclic flow depends only on the frequency of scanning of the equipment cyclic queues by the bus arbitrator,

– the aperiodic flow corresponds to the total available flow on the bus divided between the devices on the basis of the request flow.

NOTE The transfer rate thus allocated to an association in both directions is under network management surveillance.

6.3.1.2.3.5 Number of retries

The number of retries is the maximum number of retries allowed to the MCS service provider subsequent to an acknowledged transmission request made by the user in a point-to-point association.

This parameter is defined globally for both transfer directions and negotiated during the association establishment phase.

Retries continue until the value of this parameter is reached, as long as the acknowledged transmission has not been properly completed.

6.3.1.2.3.6 Anticipation factor

The anticipation factor is the maximum number of data transfers that an entity can have initiated at a given time in an association. This makes it possible to optimize the pass-band available for an association.

The anticipation factor concept is defined for each transfer direction. The anticipation factor thus defined is negotiated during the association establishment phase.

6.3.1.2.3.7 SDU size

The SDU size is the maximum size of a service data unit (MCS-ASDU) which can be submitted by an MCS user, to a given association, and it is designed for both directions of transfer.

This size can be negotiated during opening of an association and is expressed as a whole number of maximum size MCS protocol data units.

This parameter is only negotiated if the association implements segmentation, and in this case has a value greater than 1.

6.3.1.2.3.8 Termination duration

The termination duration is the maximum time interval between the association termination request and termination confirmation. This time interval corresponds to the MCS user turn-around time, as well as the times of request transfer and termination response.

This turnaround time is an intrinsic property of the device, the value of which is utilized by the association closure monitoring mechanism.

NOTE The value of this termination duration, which is not submitted by the user, is obtained via network management functions.

6.3.1.2.3.9 Priority

The concept of priority is specific to the non-association transmission mode.

In such transmissions, the priority assigned by the data transfer source concerns the relative importance of one data transfer relative to another so as to allow for the revocation of certain PDUs to free resources for others of higher priority.

NOTE This concept does not apply in associated mode transmissions as the quantity of resources implemented is reserved prior to a transfer of data. Furthermore, there is no global priority of resources of an association, making it possible to allow for its revocation, thus making it possible to free its resources for another association of higher priority. Only network management functions can allow early freeing of resources of an association despite user requirements.

6.3.1.2.4 Identification of correspondents

Each correspondent involved in an associated or non-associated mode transmission is unambiguously identified by the system by a four-part identifier consisting of:

- "AP title" to identify the AP to which the entity belongs in one of the system devices,
- "AE qualifier" which identifies the AE used in the AP context,
- "API identification" which identifies a specific activity of an AP in operation, specific use of the AE implemented for the requirements of a specific API.

During associated and non-associated mode transmissions, these indications are optionally transmitted. They are transmitted, during the establishment of an association or a non-associated mode data transfer, to make it possible for the user called or the destination or destinations to respectively:

[1] Inform them of the identification of the caller of the source.

This identification of the caller can be shortened to "AP title" and "AE qualifier", the called entity being able to deduce this information from the link address of the entity which initiated the exchange.

In addition, the "API identification" can also not be transmitted if the entity initiating the exchange proceeds to establish a bilateral relationship between the APIs and the link addresses associated with the AE.

NOTE 1 This means that there is no multiplexing of the APIs at a given link address (of ADAE type).

[2] To verify whether the identification considered by this request is that localised by the link address utilised.

NOTE 2 Indeed, every AE of an AP is projected onto one or more link addresses at directory level prior to any transmission.

[3] Selection of one of the APIs to which the transmission is addressed.

NOTE 3 This can be avoided, in the particular case where any link address is used for transmissions to a single API.

[4] To propose an AEI identification, the creation of which is triggered by establishing an association at the called entity (only applies to the associated mode).

NOTE 4 The called entity can opt to accept or refuse this identification proposal made by the calling entity. In the case of refusal, the value attributed by the called entity is returned to the calling entity in the association opening request response.

The parameters relating to the identification are transmitted to meet the requirements indicated above are shown in Table 87.

Table 87 – Identification parameters

Parameter name	**Role**			
	[1]	**[2]**	**[3]**	**[4]**
Calling AP title	C			
AE qualifier	C			
API identification	C			
AEI identification	M			
Called AP title		M		
AE qualifier		M		
API identification			M	
AEI identification				M

6.3.1.2.5 Application context

Entities which intercommunicate use a set of rules to construct the PDUs sent and to interpret the PDUs received, these constitute the bases of the application context.

The bases of an application context comprise:

– a specification of one of the ASEs, which make up the AE supporting the application context.

NOTE This means that each association can only implement one of the ASEs which can contain an AE in the AL environment.

– a specification, for the ASE considered in this context, of one of the abstract syntax options supported by the latter in the framework of the AE supporting the context,

– a specification for one of the transfer syntax options supported by the AE.

For a specific application context, its bases have a name manipulated by the MCS services.

All ASE standards which offer MCS mapping, propose contingent universally recognised names. Any other application, whether defined on the basis of standards or not, has a scope specific to the distributed application in which it is implemented.

The name of an application context is structured as follows:

Name of context :: = {

- ASE type (Universal; Application)
- ASE name (Identification)
- Abstract syntax type (Universal; Application)
- Abstract syntax name (Identification)
- Transfer syntax type (Universal; Application)
- Transfer syntax name (Identification) }

NOTE The coding of a context name is proposed in the PDUs of MCS.

In associated mode transmissions, the context name is exchanged during the establishment of the association to enable negotiation of bases of the application context of the future association.

Unlike in non-associated mode transmissions, the context name is exchanged during each transfer contiguous to data.

6.3.1.3 Services

6.3.1.3.1 Overview

The nature of the services described below is shown in Table 88.

Table 88 – List of MCS AR ASE services

Service	Type
A_ASSOCIATE	Confirmed
A_RELEASE	Confirmed
A_ABORT	Unconfirmed
A_DATA	Unconfirmed (ack)
A_UNIDATA	Unconfirmed (ack)
NOTE (ack) = acknowledgement possible	

NOTE The A_DATA and A_UNIDATA are unconfirmed within the meaning of the ISO service convention but nevertheless feature local confirmation which is generated with allowance for acknowledgement or non-acknowledgement, depending on whether this has been requested or not.

6.3.1.3.2 A_ASSOCIATE service

6.3.1.3.2.1 Functionality

This service is used to establish an association to negotiate the parameters which will control the transfer of data between the two AEIs participating in it.

6.3.1.3.2.2 Service primitives

The parameters of this service and description of its semantics are described in Table 89 and the accompanying text.

Table 89 – A_Associate service parameters

Parameter name	Req	Ind	Rsp	Cnf
Calling AEI access point	M	M (=)	M	M (=)
Called AEI access point	U	C (=)	M	M (=)
Conformity class	M	M (=)	M	M (=)
“Cyclic flow” option	U	C		
Quality of service	U	C	C	C (=)
Calling entity identification	U	C (=)		
Called entity identification	U	C (=)	U	C (=)
Application context	U	C (=)	U	C (=)
Negotiation result			M	M (=)
User information	M	M (=)	M	M (=)
For data link layer:				
Calling AE address	M	M (=)	M	M (=)
Called AE address	M	M (=)	M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

Calling AEI access point:

This parameter corresponds to the link address (of ADAEI type), making it possible to localise the AEI of the calling entity. The calling entity obtains it by means of its directory function.

Called AEI access point:

This parameter corresponds to the link address (of ADAEI type), making it possible to localise the AEI of the called entity. This access point can be proposed by the calling entity for use by the called entity. However, whether it is proposed or not, the called entity returns, in its response, the value of the access point used for its AEI.

Conformity class:

This parameter designates the MCS provider elements which are used in the context of a specific association.

The elements involved, which are designated by the associated conformity parameter names, are the following:

– association termination (PV_RE),
– acknowledgement (PH_AK),
– resend/antiduplication (PH_RA),
– segmentation/reassembly (PH_SR),
– flow control (PH_CF).

"Cyclic flow" option:

The cyclic flow option indicates the type of flow required for the association. Indeed, the flow offered by the association, depending on whether it is based on cycling messaging link services for both transmission directions or aperiodic services for either of the directions, will or will not be independent of the messaging requirements of the other system devices (6.3.1.2.3.4).

By means of this parameter, the calling entity can specify, as a condition of establishment, that the association offers a cyclic flow.

Quality of service:

For this parameter, quality of service is a subset of those defined earlier (see 6.3.1.2.3):

– transfer rate,
– number of retries,
– anticipation factor,
– SDU size.

These quality of service parameters are those which are negotiable on the basis of a value proposed by the calling entity.

Identification of the calling entity:

A calling entity is fully identified by four parameters:

– AP title,
– AE qualifier,
– API identifier,
– AEI identifier.

However, of these four parameters, the only ones present will be those which are necessary in view of the operating conditions of the system (see 6.3.1.2.4).

NOTE All these parameters may be absent. Furthermore, no modifications are made by the MCS provider.

Identification of the called entity:

A called entity is fully identified by four parameters:

– AP title,

– AE qualifier,

– API identifier,

– AEI identifier.

A called entity is fully or partially identified in an association establishment request, depending on the requirements for verification and selection adopted, in view of the operating conditions of the system (see 6.3.1.2.4).

NOTE All these parameters may be absent. Furthermore, no modifications are made by the MCS provider.

Application context:

This parameter corresponds to the name of the application context proposed by the calling entity.

The responder returns the same application context name or a different one, but compatible with that proposed.

Negotiation result:

This parameter makes it possible to report the result reserved for the association opening request, i.e. ACCEPT, REJECT_PROVIDER, REJECT_USER.

This result (acceptance or refusal) is exclusively related to the parameters exchanged in the establishment request.

User information:

The specific service elements which invoke this service use this parameter to negotiate other information characterising the association from their point of view.

For the data link layer:

List of the service parameters proposed by the calling entity for the requirements of the data link layer.

Called AE address:

This parameter corresponds to a link address (of the ADAE type) used to localise the AE of the calling entity (see 6.1.7.4.2).

Called AE address:

This parameter corresponds to the link address (of ADAE type) used to localise the AE of the called entity (see 6.1.7.4.2).

6.3.1.3.2.3 Service procedure

The chaining of the primitives leading to successful establishment of the association is shown in Figure 54.

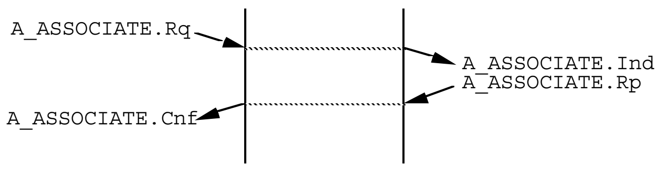


Figure 54 – A_Associate service procedure

This chaining diagram can fail:

– either due to the MCS provider being incapable of addressing the requirements of the calling entity,
– or due to disagreement by the called entity concerning its requirements,
– or due to transmission faults,
– or due to the implementing of ABORT services on this association during establishment.

NOTE In the first three cases, the service is only completed with negative confirmation, whereas in the last there is no confirmation.

The A_ABORT service is, indeed, the only which can be implemented on an association during establishment. This may be due to the action of:

– the calling entity awaiting confirmation of establishment,
– the called entity prior to its establishment response,
– the MCS provider, on specific faults or as a result of intervention at network management level.

NOTE Simultaneous opening is not considered possible as it is postulated that it is impossible to allocate, for two distinct entities, the same access points for localising the association ends. The network management is relied on to avoid this type of problem.

The A_ASSOCIATE service primitives, which are implemented on running the association establishment procedure, perform the following operations:

• A_ASSOCIATE.Rq primitive:

  Of the primitives transiting via the calling entity, only the following are processed by the requester element before transmission in the encoded PDU:

  - The “conformity class” can be reduced, provided the conformity constraints are complied with , depending on the capacities available.
  - The “cyclic rate” option, when it has the value YES, can impose a pure cyclic messaging flow at link level. Consequently, one of the cyclic messaging identifiers for which this device is configured is adopted for the association in accordance with the criteria specific to the requesting element.

– The following quality of service parameters can be reduced:

  “Transfer flow”

  “Anticipation factor”

  “SDU size”

  “Number of retries”

• A_ASSOCIATE.Ind primitive:

  Of the parameters received from the association establishment requester, only the following are processed by the responder element.

  - The “conformity class” can be deduced, provided the conformity constraints are complied with , from the capacities available.
  - The “cyclic rate” option, when it has the value YES, can impose a pure cyclic messaging flow at link level. Consequently, one of the cyclic messaging identifiers for which this device is configured is adopted for the association in accordance with the criteria specific to the responder element.
  - The following quality of service parameters can be reduced:

    “PDU size”

    “Transfer flow”

"Anticipation factor"

"SDU size"

"Number of retries"

- The "called entity identification" is utilised to make the checks arising owing to the presence of the different elements of which it is composed (see 6.3.1.2.4). If the check reveals a discrepancy between this called entity identification considered by the calling entity and the called entities effectively residing in the device which receives the association establishment request, a negative result is returned in the association establishment response.
- The "Application context" can be reduced in accordance with the reduction rules specific to the service element (see 6.1.8.3). If reduction is not possible, a negative result is returned in the association establishment response.

• A_ASSOCIATE.Rp primitive:

Of the parameters which transit via the called entity, the result is the first that has to be considered. Depending on whether it is positive or negative, the nature of the processing carried out before transmission of the establishment response is different.

If the result is negative, any resources previously reserved on reception of the establishment request are freed.

If the result is positive, the quality of service parameters are considered and, for the following, the values are adjusted:

"Transfer rate"

"Anticipation factor"

"SDU size"

"Number of retries"

• A_ASSOCIATE.Cnf primitive:

Of the parameters received from the called entity, the result is the first which has to be considered. Depending on whether it is positive or negative, the nature of the processing performed is different.

If the result is negative, the resources previously reserved on receiving the establishment request are freed.

If the result is positive, the other parameters are considered and, for each of the following, the values are adjusted on the basis of the value received from the responder element.

The parameters adjusted are the following:

- The quality of service:

"PDU size"

"Transfer rate"

"Anticipation factor"

"SDU size"

"Number of retries"

6.3.1.3.3 A_RELEASE service

6.3.1.3.3.1 Functionality

This service is used to terminate an association and, consequently, to free the resources implemented by it, as soon as its current data transfers are completed. Success of this service depends on the willingness of the responder user of this service.

6.3.1.3.3.2 Service primitives

The parameters of this service and description of its semantics are described in Table 90 and the accompanying text.

Table 90 – A_Release service parameters

Parameter name	Req	Ind	Rsp	Cnf
User information	U	C (=)	U	C (=)
Result			M	M (=)
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter. The method by which a response primitive is correlated with its corresponding preceding indication primitive is a local matter. See 1.2.				

User information:

The specific service elements which invoke this service can use this parameter to exchange additional information concerning revocation.

Result:

Simply indicates whether or not the responder user has accepted this association closure. This parameter takes the following values:

– Accepted

– Refused

– Other (definitions pending)

6.3.1.3.3.3 Service procedure

Chaining of the primitives leading to successful association termination is as indicated in Figure 55.

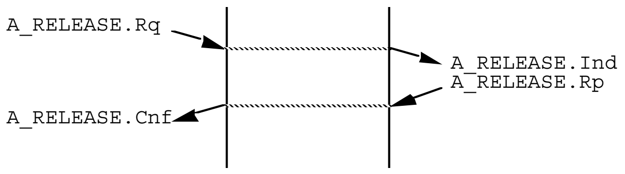


Figure 55 – A_Release service procedure

The termination request can be invoked by either the calling entity or the called entity of the association.

Simultaneous termination requests can occur when a termination request has been made by one of the correspondents of the association which receives a termination request from the other correspondent before it has received confirmation of its request.

In the case of simultaneous requests being detected by the provider, whether at called entity or calling entity level, the termination primitive chaining is broken. The provider proceeds with revocation of the association and freeing of the associated resources, after having invoked the ABORT.Rq service.

It is important to note that the requester of termination of an association cannot activate any primitive of the association other than A.ABORT.Rq until it has received confirmation of termination. Primitives can then be exchanged once more in the association if termination is refused by the corresponding entity.

NOTE It needs to however be borne in mind that a termination request can only be considered for a previously-established association, and that pre-negotiated associations can only be revoked by disabling their configuration under network management control.

Similarly, the responder to the termination request cannot activate any primitive other than A_ABORT.Rq in the association after it has received a termination indication. Primitives can once more be exchanged in the association if the responder local user refuses termination on this indication.

As soon as successful termination is confirmed, the association is revoked and the resources freed. In addition, either of the users of the association can always interrupt the running of the service by using the ABORT service, which revokes the association with the contingent loss of current data transfer.

NOTE Similarly, the running of this service can be interrupted if the network management opts to revoke the association during its creation.

6.3.1.3.4 A_ABORT service

6.3.1.3.4.1 Functionality

This service is invoked either by the user or directly by the MCS provider to revoke an association. Such revocation results in immediate freeing of the resources implemented by the association, which necessarily causes total loss of all current data transfers in it.

6.3.1.3.4.2 Service primitives

The parameters of this service and description of its semantics are shown in Table 91 and the accompanying text.

Table 91 – A_Abort service parameters

Parameter name	Req	Ind
Origin of invocation		M (=)
User information	U	C (=)

Origin of invocation:

Indicates the origin of invocation of this service, which can be invoked by the user or the provider, both at calling entity and called entity levels.

User information:

The specific application service elements which invoke this service utilise this parameter to exchange data units associated with the services that they offer. A service of this type does not guarantee their relaying.

6.3.1.3.4.3 Service procedure

The chaining of primitives relating to the revocation of an association is shown in Figure 56.

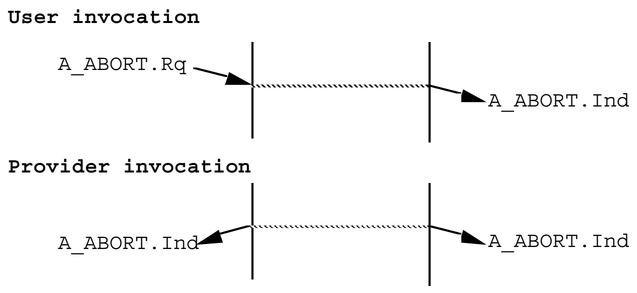


Figure 56 – A_Abort service procedure

A certain number of chaining variants, leading to special chaining, need to be considered:

– The simultaneous requesting of revocation by both the called user and the calling user results in the absence of a revocation indication at both ends.
– The simultaneous invoking of this service by the user and the provider results in there only being the option of invocation of the revocation request by the user who activates this revocation and indication of provider origin revocation at the other end of the association.

Furthermore, it is important to note that this service can be invoked by the provider if a collision should occur during termination of an association.

NOTE It should be borne in mind that a revocation request, whether at the initiative of the user or the provider, can only be considered for a pre-established association and that pre-negotiated associations can only be revoked by disabling their configuration under network management control.

6.3.1.3.5 A_DATA service

6.3.1.3.5.1 Functionality

This service enables exchange of MCS user data in an association. This transfer of data may or may not be acknowledged depending on the request, and only if the association uses the acknowledgement provider element.

In such cases, an acknowledgement provider element multipoint association cannot be used.

NOTE Acknowledgement may be requested systematically, occasionally or never in a given environment, depending on the desired trade-off between reliability of transmission and pass-band usage. However, in the case where segmentation is adopted and/or the anticipation factor is greater than 1, acknowledgement is implicitly utilised whatever the user requests.

6.3.1.3.5.2 Service primitives

The parameters of this service and description of its semantics are described in Table 92 and the accompanying text.

Table 92 – A_Data service parameters

Parameter name	Req	Ind	Cnf
Acknowledgement request	M	M (=)	
User information	M	M (=)	
Transfer result			M

Acknowledgement request:

The acknowledgement of a data unit transferred using this service can be requested using this parameter in the service. The value of this parameter indicates whether the acknowledgement is requested or not. The acknowledgement, if it is requested, is sent by the receiver MCS provider of the data transfer.

This parameter is meaningless when segmentation is adopted, as in this case the acknowledgement provider element is implicitly utilised.

User information:

The specific application service elements which invoke this service utilise this parameter to exchange data associated with the services that they offer.

Transfer result:

This parameter indicates whether transfer has taken place correctly or not. When an acknowledgement request is made, this result provides an indication concerning whether it has arrived in due time, whereas when it is not requested it is a local information item qualifying the sending process.

6.3.1.3.5.3 Service procedure

The chaining of primitives leading to a successful data transfer depending on whether acknowledgement is requested or not is shown in Figure 57.

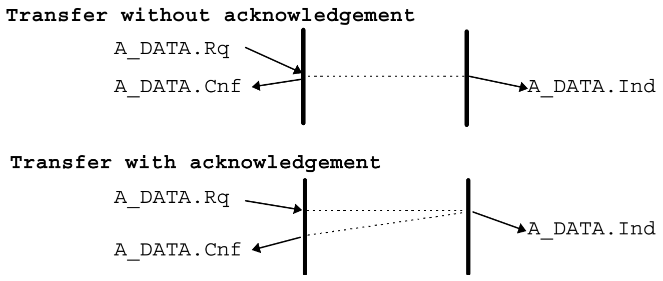

Transfer without acknowledgement
A_DATA.Rq
A_DATA.Cnf
A_DATA.Ind
Transfer with acknowledgement
A_DATA.Rq
A_DATA.Cnf
A_DATA.Ind

Figure 57 – A_Data service procedure

The chaining of these primitives cannot take place correctly except within the limits set by the quality of service adopted for the association.

NOTE It is thus that, for instance, exceeding of the data unit size by the sources, exceeding of the transfer rate adopted, or exceeding of the service size will result in non-completion of this chaining of primitives.

In the case of a transfer of data with acknowledgement, retries can occur to compensate for the loss of DLPDUs.

In addition, requests and acknowledgements of a number of transfers can be interlaced to optimise the bus traffic.

Finally, in the case of service requests of sizes greater than those of the protocol data units, they are segmented so that they can be relayed.

6.3.1.3.6 A_UNIDATA service

6.3.1.3.6.1 Functionality

This service enables the exchange of MCS user data outside an application association. It may or may not be the subject of an acknowledgement, depending on the operating conditions of the latter.

6.3.1.3.6.2 Service primitives

The parameters of this service and description of its semantics are described in Table 93 and the accompanying text.

Table 93 – A_Unidata service parameters

Parameter name	Req	Ind	Cnf
Acknowledgement request	M	M (=)	
Quality of service	M	M	
Source identification	U	C (=)	
Destination identification	U	C (=)	
Application context	U	C (=)	
User information	M	M (=)	
Transfer result			M
For the data link layer:			
Calling AE address	M	M (=)	
Called AE address	M	M (=)	

Acknowledgement request:

The acknowledgement of a data unit transferred with this service can be requested by means of this service parameter. The value of this parameter indicates whether acknowledgement is requested or not. This acknowledgement, if it is requested, is sent by the receiver MCS provider of the data transfer. Acknowledgement can only be requested for point-to-point data transfers.

Quality of service:

Quality of service is based on the parameters detailed in §4 of this section. Of these service quality parameters, during transfer of data in the non-associated mode, only one priority is transported contiguous with the data.

This priority is proposed by the source MCS user of this service, and determines the exchange of this service at provider level. The latter makes the commitment at source level to

– account for invoking this service if the resources are free or occupied by other invocations of lower priority not yet transmitted,
– transmit this service invocation unless the invocation is that of lowest priority pending, should another invocation of higher priority occur and all the resources be occupied.

The latter makes the commitment at destination level to

– receive an invocation of the service if the resources are free or occupied by invocations of lower priority not yet restored to the user,
– restore the invocation to the user, unless the invocation is that of lowest priority pending, when another of higher priority is received and all the resources are occupied.

Source identification:

The source identification identifies the initiator of the non-association data transfer service. A source in the context of the application layer architecture is fully identified by four parameters:

– AP title,
– AE qualifier,
– API identifier,
– AEI identifier.

Of these four parameters, the only ones present will be those necessary in view of the operating conditions of the system.

NOTE It is thus that the API identification is not necessary if each AE qualifier is operated by one single API.

Optionally, the value of this parameter is proposed by the user, which initialises a non-associated mode data transfer request. These parameters are present in the non-associated mode data transfer indication at called entity level, if they were present in the request. As for the value of these parameters in the data transfer indication, it is equal to that proposed by the source in the request.

Destination identification:

The destination identification identifies the receiver of the non-associated mode data transfer. A destination, in the context of the application layer architecture, is totally identified by four parameters:

– AP title,
– AE qualifier,
– API identifier,
– AEI identifier.

A called entity is fully or partially identified in a non-associated mode data transfer request, depending on the requirements of verification and selection adopted, in view of the system operating conditions.

The verification and selection possibilities offered at called entity level are described in 6.3.1.2.4.

NOTE For instance: (1) transit of the destination AP title makes it possible to verify that the AP localised by a link address is effectively that sought by the application; (2) transit of the API identifier makes it possible to select from it one of all those associated with the same AE qualifier.

Optionally, the value of this parameter is proposed by the operator who initialises a non-associated mode point-to-point data transfer request. It cannot be proposed in the case of multipoint data transfers.

Application context:

This parameter identifies the application context in which the source specifies to the destination that the non-associated data transfer should be interpreted.

The destination, depending on whether or not it supports this context, may or may not carry out the service requested.

Optionally, this parameter is proposed by the user who initialises a non-associated mode data transfer.

NOTE This parameter can, for instance, be transmitted on an *ad hoc* basis during an initial exchange between two entities to enable the source to verify that the destination is capable of interpreting the data units transmitted.

User information:

The specific application service elements which invoke this service utilise this parameter to exchange data units associated with the services that they offer.

Transfer result:

This parameter indicates whether the transfer has taken place correctly or not. Depending on whether or not an acknowledgement request has been made, this indication respectively qualifies the effective arrival of the acknowledgement in due time or the proper local execution of the transmission.

In the event of failure, this information states the type of fault, so as to indicate whether it has occurred locally or at the remote correspondent.

NOTE A fault detected by a remote correspondent provider necessarily results in the latter not supplying data to its user.

For the data link layer:

List of the service parameters proposed by the source user of the service for the requirements of the data link layer.

Source AE address:

This parameter corresponds to a link address (of the ADAE type) used to localise the source AE of the service (see 6.1.7.4.2).

Destination AE address:

This parameter corresponds to the link address (of ADAE type) used to localise the destination AE of the service (see 6.1.7.4.2).

6.3.1.3.6.3 Service procedure

The primitive chaining leading to successful data transfer, depending on whether or not acknowledgement is requested, is shown in Figure 58.

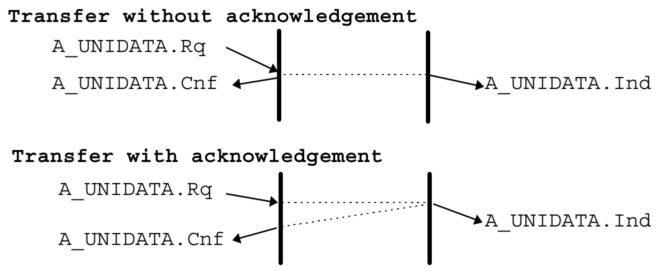


Figure 58 – A_Unidata service procedure

The primitive chaining can only take place correctly if the application context necessary for interpretation of the data is supported at destination level, and if the destination of which the identification is specified exists at receiver entity level.

When the priority requested by the source is not supported by the destination, the latter still carries out primitive chaining, using the priority level closest to that requested.

6.3.1.4 Mechanisms

6.3.1.4.1 MCS state machines

All MCS sequences which can take place, from the point of view of the user, are described by two state machines.

One machine for associated mode transmission services and the other for non-associated mode transmission services.

6.3.1.4.2 Associated mode primitive sequence

The service sequences, shown in Figure 59, depend on the state of the association with which they interact (see 6.1.6).

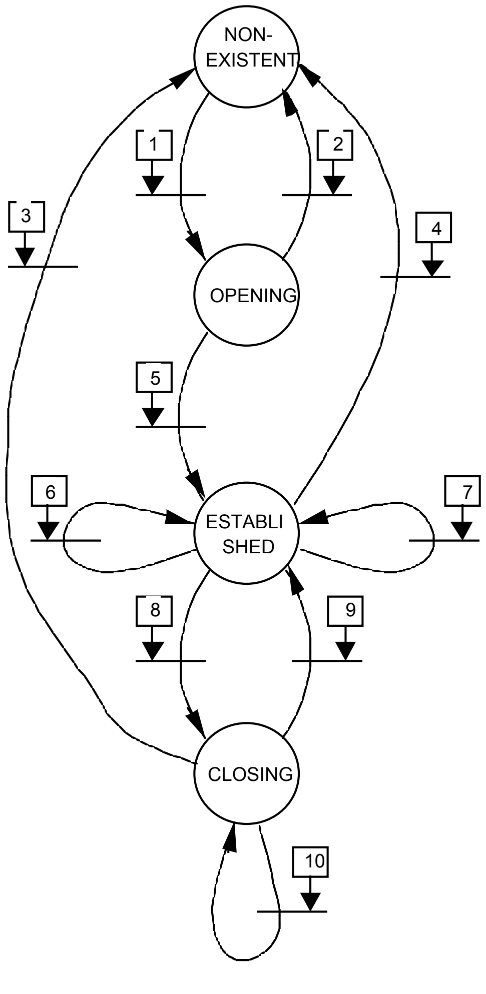


Figure 59 – Associated mode service state chart

List of events:

1. A_ASSOCIATE.Rq(); A_ASSOCIATE.Ind()
2. A_ASSOCIATE.Cnf(-); A_ASSOCIATE.Rp(-)
   A_ABORT.Ind(Provider, User); A_ABORT.Rq()
3. A_RELEASE.Cnf(+); A_ABORT.Ind (Provider, User); A_ABORT.Rq()
4. A_ABORT.Rq(); A_ABORT.Ind(Provider, User)
5. A_ASSOCIATE.Cnf(+); A_ASSOCIATE.Rp(+)
6. A_DATA.Rq
7. A_DATA.Ind(); A_DATA.Cnf(+/-)
8. A_RELEASE.Rq(); A_RELEASE.Ind()
9. A_RELEASE.Cnf(-); A_RELEASE.Rp(-)
10. A_DATA.Ind(); A_DATA.Cnf(+/-)

6.3.1.4.3 Non-associated mode primitive sequence

These primitive sequences are not constrained and can be carried out within the limits of the resources available, as shown in Figure 60.

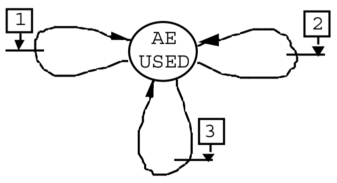


Figure 60 – Non-associated mode service state chart

List of events:

1. A_UNIDATA.Rq()
2. A_UNIDATA.Cnf(+/-)
3. A_UNIDATA.Ind()

Bibliography

IEC 61158-6-7, *Industrial communication networks – Fieldbus specifications – Part 6-7: Application layer protocol specification – Type 7 elements*

IEC 61784-1 (Ed.2.0), *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
P.O. Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch