IEC 61158-6-8

Edition 1.0 2007-12

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications – Part 6-8: Application layer protocol specification – Type 8 elements

IEC 61158-6-8:2007(E)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XD

ICS 35.100.70; 25.040.40

ISBN 2-8318-9478-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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IEC draws attention to the fact that it is claimed that compliance with this standard may involve the use of patents as follows, where the [xx] notation indicates the holder of the patent right:

Type 8:

DE 197 39 297 C2 [PxC] "Automatisierungssystem und Steuervorrichtung zur transparenten Kommunikation zwischen verschiedenen Netzwerken."

US 2002/0042845 A1 [PxC] "Automation System and connecting Apparatus for the Transparent Communication between two Networks."

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International Standard IEC 61158-6-8 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 61158-6 subseries cancel and replace IEC 61158-6:2003.. This edition of this part constitutes a technical revision.

This edition of IEC 61158-6 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 6 of the third edition into multiple parts numbered -6-2, -6-3, …

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

FDIS	Report on voting
65C/476/FDIS	65C/487/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- withdrawn;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 protocol provides the application service by making use of the services available from the data-link or other immediately lower layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer application entities (AEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

- as a guide for implementors and designers;
- for use in the testing and procurement of equipment;
- as part of an agreement for the admittance of systems into the open systems environment;
- as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-8: Application layer protocol specification – Type 8 elements

1 Scope

1.1 General

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 and material specific to Type 8 fieldbus. 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 specifies interactions between remote applications and defines the externally visible behavior provided by the Type 8 fieldbus application layer in terms of

a) the formal abstract syntax defining the application layer protocol data units conveyed between communicating application entities;
b) the transfer syntax defining encoding rules that are applied to the application layer protocol data units;
c) the application context state machine defining the application service behavior visible between communicating application entities;
d) the application relationship state machines defining the communication behavior visible between communicating application entities.

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

1) define the wire-representation of the service primitives defined in IEC 61158-5-8, and
2) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the Type 8 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) and the OSI application layer structure (ISO/IEC 9545).

1.2 Specifications

The principal objective of this standard is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-8.

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 protocols standardized in the IEC 61158-6 series.

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.

Conformance is achieved through implementation of this application layer protocol specification.

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 61158-3-8, *Industrial communication networks – Fieldbus specifications – Part 3-8: Data-link layer service definition – Type 8 elements*

IEC 61158-4-8, *Industrial communication networks – Fieldbus specifications – Part 4-8: Data-link layer protocol specification – Type 8 elements*

IEC 61158-5-8, *Industrial communication networks – Fieldbus specifications – Part 5-8: Application layer service definition – Type 8 elements*

ISO/IEC 7498 (all parts), *Information technology – Open Systems Interconnection – Basic Reference Model*

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

ISO/IEC 8824, *Information technology – Open Systems Interconnection – Specification of Abstract Syntax Notation One (ASN.1)*

ISO/IEC 8825, *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*

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

3 Terms and definitions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions apply.

3.1 ISO/IEC 7498-1 terms

This standard is partly based on the concepts developed in ISO/IEC 7498-1, and makes use of the following terms defined therein:

3.2
application entity

3.3
application process

3.4
application protocol data unit

3.5
application service element

3.6
application entity invocation

3.7
application transaction

3.8
transfer syntax

3.9 ISO/IEC 8822 terms

For the purposes of this document, the following term as defined in ISO/IEC 8822 applies:

3.10
abstract syntax

3.11 ISO/IEC 9545 terms

For the purposes of this document, the following terms as defined in ISO/IEC 9545 apply:

3.12
application-context

3.13
application-process-type

3.14
application-service-element

3.15
application control service element

3.16 ISO/IEC 8824 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8824 apply:

3.17
any type

3.18
bitstring type

3.19
Boolean type

3.20
choice type

3.21
component type

3.22
false

3.23
integer type

3.24
module

3.25
null type

3.26
object identifier

3.27
octetstring type

3.28
production

3.29
simple type

3.30
sequence of type

3.31
sequence type

3.32
structured type

3.33
tag

3.34
tagged type

3.35
true

3.36
type

3.37 ISO/IEC 8825 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8825 apply:

3.38
encoding (of a data value)

3.39
data value

3.40 Terms and definitions from IEC 61158-5-8

3.41
application relationship

3.42
client

3.43
error class

3.44
publisher

3.45
server

3.46
subscriber

3.47 Other terms and definitions

The following terms and definitions are used in this standard.

3.48
called
service user or a service provider that receives an indication primitive or a request APDU

3.49
calling
service user or a service provider that initiates a request primitive or a request APDU

3.50
management information
network accessible information that supports the management of the Fieldbus environment

3.51
receiving
service user that receives a confirmed primitive or an unconfirmed primitive, or a service provider that receives a confirmed APDU or an unconfirmed APDU

3.52
resource
resource is a processing or information capability of a subsystem

3.53
sending
service user that sends a confirmed primitive or an unconfirmed primitive, or a service provider that sends a confirmed APDU or an unconfirmed APDU

4 FAL syntax description

4.1 FAL-AR PDU abstract syntax

4.1.1 Top level definition

The productions defined here shall be used with the Peripherals Encoding Rules (see 5.2) for APDU encoding.

```
APDU ::= CHOICE {
            [PRIVATE 0] ConfirmedSend-RequestPDU,
            [PRIVATE 1] ConfirmedSend-ResponsePDU,
            [PRIVATE 2] UnconfirmedSend-PDU,
            [PRIVATE 3] UnconfirmedAcknowledgedSend-CommandPDU,
            [PRIVATE 4] Establish-RequestPDU,
            [PRIVATE 5] Establish-ResponsePDU,
            [PRIVATE 6] Establish-ErrorPDU,
            [PRIVATE 7] Abort-PDU,
            [PRIVATE 8] DataSendAcknowledge-PDU
}
```

4.1.2 Confirmed send service

```
ConfirmedSend-RequestPDU ::= SEQUENCE {
      [APPLICATION 0] AddressAREP,
      InvokeID,
      ConfirmedServiceRequest
}
ConfirmedSend-ResponsePDU ::= SEQUENCE {
      [APPLICATION 1] AddressAREP,
      InvokeID,
      pduBody     CHOICE {
         ConfirmedServiceResponse,
         ConfirmedServiceError
      }
}
```

4.1.3 Unconfirmed send service

```
UnconfirmedSend-PDU ::= SEQUENCE {
      [APPLICATION 2] AddressAREP,
      InvokeID,
      pduBody     CHOICE {
         UnconfirmedServiceRequest,
         UnconfirmedSendPD-PDU
      }
}
```

4.1.4 Unconfirmed acknowledge send service

```
UnconfirmedAcknowledgeSend-CommandPDU ::= SEQUENCE {
      [APPLICATION 3] AddressAREP,
      InvokeID,
      UnconfirmedServiceRequest
}
```

4.1.5 Establish service

```
Establish-RequestPDU ::= SEQUENCE {
      [APPLICATION 4] AddressAREP,
      ConType,
      MaxOSCC,
      MaxOSCS,
      MAXUCSC,
      MAXUCSS,
      CIU,
      InvokeID,
      initiateRequest                    [PRIVATE 0] IMPLICIT Initiate-RequestPDU
}

Establish-ResponsePDU ::= SEQUENCE {
      [APPLICATION 5] AddressAREP,
      InvokeID,
      initiateResponse                   [PRIVATE 0] IMPLICIT Initiate-ResponsePDU
}

Establish-ErrorPDU ::= SEQUENCE {
      [APPLICATION 6] AddressAREP,
      InvokeID,
      initiateError                      [PRIVATE 0] IMPLICIT Initiate-ErrorPDU
}
```

4.1.6 MaxOSCC

```
MaxOSCC ::= Unsigned8
```

4.1.7 MaxOSCS

```
MaxOSCS ::= Unsigned8
```

4.1.8 MaxUCSC

```
MaxUCC ::= Unsigned8
```

4.1.9 MaxUCSS

```
MaxUCS ::= Unsigned8
```

4.1.10 CIU

```
CIU ::= Unsigned32
```

4.1.11 InvokeID

```
InvokeID ::=  Unsigned8
```

4.1.12 ConType

```
ConType ::= ENUMERATED {
   mmaz            (0)
}
```

4.1.13 Data send acknowledge service

```
DataSendAcknowledge-PDU ::= SEQUENCE {
      Protocol-Code,[APPLICATION 8],Address2ARP,      --- Protocol-Code in the higher nibble of the octet!!!
      Block-Number,
      Block-Length,
      Protocol-Data,
}
```

4.1.14 Protocol-Code

```
Protocol-Code ::= ENUMERATED {
   TCP/IP          (1)                          --- TCP/IP protocol
}
```

4.1.15 Block-Number

```
Block-Number ::= Unsigned8                       --- 0  no blocking
                                                 ---- 1…254 block number
                                                 ---- 255 last block
```

4.1.16 Block-Length

```
Block-Length ::= Unsigned
```

4.1.17 Protocol-Data

```
Protocol-Data::= Any                             --- transparent protocol transfer
```

4.1.18 Address2 ARP

```
Address2ARP ::= SEQUENCE {
   Destination-Address,
   Source-Address,
   Destination-Node,
   Destination-Subnode,
   Source-Node,
   Source-Subnode
}
```

4.1.19 Destination-Address

```
Destination-Address ::= OctetString                    --- 3 Octets
```

4.1.20 Source-Address

```
Source-Address ::= OctetString                         --- 3 Octets
```

4.1.21 Destination-Node

```
Destination-Node ::= Unsigned8
```

4.1.22 Source-Node

```
Source-Node ::= Unsigned8
```

4.1.23 Destination-Subnode

```
Destination-Subnode ::= Unsigned8
```

4.1.24 Source-Subnode

```
Source-Subnode ::= Unsigned8
```

4.2 Abstract syntax of PDUBody

4.2.1 Abort service

```
Abort-PDU ::= SEQUENCE {
      [APPLICATION 7] AddressAREP,
      Identifier,
      ReasonCode,
      AdditionalDetail
}
```

4.2.2 ConfirmedServiceRequest

```
ConfirmedServiceRequest::= CHOICE {
   read-Request                  [0] IMPLICIT Read-RequestPDU,
   write-Request                 [3] IMPLICIT Write-RequestPDU,
   start-Request                 [6] IMPLICIT Start-RequestPDU,
   stop-Request                  [9] IMPLICIT Stop-RequestPDU,
   status-Request                [15] IMPLICIT Status-RequestPDU,
   identify-Request              [18] IMPLICIT Identify-RequestPDU,
   getAttributes1-Request        [21] IMPLICIT GetAttributes-RequestPDU,    -- short form
   getAttributes2-Request        [35] IMPLICIT GetAttributes-RequestPDU,    -- long form
   reset-Request                 [36] IMPLICIT Reset-RequestPDU,
   resume-Request                [39] IMPLICIT Resume-RequestPDU
}
```

4.2.3 ConfirmedServiceResponse

```
ConfirmedServiceResponse ::= CHOICE {
   read-Response                 [1] IMPLICIT Read-ResponsePDU,
   write-Response                [4] IMPLICIT Write-ResponsePDU,
   start-Response                [7] IMPLICIT Start-ResponsePDU,
   stop-Response                 [10] IMPLICIT Stop-ResponsePDU,
   status-Response               [16] IMPLICIT Status-ResponsePDU,
   identify-Response             [19] IMPLICIT Identify-ResponsePDU,
   getAttributes-Response        [22] IMPLICIT GetAttributes-ResponsePDU,
   reset-Response                [37] IMPLICIT Reset-ResponsePDU,
   resume-Response               [40] IMPLICIT Resume-ResponsePDU
}
```

4.2.4 ConfirmedServiceError

```
ConfirmedServiceError ::= CHOICE {
   read-Error                    [2] IMPLICIT ErrorType,
   write-Error                   [5] IMPLICIT ErrorType,
   start-Error                   [8] IMPLICIT ErrorFiType,
   stop-Error                    [11] IMPLICIT ErrorFiType,
   status-Error                  [17] IMPLICIT ErrorType,
   identify-Error                [20] IMPLICIT ErrorType,
   getAttributes-Error           [23] IMPLICIT ErrorType,
   reset-Error                   [38] IMPLICIT ErrorFiType,
   resume-Error                  [41] IMPLICIT ErrorFiType
}
```

4.2.5 Error type

```
ErrorType ::= SEQUENCE {
   errorClass                    [0] IMPLICIT ErrorClass,
   optionalParametersMap         [10] IMPLICIT Gn_OptionalParametersMap8 OPTIONAL,
   additionalCode                [1] IMPLICIT Integer16 OPTIONAL,
   additionalDescription         [2] IMPLICIT VisibleString OPTIONAL,
}
```

4.2.6 Error Fi type

```
ErrorFiType ::= SEQUENCE {
   errorClass                    [0] IMPLICIT ErrorClass,
   additionalCode                [1] IMPLICIT Integer16 OPTIONAL,
   fiState                       [3] IMPLICIT Integer8
}
```

4.2.7 Error class

```
ErrorClass ::=  CHOICE
{
    vfdState                [1]   IMPLICIT  Integer8 {
                                      other                           (0)
    },
    applicationReference    [2]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      application-unreachable         (1),
                                      application-reference-invalid   (2),
                                      context-unsupported             (3)
    },
    definition              [3]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      object-undefined                (1),
                                      object-attributes-inconsistent  (2),
                                      name-already-exists             (3),
                                      type-unsupported                (4),
                                      type-inconsistent               (5)
    },
    resource                [4]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      memory-unavailable              (1)
    },
    service                 [5]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      object-state-conflict           (1),
                                      pdu-size                        (2),
                                      object-constraint-conflict      (3),
                                      parameter-inconsistent          (4),
                                      illegal-parameter               (5)
    },
    access                  [6]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      object-invalidated              (1),
                                      hardware-fault                  (2),
                                      object-access-denied            (3),
                                      invalid-address                 (4),
                                      object-attribute-inconsistent   (5),
                                      object-access-unsupported       (6),
                                      object-non-existent             (7),
                                      type-conflict                   (8),
                                      named-access-unsupported        (9),
                                      access-to-element-              (10)
                                      unsupported
    },
    objectDescription       [7]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      name-length-overflow            (1),
                                      od-overflow                     (2),
                                      od-write-protected              (3),
                                      extension-length-overflow       (4),
                                      od-description-length-          (5),
                                      overflow
                                      operational-problem             (6)
    },
    conclude                [9]   IMPLICIT  Integer8 {
                                      other                           (0),
                                      further-communication-          (1)
                                      required
    },
    other                   [8]   IMPLICIT  Integer8 {
                                      other                           (0)
    }
}
```

4.2.8 Unconfirmed PDUs

```
UnconfirmedServiceRequest ::= CHOICE {
   informationReport-Request          [12] IMPLICIT InformationReport-RequestPDU,
   reject-Request                     [34] IMPLICIT Reject-RequestPDU
}

UnconfirmedSendPD-PDU ::= BIT STRING
```

4.2.9 Management ASE

4.2.9.1 Get attributes service

```
GetAttributes-Request-PDU ::= SEQUENCE {
   listOfAttributes                    [PRIVATE 0] IMPLICIT Mn_SelectedAttributes,
   accessSpecification  CHOICE {
      index                                [1] IMPLICIT Gn_NumericID,
      variableName                     [2] IMPLICIT Gn_Name,
      fiName                           [5] IMPLICIT Gn_Name,
      startIndex                       [7] IMPLICIT Gn_NumericID
   }
}

GetAttributes-ResponsePDU ::= SEQUENCE {
   more                                [PRIVATE 0] IMPLICIT Gn_MoreFollows,
   listOfObjectDefinition              [PRIVATE 1] IMPLICIT SEQUENCE OF Gn_ObjectDefinition
}
```

4.2.10 Application process ASE

4.2.10.1 Get status service

```
Status-RequestPDU ::= NULL

Status-ResponsePDU ::= SEQUENCE {
   logicalStatus                       [PRIVATE 0] IMPLICIT ENUMERATED {
      ready-for-communication              (0),
      limited-services-permitted           (2),
   },
   physicalStatus                      [PRIVATE 1] IMPLICIT ENUMERATED {
      operational                          (0),
      partially-operational                (1),
      inoperable                           (2),
      needs-commissioning                  (3)
   },
   localDetail                         [PRIVATE 2] IMPLICIT BitString OPTIONAL
 }
```

4.2.10.2 Identify service

```
Identify-RequestPDU ::= NULL

Identify-ResponsePDU ::= SEQUENCE {
   vendorName                          [PRIVATE 0] IMPLICIT VisibleString,
   modelIdentifier                     [PRIVATE 1] IMPLICIT VisibleString,
   vendorRevision                      [PRIVATE 2] IMPLICIT VisibleString
}
```

4.2.10.3 Initiate service

```
Initiate-RequestPDU ::= SEQUENCE {
   versionObjectDefinitionsCalling     [PRIVATE 0] IMPLICIT Integer16,
   apDescriptorCalling                 [PRIVATE 1] IMPLICIT OctetString,
   accessProtectionSupportedCalling    [PRIVATE 2] IMPLICIT Ap_AccessProtectionSupported,
   passwordAndAccessGroupsCalling      [PRIVATE 3] IMPLICIT Ap_AccessControl,
   configuredMaxPduSizeSending         [PRIVATE 4] IMPLICIT Unsigned8,
   configuredMaxPduSizeReceiving       [PRIVATE 5] IMPLICIT Unsigned8,
   listOfSupportedServicesCalling      [PRIVATE 6] IMPLICIT Mn_PduSupportedMap
}

Initiate-ResponsePDU ::= SEQUENCE {
   versionObjectDefinitionsCalled      [PRIVATE 0] IMPLICIT Integer16,
   apDescriptorCalled                  [PRIVATE 1] IMPLICIT OctetString,
   accessPrivilegeSupportedCalled      [PRIVATE 2] IMPLICIT Ap_AccessProtectionSupported,
   passwordAndAccessGroupsCalled       [PRIVATE 3] IMPLICIT Ap_AccessControl
}
```

```
Initiate-ErrorPDU ::= SEQUENCE {
   errorCode                          [PRIVATE 0] IMPLICIT  ENUMERATED {
      other                              (0),
      max-fal-pdu-size-insufficient      (1),
      service-not-supported              (2),
      version-obj-def-incompatible       (3),
      user-initiate-denied               (4),
      password-error                     (5),
      profile-number-incompatible        (6)
      },
   maxPduLengthSendingCalled          [PRIVATE 1] IMPLICIT Unsigned8,
   maxPduLengthReceivingCalled        [PRIVATE 2] IMPLICIT Unsigned8,
   listOfSupportedServicesCalled      [PRIVATE 3] IMPLICIT Mn_PduSupportedMap
 }
```

4.2.10.4 Reject service

```
Reject-RequestPDU  ::=  SEQUENCE  {
   original-invokeID                  [PRIVATE 0] IMPLICIT Integer8,
   reject-code                        [PRIVATE 1] IMPLICIT ENUMERATED {
      pdu-size                           (5)
   }
}
```

4.2.11 Function invocation ASE

4.2.11.1 Reset service

```
Reset-RequestPDU ::= SEQUENCE {
   keyAttribute                       Gn_KeyAttribute
}

Reset-ResponsePDU ::= NULL
```

4.2.11.2 Resume service

```
Resume-RequestPDU ::= SEQUENCE {
   keyAttribute                       Gn_KeyAttribute
}

Resume-ResponsePDU ::= NULL
```

4.2.11.3 Start service

```
Start-RequestPDU ::= SEQUENCE {
   keyAttribute                       Gn_KeyAttribute
}

Start-ResponsePDU ::= NULL
```

4.2.11.4 Stop service

```
Stop-RequestPDU ::= SEQUENCE {
   keyAttribute                       Gn_KeyAttribute
}

Stop-ResponsePDU ::= NULL
```

4.2.12 Variable ASE

4.2.12.1 Information report service

```
InformationReport-RequestPDU  ::=  SEQUENCE  {
   index                              Gn_NumericID,
   subIndex                           [PRIVATE 0] IMPLICIT Gn_SubIndex OPTIONAL,
   value                              [PRIVATE 1] IMPLICIT ANY
}
```

4.2.12.2 Read service

```
Read-RequestPDU ::= SEQUENCE {
   index                                   Gn_NumericID,
   subIndex                            [PRIVATE 0] IMPLICIT Gn_SubIndex OPTIONAL
}

Read-ResponsePDU ::= SEQUENCE {
   value                                   [PRIVATE 0] IMPLICIT ANY
}
```

4.2.12.3 Write service

```
Write-RequestPDU ::= SEQUENCE {
   index                                   Gn_NumericID,
   subIndex                            Gn_SubIndex OPTIONAL,
   value                                   [PRIVATE 0] IMPLICIT ANY
}

Write-ResponsePDU ::= NULL
```

4.3 Type definitions for ASEs

4.3.1 AP ASE types

4.3.1.1 Ap_AccessProtectionSupported

```
Ap_AccessProtectionSupported ::= Boolean        -- True means Access Protection is supported.
                                                -- False means Access Protection is not supported.


Ap_AccessControl ::= BitString {            -- The Password (Unsigned8) is encoded as a bit string.
   password_Bit1                            (8),
   password_Bit2                            (7),
   password_Bit3                            (6),
   password_Bit4                            (5),
   password_Bit5                            (4),
   password_Bit6                            (3),
   password_Bit7                            (2),
   password_Bit8                            (1),
   access_Groups-1                          (16),
   access_Groups-2                          (15),
   access_Groups-3                          (14),
   access_Groups-4                          (13),
   access_Groups-5                          (12),
   access_Groups-6                          (11),
   access_Groups-7                          (10),
   access_Groups-8                          (9)
}
```

4.3.2 AR ASE types

4.3.2.1 Reason code

```
ReasonCode ::= Unsigned8
```

4.3.2.1.1 Additional detail

```
AdditionalDetaill ::= OctetString
```

4.3.2.2 AREP

```
AddressAREP::= Unsigned8                    -- Least significant octet of DLCEP address
```

4.3.3 Function Invocation ASE types

4.3.3.1 Fi_AccessPrivilege

```
Fi_AccessPrivilege ::= BitString {
   rightToStartPassword              (24),
   rightToStopPassword               (23),
   rightToDeletePassword             (22),
   rightToStartAccessGroup           (20),
   rightToStopAccessGroup            (19),
   rightToDeleteAccessGroup          (18),
   rightToStartAllPartner            (32),
   rightToStopAllPartner             (31),
   rightToDeleteAllPartner           (30),
   password_Bit1                     (8),    -- The Password (Unsigned8) is encoded as a bit string.
   password_Bit2                     (7),
   password_Bit3                     (6),
   password_Bit4                     (5),
   password_Bit5                     (4),
   password_Bit6                     (3),
   password_Bit7                     (2),
   password_Bit8                     (1),
   access_Groups-1                   (16),
   access_Groups-2                   (15),
   access_Groups-3                   (14),
   access_Groups-4                   (13),
   access_Groups-5                   (12),
   access_Groups-6                   (11),
   access_Groups-7                   (10),
   access_Groups-8                   (9)
}
```

4.3.3.2 Fi_State

```
Fi_State ::= Unsigned8 {
   unrunnable                        (1),
   idle                              (2),
   running                           (3),
   stopped                           (4),
   starting                          (5),
   stopping                          (6),
   resuming                          (7),
   resetting                         (8)
}
```

4.3.4 Management ASE types

4.3.4.1 Mn_PduSupportedMap

```
Mn_PduSupportedMap ::= BIT STRING {
   getAttributes-RequestPDU          (1),    -- Requester
   start-RequestPDU                  (8),
   stop-RequestPDU                   (9),
   resume-RequestPDU                 (9),
   reset-RequestPDU                  (9),
   read-RequestPDU                   (11),
   write-RequestPDU                  (12),
   informationReport-RequestPDU      (17),
   getAttributes-ResponsePDU         (25),   -- Responder
   start-ResponsePDU                 (33),
   stop-ResponsePDU                  (33),
   resume-ResponsePDU                (33),
   reset-ResponsePDU                 (33),
   read-ResponsePDU                  (35),
   write-ResponsePDU                 (36),
   informationReport-ResponsePDU     (41)
}
```

4.3.5 Variable ASE types

4.3.5.1 General types

4.3.5.1.1 Gn_Deletable

```
Gn_Deletable ::= Boolean          -- True means deletable.
                                  -- False means not deletable.
```

4.3.5.1.2 Gn_Reusable

```
Gn_Reusable ::= Boolean           -- True means reusable.
                                  -- False means not reusable.
```

4.3.5.1.3 Gn_KeyAttribute

```
Gn_KeyAttribute ::= CHOICE {
-- When this type is specified, only the key attributes of the class referenced are valid.
   numericID                      [0] IMPLICIT Gn_NumericID,
   name                           [1] IMPLICIT Gn_Name,
   listName                       [2] IMPLICIT Gn_Name,
   numericAddress                 [4] IMPLICIT Gn_NumericAddress,
   symbolicAddress                [5] IMPLICIT Gn_SymbolicAddress
}
```

4.3.5.1.4 Gn_Length

```
Gn_Length ::= Unsigned8
```

4.3.5.1.5 Gn_MoreFollows

```
Gn_MoreFollows ::= Boolean
```

4.3.5.1.6 Gn_Name

```
Gn_Name ::= OctetString
```

4.3.5.1.7 Gn_NumericID

```
Gn_NumericID ::= Unsigned16       -- The values of this parameter are unique within an AP.
```

4.3.5.1.8 Gn_ObjectDefinition

```
Gn_ObjectDefinition ::= OctetString   -- The semantics of this parameter are application specific.
```

4.3.5.1.9 Gn_SubIndex

```
Gn_SubIndex ::= Unsigned8
```

4.3.5.2 Gn_ObjectClass

```
Gn_ObjectClass ::= ENUMERATED {
   functionInvocation             (3),
   fixedLengthStringDataType      (5),
   structuredDataType             (6),
   fixedLengthStringVariable      (7),
   arrayVariable                  (8),
   dataStructureVariable          (9),
}
```

4.3.5.3 Gn_TypeDescription

```
Gn_TypeDescription ::= CHOICE {
   boolean                          [1]  Gn_Length,
   integer8                         [2]  Gn_Length,
   integer16                        [3]  Gn_Length,
   integer32                        [4]  Gn_Length,
   unsigned8                        [5]  Gn_Length,
   unsigned16                       [6]  Gn_Length,
   unsigned32                       [7]  Gn_Length,
   float                            [8]  Gn_Length,
   visiblestring                    [9]  Gn_Length,
   octetstring                      [10] Gn_Length,
   binaryDate                       [11] Gn_Length,
   timeOfDay                        [12] Gn_Length,
   timeDifference                   [13] Gn_Length,
   bitstring                        [14] Gn_Length
}
```

4.4 Object definitions

4.4.1 Top level definition

```
Object-Definition ::= CHOICE {
          [PRIVATE 0] ListHeader,
          [PRIVATE 1] DataTypeList,
          [PRIVATE 2] StaticList,
          [PRIVATE 3] FunctionInvocationDefinition
}
```

4.4.2 ListHeader

```
ListHeader ::= SEQUENCE {
   numericId                                  [PRIVATE 0] IMPLICIT Unsigned16,
   romRamFlag                                 [PRIVATE 1] IMPLICIT Boolean,
   maxNameLength                              [PRIVATE 2] IMPLICIT Unsigned8,
   accessProtectionSupported                  [PRIVATE 3] IMPLICIT Boolean,
   versionOfObjectDefinition                  [PRIVATE 4] IMPLICIT Integer16,
   localReferenceOfListHeader                 [PRIVATE 5] IMPLICIT Unsigned32 OPTIONAL,
   numberOfEntriesInDataTypeList              [PRIVATE 6] IMPLICIT Unsigned16,
   localReferenceOfDataTypeList               [PRIVATE 7] IMPLICIT Unsigned32 OPTIONAL,
   firstNumericIdOfStaticList                 [PRIVATE 8] IMPLICIT Unsigned16,
   numberOfEntriesInStaticList                [PRIVATE 9] IMPLICIT Unsigned16,
   localReferenceOfStaticList                 [PRIVATE 10] IMPLICIT Unsigned32 OPTIONAL,
   firstNumericIdOfVariableListDefinition     [PRIVATE 11] IMPLICIT Unsigned16,
   numberOfEntriesInVariableListDefinition        [PRIVATE 12] IMPLICIT Unsigned16,
   localReferenceOfVariableListDefinition     [PRIVATE 13] IMPLICIT Unsigned32 OPTIONAL,
   firstNumericIdOfFunctionInvocationDefinition [PRIVATE 14] IMPLICIT Unsigned16,
   numberOfEntriesInFunctionInvocationDefinition [PRIVATE 15] IMPLICIT Unsigned16,
   localReferenceOfFunctionInvocationDefinition [PRIVATE 16] IMPLICIT Unsigned32 OPTIONAL
}
```

4.4.3 DataTypeList

```
DataTypeList ::= CHOICE {
        [PRIVATE 0] DataTypeDefinition,
            [PRIVATE 1] StructuredDataTypeDefinition
}

DataTypeDefinition ::= SEQUENCE {
   numericId                                Gn_NumericID,
   objectClass                              Gn_ObjectClass,
   dataTypeNameLength                       Gn_Length,
   dataTypeName                             [PRIVATE 0] IMPLICIT VisibleString OPTIONAL
}

StructuredDataTypeDefinition ::= SEQUENCE {
   numericId                                Gn_NumericID,
   objectClass                              Gn_ObjectClass,
   numberOfElements                      [PRIVATE 0] IMPLICIT Integer8,
   recordList      SEQUENCE OF SEQUENCE{
      numericIdOfDataTypeDefinition         Gn_NumericID,
      dataLength                            Gn_Length
   }
}
```

4.4.4 StaticList

```
StaticList ::= CHOICE {
        [PRIVATE 0] VariableDefinition,
        [PRIVATE 1] ArrayDefinition,
        [PRIVATE 2] StructureDefinition
}

VariableDefinition ::= SEQUENCE {
   numericId                                Gn_NumericID,
   objectClass                              Gn_ObjectClass,
   numericIdOfDataTypeDefinition            Gn_NumericID,
   dataLength                               Gn_Length,
   accessPrivilege                          Vr_AccessPrivilege OPTIONAL,
   localReferenceOfVariable              [PRIVATE 0] IMPLICIT Unsigned32 OPTIONAL,
   variableName                          [PRIVATE 1] IMPLICIT VisibleString OPTIONAL,
   extension                             [PRIVATE 2] IMPLICIT OctetString OPTIONAL
}

ArrayDefinition ::= SEQUENCE {
   numericId                                Gn_NumericID,
   objectClass                              Gn_ObjectClass,
   numericIdOfDataTypeDefinition            Gn_NumericID,
   dataLength                               Gn_Length,
   numberOfElements                      [PRIVATE 0] IMPLICIT Unsigned8,
   accessPrivilege                          Vr_AccessPrivilege OPTIONAL,
   localReferenceOfArray                 [PRIVATE 1] IMPLICIT Unsigned32 OPTIONAL,
   arrayName                             [PRIVATE 2] IMPLICIT VisibleString OPTIONAL,
   extension                             [PRIVATE 3] IMPLICIT OctetString OPTIONAL
}

StructureDefinition ::= SEQUENCE {
   numericId                                Gn_NumericID,
   objectClass                              Gn_ObjectClass,
   numericIdOfDataTypeDefinition            Gn_NumericID,
   accessPrivilege                          Vr_AccessPrivilege OPTIONAL,
   structureName                         [PRIVATE 0] IMPLICIT VisibleString OPTIONAL,
   extension                             [PRIVATE 1] IMPLICIT OctetString OPTIONAL,
   localReferenceOfElement               [PRIVATE 2] IMPLICIT SEQUENCE OF Unsigned32 OPTIONAL
}
```

4.4.5 FunctionInvocationDefinition

```
FunctionInvocationDefinition ::= SEQUENCE {
   numericId                          Gn_NumericID,
   objectClass                        Gn_ObjectClass,
   numberOfRelatedObjects             [PRIVATE 0] IMPLICIT Unsigned8,
   accessPrivilege                    Fi_AccessPrivilege OPTIONAL,
   deletable                          Gn_Deletable,
   reusable                           Gn_Reusable,
   functionInvocationState            FI_State,
   numericIdOfLoadRegion              SEQUENCE OF Gn_NumericID,
   functionInvocationName             [PRIVATE 1] IMPLICIT VisibleString OPTIONAL,
   extension                          [PRIVATE 2] IMPLICIT OctetString OPTIONAL
}
```

4.5 Abstract syntax of Data types

4.5.1 Notation for the Boolean type

```
Boolean ::= BOOLEAN                -- TRUE if the value is non-zero.
                                   -- FALSE if the value is zero.
```

4.5.2 Notation for the Integer type

```
Integer ::= INTEGER                -- any integer
Integer8 ::= INTEGER  (-128..+127) -- range -2^7 <= i <= 2^7-1
Integer16 ::= INTEGER  (-32768..+32767) -- range -2^15 <= i <= 215-1
Integer32 ::= INTEGER              -- range -2^31 <= i <= 2^31-1
```

4.5.3 Notation for the Unsigned type

```
Unsigned ::= INTEGER               -- any non-negative integer
Unsigned8 ::= INTEGER  (0..255)    -- range 0 <= i <= 2^8-1
Unsigned16 ::= INTEGER  (0..65535) -- range 0 <= i <= 2^16-1
Unsigned32 ::= INTEGER             -- range 0 <= i <= 2^32-1
```

4.5.4 Notation for the Floating Point type

```
Floating32 ::= BIT STRING  SIZE (4)    --  IEC-60559Single precision
```

4.5.5 Notation for the BitString type

```
BitString ::= BIT STRING           -- For generic use
```

4.5.6 Notation for the OctetString type

```
OctetString ::= OCTET STRING       -- For generic use
```

4.5.7 Notation for VisibleString type

```
VisibleString ::= VISIBLE STRING   -- For generic use
```

4.5.8 Notation for TimeOfDay type

```
TimeOfDay ::= OctetString6
```

4.5.9 Notation for TimeDifference type

```
TimeDifference ::= OctetString6
```

4.5.10 Notation for BinaryDate2000 type

BinaryDate2000 ::= OctetString8

5 Transfer syntax

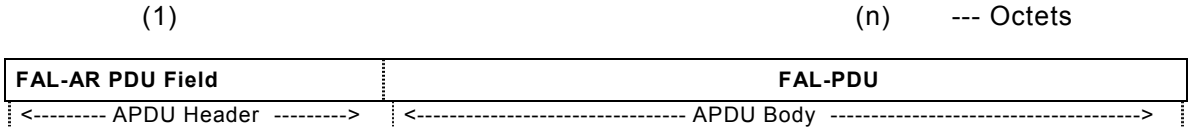
5.1 Peripherals encoding rules (PER)

The Peripherals Encoding Rule is the encoding of the PDU types defined in 4.1.

5.2 Encoding of APDU types

5.2.1 Overview of APDU encoding

The APDUs encoded with the PER shall have a uniform format. The APDUs shall consist of two major parts, the “APDU Header” part and the “APDU Body” part as shown in Figure 1.



5.2.2 APDU header encoding

In 4.1, an APDU header is defined as a tagged type of the tag class 'APPLICATION'.

The APDU Header (also called FAL-AR PDU Field) shall be encoded using one or more octets as described in this subclause.

Within the APDU header, the PDU Type tag (e.g. Establish-RequestPDU, ConfirmedSend-RequestPDU...) and the address information (AddressAREP) is encoded .

If the value of the PDU type is < 3, the APDU header shall be encoded using one octet as defined in Figure 2.

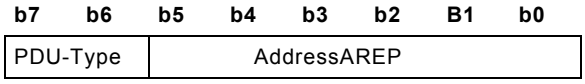


Figure 2 – APDU header

If the value of the PDU type is >= 3 an extension octet is used for the encoding of the tag. The use of a tag extension octet shall be indicated by setting both bits in the PDU type field of the first octet to 1. If the address information (AddressAREP) is greater than 62, an address extension octet shall be used for the encoding of the address value. In this case, the use of an address extension shall be indicated by setting all bits of the address field in the first octet to 1 (see Figure 3 and Figure 4).

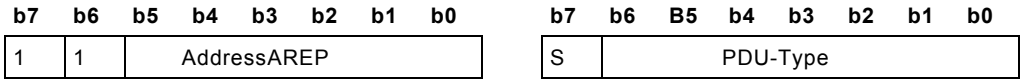


Figure 3 – PDU with type extension

The S field is reserved for system management extensions. For FAL-PDUs this flag is set to 0.

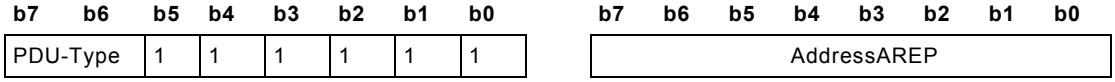


Figure 4 – PDU with address extension

Figure 5 shows the encoding of an APDU header using the tag extension and the address extension octet.

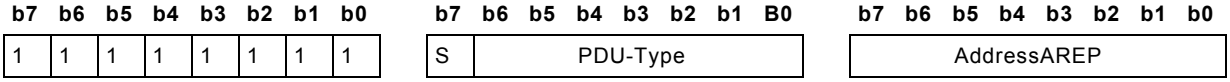


Figure 5 – PDU with type and length extension

Special encoding of the Establish-Request PDU type:

The encoding of the Establish-Request PDU differs from the rules described above, since in this PDU additional parameters, which contain the AR context, are passed. The parameters are the connection type (master-master connection for acyclic data transfer), the parameter CIU (Control Interval User-triggerd) and the outstanding service counters. The connection type parameter is encoded in the most-significant three bits. The least-significant 5 bits contain the number of the additional establish parameters.

If the tag for the address requires an extension (the Establish PDU type has an extension), a minimum PDU length of 9 octets is used in an establish request (see Figure 6).

Example for Establish-RequestPDU:

Establish-RequestPDU tag : 4
AddressAREP : 64
ConnectionType : 0 for MMAZ
CIU : FFFFFFFF
S : 0
MaxOSCC : 1
MaxOSCS : 1
MaxUCSC : 1
MaxUCSS : 1

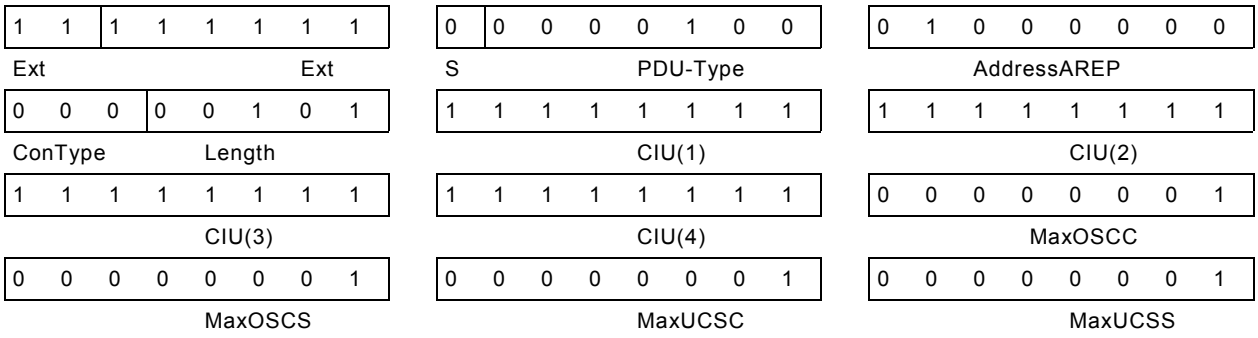


Figure 6 – Example of an Establish-Request PDU

5.2.3 APDU body encoding

The format of the APDU body is described in 4.1 using the ASN.1 syntax. In the following clauses the encoding of the used language elements is described.

5.3 Encoding of tagged type values

5.3.1 Encoding of tagged type values of tag class PRIVATE

Tagged type values with tags of class PRIVATE shall be encoded in the same way as their base types. Tags of class PRIVATE are not explicit encoded (see Figure 7). They are used only to reach syntactical correctness of the ASN.1 definitions.

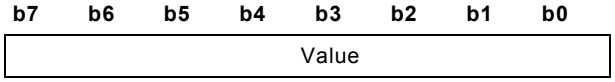


Figure 7 – Encoding of a PRIVATE tagged value

The following restrictions exist for the use of PRIVATE tagged types.

- The length and definition of the encoding of a PRIVATE tagged type shall not change.

- In a SEQUENCE construct no more than one PRIVATE tagged type may be OPTIONAL.

- A private tagged type shall not be contained in a CHOICE construct.

5.3.2 Encoding of context specific tagged type values

5.3.2.1 Overview

Context specific tagged type values are coded as a sequence of one or more Identification information (ID-info) octets, followed by one ore more Value octets (ContentsOctets) as defined in the following clauses. The resulting format is shown in Figure 8.

Figure 8 – Encoding of a context specific tagged value

5.3.2.2 Encoding of the identification information (ID-info)

The ID-info is composed of three fields: tag, structure flag and length field (see Figure 9).

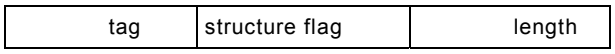


Figure 9 – Identification information fields

The length field contains either the number of the subsequent data octets or the number of the following values, as defined in this subclause.

If the structure flag is set to 1, it indicates that a structure follows. Within the structure encoding each value is identified by its own ID-info. In this case, the number of the values within the structure is encoded in the length field of the ID-info. In the length field of the last value of the structure, the length of the values encoding in octets is contained.

If the structure flag is 0, and the value is not part of a structure as described before, the following values are not tagged. In this case the types and lengths of the contained values are known implicitly; the number of the contained values(parameters) is encoded in the length field.

If the structure flag is 0, and the value is part of another structure, the length field shall contain:

the number of the following values, if this value is not the last value within the structure,

the number of the value encoding octets, if this value is the last value within the structure.

The tag field contains the tag value defined within the ASN.1 syntax definition. If the tag value is < 15 and the length value is < 7, the ID-info shall be encoded using 1 octet (see Figure 10).

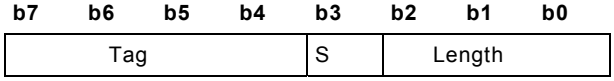


Figure 10 – ID-info for tag 0 .. 14 , length entry 0 .. 6

If the tag value is >= 15 and the length value is < 7, the ID-info shall be encoded using 2 octets (see Figure 11).

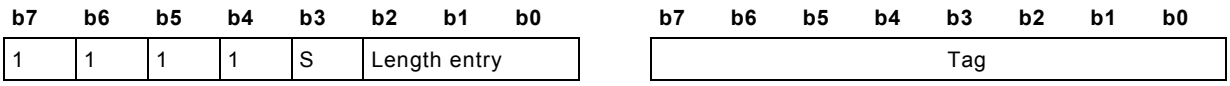


Figure 11 – ID-info for tag 15 .. 255 , length entry 0 .. 6

If the tag value is < 15 and the length value is >= 7, the ID-info shall be encoded using 2 octets (see Figure 12).

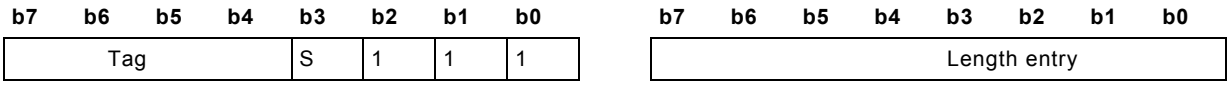


Figure 12 – ID-info for tag 0 .. 14 , length entry 7 .. 255

If the tag value is >= 15 and the length value is >= 7, the ID-info shall be encoded using 3 octets (see Figure 13).

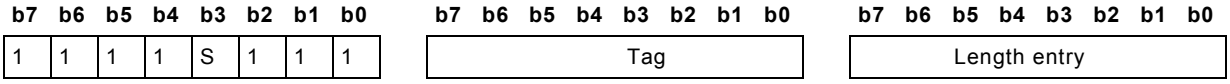


Figure 13 – ID-info for tag 15 .. 255 , length entry 7 .. 255

5.3.2.3 Example

Data of the data type Boolean, for example, is coded as shown in Figure 14 and Figure 15:

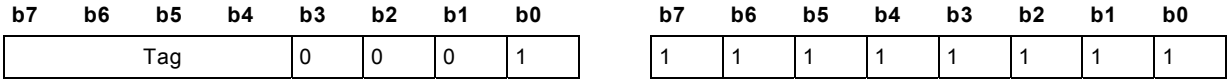


Figure 14 – Encoding of Boolean value TRUE

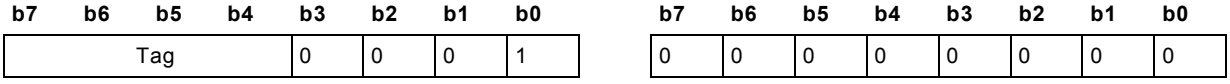


Figure 15 – Encoding of Boolean value FALSE

5.4 Encoding of simple values

5.4.1 Encoding of a Boolean value

1) The encoding of a Boolean value shall be primitive, and the ContentsOctets shall consist of exactly one octet.

2) The value TRUE is coded by setting all bits of the octet to 1, the value FALSE is coded by setting all bits of the octet to 0.

5.4.2 Encoding of String values (visible string, octet string, bit string)

In the encoding of strings, length entries, which give the number of following octets, are placed in the first octet of the individual string elements (see Figure 16). User data without a tag are provided with no ID-info. The data is identified by its position within the PDU and the length is implicitly known and fixed.

Octet 1	**Octet 2**	**Octet 3**		**Octet n + 1**
Length = n	Element 1	Element 2		Element n

Figure 16 – Encoding of Strings

5.4.3 Encoding of an Integer value

a) The encoding of a fixed-length Integer value of Integer8, Integer16, and Integer32 types shall be primitive, and the ContentsOctets shall consist of exactly one, two, or four octets, respectively.

b) The ContentsOctets shall be a two's complement binary number equal to the integer value, and consist of bits 8 to 1 of the first octet, followed by bits 8 to 1 of the second octet, followed by bits 8 to 1 of each octet in turn up to and including the last octet of the ContentsOctets.

5.4.4 Encoding of an Unsigned value

a) The encoding of a fixed-length Unsigned value of Unsigned8, Unsigned16, and Unsigned32 types shall be primitive, and the ContentsOctets shall consist of exactly one, two, or four octets, respectively.

b) The ContentsOctets shall be a binary number equal to the Unsigned value, and consist of bits 8 to 1 of the first octet, followed by bits 8 to 1 of the second octet, followed by bits 8 to 1 of each octet in turn up to and including the last octet of the ContentsOctets.

5.4.5 Encoding of a Floating-point value

a) The encoding of a Floating32 value shall be primitive, and the ContentsOctets shall consist of exactly four or eight octets, respectively.

b) The ContentsOctets shall contain floating-point values defined in conformance with ANSI/IEEE Standard 754. The sign is encoded in bit 8 of the first octet. It is followed by the exponent starting from bit 7 of the first octet, and then the mantissa starting from bit 7 of the second octet for Floating32.

5.4.6 Encoding of a BinaryDate value

a) The encoding of a BinaryDate value shall be primitive.

b) The Length field shall indicate as a binary number the number of octets in the BinaryDate value.

c) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 17.

bits	8	7	6	5	4	3	2	1	
octets									
1	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
2	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…59 999 ms
3	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…59 min
4	SU	0	0	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…23 hours
	day of week			**day of month**					1…7 d. of w.
5	2^{2}	2^{1}	2^{0}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…31 d. of m.
6	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…12 months
7	0	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0 … 99 years
	msb								

Figure 17 – Encoding of BinaryDate value

5.4.7 Encoding of a BinaryDate2000 value

a) The encoding of a BinaryDate2000 value shall be primitive.

b) The Length field shall indicate as a binary number the number of octets in the BinaryDate2000 value.

c) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 18.

bits	8	7	6	5	4	3	2	1	
octets									
1	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
2	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…59 999 ms
3	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…59 min
4	SU	0	0	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…23 hours
	day of week			**day of month**					1…7 d. of w.
5	2^{2}	2^{1}	2^{0}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…31 d. of m.
6	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…12 months
7	0	0	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	0 … 9999 years
8	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	with century
	msb								

Figure 18 – Encoding of BinaryDate2000 value

5.4.8 Encoding of a Time-of-day value

a) The encoding of a Time Of Day value shall be primitive.

b) The Length field shall indicate as a binary number the number of octets in the Time Of Day value.

c) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 19.

bits	8	7	6	5	4	3	2	1	
octets									
1	0	0	0	0	2^{27}	2^{26}	2^{25}	2^{24}	number of
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	milliseconds since
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	midnight
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	number of days since 01.01.84
6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	optional
	msb								

Figure 19 – Encoding of Time-of-day value

5.4.9 Encoding of a Time-difference value

a) The encoding of a Time Difference value shall be primitive.

b) The Length field shall indicate as a binary number the number of octets in the Time Difference value.

c) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 20.

bits	8	7	6	5	4	3	2	1	
octets									
1	0	0	0	0	2^{27}	2^{26}	2^{25}	2^{24}	number of
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	milliseconds
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	number of days
6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	optional
	msb								

Figure 20 – Encoding of Time-difference value

5.4.10 Encoding of a Time value

a) The encoding of a Time value shall be primitive.

b) The Length field shall indicate as a binary number the number of octets in the Time value.

c) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 21.

bits	8	7	6	5	4	3	2	1	
octets 1	SN	2^{62}	2^{61}	2^{60}	2^{59}	2^{58}	2^{57}	2^{56}	
2	2^{55}	2^{54}	2^{53}	2^{52}	2^{51}	2^{50}	2^{49}	2^{48}	
3	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	
4	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	
5	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	
6	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
7	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	signed integer
8	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	of 8 octet length of 1/32ms unit
	MSB								

Figure 21 – Encoding of Time value

5.4.11 Encoding of a Null value

a) The encoding of a NULL value shall be primitive.

b) The ContentsOctet shall be omitted.

5.4.12 Encoding of an ANY value

The Data Type ANY contains one or more data elements of the Data Types which are chained together without any gap. The composition is known implicitly.

5.4.13 Encoding of structured types

When a structured type is encoded, the structure flag of the Identification Information shall be set to one. The Length field, whether or not it is extended, shall contain the number of components of the structured type being encoded.

5.4.14 Encoding of a SEQUENCE value

The SEQUENCE type is comparable to a record. It represents a collection of user data of the same or of different Data Types.

A SEQUENCE type value may contain a simple variable or a further structured variable as its components. If a SEQUENCE type contains another structured type value, it shall be counted as a single component even if it contains several components.

5.4.15 Encoding of a SEQUENCE OF value

The SEQUENCE OF type represents a succession of components. It is comparable to an array.

A SEQUENCE OF type value may contain one or more simple or constructed variables. If a SEQUENCE OF type contains another structured type value, it shall be counted as a single component even if it contains several components.

The encoding is as for the structure SEQUENCE. For the statement of the number of components the number of repetitions shall be taken into account.

5.4.16 Encoding of a CHOICE value

A CHOICE type represents a selection from a set of predefined values. The components of a CHOICE construct shall have different tags to allow proper identification. Instead of the CHOICE construct, the actually selected component is encoded. Only one component shall be encoded for a CHOICE.

5.4.17 Encoding of an ENUMERATED value

An ENUMERATED value shall be encoded as an Unsigned8 value.

5.4.18 Encoding of an Object-definition value

The encoding of the individual object definitions onto the parameters "List Of Objects and Attributes" (data type Gn_ObjectDefinition) of the GetAttributePDUs is shown in this subclause.

The objectClass attribute is the identifier of the object and indicates the class to which this object belongs. The other object attributes are object specific and shall be encoded as a string of octets. In addition to the object attributes, the object class shall be transmitted in the GetAttributes service, except List Header, whose numeric ID is zero. An example of the structure of an Object Definition is shown in Figure 22.

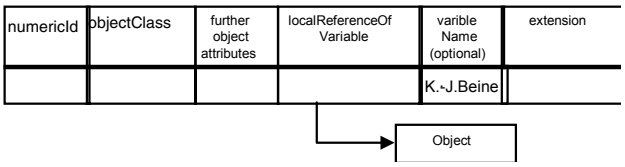


Figure 22 – Example for an Object definition

6 Protocol machine overview

Interface to FAL services and protocol machines are specified in this subclause.

NOTE The state machines specified in this subclause and ARPMs defined in the following clauses only define the valid events for each. It is a local matter to handle invalid events.

The behavior of the FAL is described by three integrated protocol machines. Specific sets of these protocol machines are defined for different AREP types. The three protocol machines are: FAL Service Protocol Machine (FSPM), the Application Relationship Protocol Machine (ARPM), and the Data Link Layer Mapping Protocol Machine (DMPM). Figure 23 shows the primitives exchanged between protocol machines.

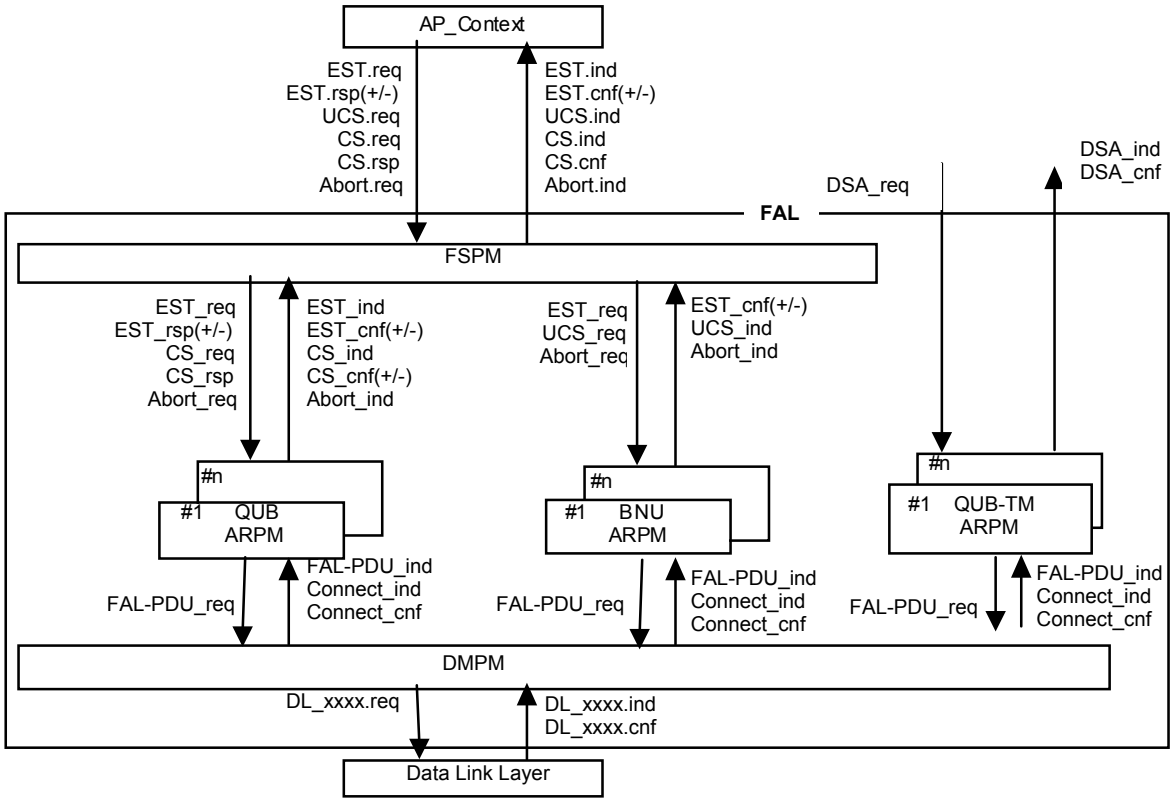


Figure 23 – Primitives exchanged between protocol machines

7 AP-context state machine

7.1 Primitive definitions

7.1.1 Primitives exchanged between FAL-user and AP-Context

Primitives exchanged between FAL-user and AP-Context are shown in Table 1 and Table 2.

Table 1 – Primitives issued by FAL-user to AP-context

Primitive name	Source	Associated parameters and functions
Terminate.req	FAL-User	Refer to FAL service definition (61158-508)
Initiate.req	FAL-User	
Initiate.rsp(+)	FAL-User	
Initiate.rsp(-)	FAL-User	
ConfirmedService.req	FAL-User	
ConfirmedService.rsp	FAL-User	
UnconfirmedService.req	FAL-User	

Table 2 – Primitives issued by AP-context to FAL-user

Primitive name	Source	Associated parameters and functions
Terminate.ind	AP-Context	Refer to FAL service definition (61158-508)
Initiate.ind	AP-Context	
Initiate.cnf(+)	AP-Context	
Initiate.cnf(-)	AP-Context	
ConfirmedService.ind	AP-Context	
ConfirmedService.cnf	AP-Context	
UnconfirmedService.ind	AP-Context	

7.2 State machine description

The attributes used in this state machine are defined as elements of the AP attribute *List Of In-Use AR Endpoint Info*. See Figure 24 for the state machine.

CLOSED

The AP-Context for an AR is not open. Only the service primitives Initiate.req, Establish.ind, Terminate.req and Abort.ind are allowed. All other service primitives shall be rejected with the Terminate service.

OPENING-REQUESTING (REQ)

The local FAL user wishes to open the AP-Context for an AR. Only the service primitives Establish.cnf(+), Establish.cnf(-), Terminate.req and Abort.ind are allowed. All other services shall be rejected with the Terminate service.

OPENING-RESPONDING (RSP)

The remote AP-Context wishes to open the AP-Context for an AR. Only the service primitives Initiate.rsp(+), Initiate.rsp(-), Terminate.req and Abort.ind are allowed. All other service primitives shall be rejected with the Terminate service.

OPEN

The AP-Context for an AR is open. The service primitives Initiate.req, Initiate.rsp(+), Initiate.rsp(-) are not allowed and shall be rejected with the Terminate service. The following actions shall be taken to reset the AP-Context for an AR.

Set the *Outstanding Services Requ*esting Counte*r* and *Outstanding Services Responding Counter* to 0.

Set the *Context State* to "CLOSED"

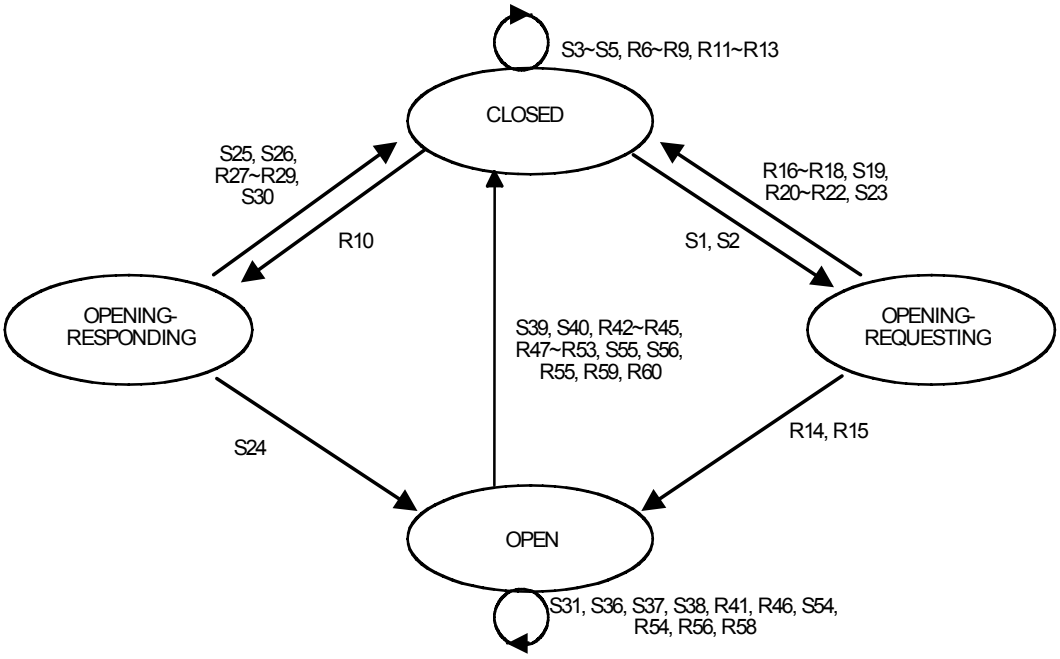


Figure 24 – AP to AP-context initiation state machine

7.3 AP to AP-context initiation state transitions

The AP to AP-Context initiation state transitions are defined in Table 3 and Table 4. In the tables of this subclause "Data" parameter for FAL Service Protocol Machine is expressed by "FalApduBody" to emphasize its semantics.

Table 3 – AP-context state machine sender transactions

#	Current state	Event or condition => action	Next State

S1	CLOSED	Initiate.req
		&& ApContextTest = "True"
		&& ApExplicitConnection = "True"
		=>
		EST.req {
		FalApduBody := "Establish-CommandPDU"
		}
		or
		EST.req {
		FalApduBody := "Establish-RequestPDU"
		}
		or
		EST.req {
		FalApduBody := "Establish-Request2PDU"
		}
			REQ

S2	CLOSED	Initiate.req
		&& ApContextTest = "True"
		&& ApExplicitConnection = "False"
		=>
		EST.req {
		FalApduBody := "NULL"
		}
			REQ

S3	CLOSED	Initiate.req
		&& ApContextTest = ""False""
		=>
		Terminate.ind {
		LocallyGenerated := "True",
		TerminateIdentifier := "FAL",
		ReasonCode := "Context error"
		}
			CLOSED

#	Current state	Event or condition => action	Next State
S4	CLOSED	Terminate.req => (no actions taken)	CLOSED

S5	CLOSED	FAL service.primitive <> “Initiate”
		&& FAL service.primitive <> “Terminate”
		=>
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “User error”
		}
			CLOSED

S19	REQ	Terminate.req => Abort.req { Originator:= “TerminateIdentifier of Terminate.req”, ReasonCode := “ReasonCode of Terminate.req” }, ResetArep	CLOSED

S23	REQ	FAL service.primitive <> “Initiate.rsp””
		&& FAL service.primitive <> “Terminate.req”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “User error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “User error”
		},
		
		ResetArep
			CLOSED

S24	RSP	Initiate.rsp(+)
		=>
		EST.rsp(+) {
		FalApduBody := “Establish-AffirmativePDU”
		}
		or
		EST.rsp(+) {
		FalApduBody = “Establsih-ResponsePDU”
		}
			OPEN

S25	RSP	Initiate.rsp(-)
		=>
		EST.rsp(-){
		FalApduBody := “Establish-NegativePDU”
		},
		or
		EST.rsp(-) {
		FalApduBody = “Establsih-ErrorPDU”
		},
		
		ResetArep
			CLOSED

S26	RSP	Terminate.req => Abort.req { Originator := “TerminateIdentifier of Terminate.req”, ReasonCode := “ReasonCode of Terminate.req” }, ResetArep	CLOSED

#	Current state	Event or condition => action	Next State

S30	RSP	FAL service.primitive <> “Initiate.rsp”
		&& FAL service.primitive <> “Terminate.req”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “User error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “User error”
		},
		
		ResetArep
			CLOSED

S31	OPEN	ConfirmedService.req && ConfirmedServiceCheck = “True” && OutstandingServicesRequestingCounter < NegotiatedMaxOutstanding-ServicesRequesting && InvokeIdExistent = “False” && PDU length ≤ NegotiatedMaxPduSizeSending && RequestedServiceSupportedTest = “True” => CS.req { FalApduBody := “ConfirmedSend-CommandPDU” }, or CS.req { FalApduBody := “ConfirmedSend-RequestPDU” }, OutstandingServicesRequestingCounter := OutstandingServicesRequestingCounter+1	OPEN

S36	OPEN	UnconfirmedService.req
		&& UnconfirmedServiceCheck = “True”
		&& PDU length ≤ NegotiatedMaxPduSizeSending
		&& RequestedServiceSupportedTest = “True”
		&& ImmediateAcknowledge = “False”
		=>
		UCS.req {
		FalApduBody := “UnconfirmedSend-CommandPDU”
		}
		or
		UCS.req {
		FalApduBody := “UnconfirmedSend-PDU”
		}
			OPEN

S37	OPEN	UnconfirmedService.req
		&& UnconfirmedServiceCheck = “True”
		&& PDU length ≤ NegotiatedMaxPduSizeSending
		&& RequestedServiceSupportedTest = “True”
		&& ImmediateAcknowledge = “True”
		=>
		UCA.req {
		FalApduBody := “UnconfirmedAcknowledgedSend-CommandPDU”
		}
		or
		UCA.req {
		FalApduBody := “UnconfirmedAcknowledgedSend-RequestPDU”
		}
			OPEN

S38	OPEN	AR_ASE service request && ArServiceCheck = “True” && RequestedServiceSupportedTest = “True” => ArFspmService NOTE This state is provided to access the FSPM direct from the FAL User. The function ArFspmService generates an FSPM primitive as defined later in this subclause.	OPEN

#	Current state	Event or condition => action	Next State
S39	OPEN	Terminate.req => Abort.req { Originator := “TerminateIdentifier of Terminate.req”, ReasonCode := “ReasonCode of Terminate.req” }, ResetArep	CLOSED

S40	OPEN	Faulty, unknown or not-allowed FAL service.primitive
		=>
		Abort.req {
		AbortIdentifier := “FAL”,
		ReasonCode := “User error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “User error”
		},
		
		ResetArep
			CLOSED

S54	OPEN	ConfirmedService.rsp && ConfirmedServiceCheck = “True” && InvokeIdExistent = “True” && SameService = “True” && PDU length ≤ NegotiatedMaxPduSizeSending => CS.rsp { FalApduBody := “ConfirmedSend-AffirmativePDU” }, or CS.rsp { FalApduBody := “ConfirmedSend-NegativePDU” }, or CS.rsp { FalApduBody := “ConfirmedSend-ResponsePDU” }. OutstandingServicesRespondingCounter := OutstandingServicesRespondingCounter-1 NOTE An extra protocol means shall be provided to detemine whether ConfirmedSend-AffirmativePDU or ConfirmedSend-NegativePDU is used.	OPEN

S55	OPEN	ConfirmedService.rsp
		&& ConfirmedServiceCheck = “True”
		&& InvokeIdExistent = “False”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “InvokeID-error-response”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “InvokeID-error-response”
		},
		
		ResetArep
			CLOSED

#	Current state	Event or condition => action	Next State

S56	OPEN	ConfirmedService.rsp
		&& ConfirmedServiceCheck = “True”
		&& InvokeIdExistent = “True”
		&& SameService = “False”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Service-error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Service-error”
		},
		
		ResetArep
			CLOSED

Table 4 – AP-context state machine receiver transactions

#	Current state	Event or condition => action	Next state
R6	CLOSED	Abort.ind => (no actions taken)	CLOSED

R7	CLOSED	Faulty or unknown AR_FSPM service primitive
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “AR_ASE error”
		}
			CLOSED

R8	CLOSED	AR_FSPM service primitive <> “EST.ind”
		&& AR_FSPM service.primitive <> “Abort.ind”
		=>
		Abort.req {
		Originator:= “FAL”,
		ReasonCode := “Connection State Conflict”
		}
			CLOSED

R9	CLOSED	EST.ind
		&& FalApduBody = not allowed, unknown or faulty FAL PDU
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “FAL PDU error”
		}
			CLOSED

R10	CLOSED	EST.ind
		&& (FalApduBody = “Establish-CommandPDU”
		|| FalApduBody = “Establish-RequestPDU”
		|| FalApduBody = “Establish-Request2PDU”)
		&& ApContextTest = “True”
		&& MaxFalPduLengthTest = "True"
		&& ServicesSupportedTest = “True”
		=>
		NegotiateOutstandingServices,
		
		Initiate.ind {
		}
			RSP

R11	CLOSED	EST.ind
		&& (FalApduBody = “Establish-CommandPDU”
		|| FalApduBody = “Establish-RequestPDU”
		|| FalApduBody = “Establish-Request2PDU”)
		&& ApContextTest = “False”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “AR error”
		}
			CLOSED

#	Current state	Event or condition => action	Next state

R12	CLOSED	EST.ind
		&& (FalApduBody = “Establish-CommandPDU”
		|| FalApduBody = “Establish-RequestPDU”
		|| FalApduBody = “Establish-Request2PDU”)
		&& ApContextTest = “True”
		&& MaxFalPduLengthTest = “False”
		=>
		EST.rsp(-) {
		FalApduBody := “Establish-NegativePDU”,
		ErrorCode := “Max-Fal-Fdu-Size-Insufficient”
		}
		or
		EST.rsp(-) {
		FalApduBody := “Establish-ErrorPDU”,
		ErrorCode := “Max-Fal-Fdu-Size-Insufficient”
		}
			CLOSED

R13	CLOSED	EST.ind
		&& (FalApduBody = “Establish-CommandPDU”
		|| FalApduBody = “Establish-RequestPDU”
		|| FalApduBody = “Establish-Request2PDU”)
		&& ApContextTest = “True”
		&& MaxFalPduLengthTest = “True”
		&& ServicesSupportedTest = “False”
		=>
		EST.rsp(-) {
		FalApduBody := “Establish-NegativePDU”,
		ErrorCode := “Service-Not-Supported”
		}
		or
		EST.rsp(-) {
		FalApduBody := “Establish-ErrorPDU”,
		ErrorCode := “Service-Not-Supported”
		}
			CLOSED

R14	REQ	EST.cnf(+)
		&& (FalApduBody = “Establish-AffirmativePDU”
		|| FalApduBody = “Establish-ResponsePDU”)
		&& ApExplicitConnection = “True”
		=>
		Initiate.cnf(+) {
		}
			OPEN

R15	REQ	EST.cnf(+)
		&& FalApduBody = “NULL”
		&& ApExplicitConnection = “False”
		=>
		Initiate.cnf(+) {
		}
			OPEN

R16	REQ	EST.cnf(-) && (FalApduBody = “Establish-NegativePDU” || FalApduBody = “Establish-ErrorPDU”) && ApExplicitConnection = “True” => “Initiate.cnf(-) { ErrorCode := “Errorcode of EST.cnf(-)” }, ResetArep	CLOSED
R17	REQ	EST.cnf(-) && FalApduBody = “NULL” && ApExplicitConnection = “False” => Initiate.cnf(-) { ErrorCode := “Errorcode in EST.cnf” }, ResetArep	CLOSED

#	Current state	Event or condition => action	Next state
R18	REQ	Abort.ind => Terminate.ind { LocallyGenerated := “LocallyGenerated of Abort.ind”, TerminateIdentifier := “Originator of Abort.ind”, ReasonCode := “ReasonCode of Abort.ind” }, ResetArep	CLOSED

R20	REQ	Faulty or unknown AR_FSPM service primitive
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		=>
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		
		ResetArep
			CLOSED

R21	REQ	AR_FSPM service.primitive <> “EST.cnf”
		&& AR_FSPM service.primitive <> “Abort.ind”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Connection State Conflict”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Connection State Conflict”
		},
		
		ResetArep
			CLOSED

R22	REQ	EST.cnf
		&& FalApduBody =“ not allowed, unknown or faulty FAL PDU”
		=>
		Abort.req {
		AbortIdentifier := “FAL”,
		ReasonCode := “FAL PDU error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “FAL PDU error”
		},
		
		ResetArep
			CLOSED

R27	RSP	Abort.ind => Terminate.ind { LocallyGenerated := “LocallyGenerated of Abort.ind”, TerminateIdentifier := “Originator of Abort.ind”, ReasonCode := “ReasonCode of Abort.ind” }, ResetArep	CLOSED

#	Current state	Event or condition => action	Next state

R28	RSP	Faulty or unknown AR_FSPM service primitive
		=>
		Abort.req {
		AbortIdentifier := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		
		ResetArep
			CLOSED

R29	RSP	AR_FSPM service primitive <> “ Abort.ind”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “State Conflict with AR_ASE”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “AP_ASE”,
		ReasonCode := “Connection State Conflict with AR_ASE”
		},
		
		ResetArep
			CLOSED

R41	OPEN	CS.ind && (FalApduBody = “ConfirmedSend-CommandPDU” || FalApduBody = “ConfimredSend-RequestPDU”) && PDU length ≤ NegotiatedMaxPduSizeReceiving && OutstandingServicesRespondingCounter < NegotiatedMaxOutstanding-ServicesResponding && InvokeIdExistent = “False” && IndicatedServiceSupportedTest = “True” => ConfirmedService.ind { }, OutstandingServicesRespondingCounter := OutstandingServicesRespondingCounter+1	OPEN

R42	OPEN	CS.ind
		&& (FalApduBody = “ConfirmedSend-CommandPDU”
		|| FalApduBody = “ConfimredSend-RequestPDU”)
		&& PDU length > NegotiatedMaxPduSizeReceiving
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		ResetArep
			CLOSED

#	Current state	Event or condition => action	Next state

R43	OPEN	CS.ind
		&& (FalApduBody = “ConfirmedSend-CommandPDU”
		|| FalApduBody = “ConfimredSend-RequestPDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& OutstandingServicesResponding ≥ NegotiatedMaxOutstanding-ServicesResponding
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Max-services-overflow”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Max-Services-Overflow”
		},
		
		ResetArep
			CLOSED

R44	OPEN	CS.ind
		&& (FalApduBody = “ConfirmedSend-CommandPDU”
		|| FalApduBody = “ConfimredSend-RequestPDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& OutstandingServicesRespondingCounter < NegotiatedMaxOutstanding-ServicesResponding
		&& InvokeIdExistent = “True”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “InvokeID-error-request”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “InvokeID-error-request”
		},
		
		ResetArep
			CLOSED

R45	OPEN	CS.ind
		&& (FalApduBody = “ConfirmedSend-CommandPDU”
		|| FalApduBody = “ConfimredSend-RequestPDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& OutstandingServicesRespondingCounter < NegotiatedMaxOutstandingServicesResponding
		&& InvokeIdExistent = “False”
		&& IndicatedServiceSupportedTest = “False”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Feature-not-supported”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Feature-not-supported”
		},
		
		ResetArep
			CLOSED

R46	OPEN	UCS.ind
		&& (FalApduBody = “UnconfirmedSend-CommandPDU”
		|| FalApduBody = “UnconfimredSend-PDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& IndicatedServiceSupportedTest = “True”
		=>
		UnconfirmedService.ind {
		}
			OPEN

#	Current state	Event or condition => action	Next state

R47	OPEN	UCS.ind
		&& (FalApduBody = “UnconfirmedSend-CommandPDU”
		|| FalApduBody = “UnconfimredSend-PDU”)
		&& PDU length > NegotiatedMaxPduSizeReceiving
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		ResetArep
			CLOSED

R48	OPEN	UCS.ind
		&& (FalApduBody = “UnconfirmedSend-CommandPDU”
		|| FalApduBody = “UnconfimredSend-PDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& IndicatedServiceSupportedTest = “False”
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Feature-not-supported”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Feature-not-supported”
		},
		
		ResetArep
			CLOSED

R49	OPEN	Abort.ind => Terminate.ind { LocallyGenerated := “LocallyGenerated of Abort.ind”, TerminateIdentifier := “Originator of Abort.ind”, ReasonCode := “ReasonCode of Abort.ind” }, ResetArep	CLOSED

R50	OPEN	EST.ind
		&& (FalApduBody = “Establish-CommandPDU”
		|| FalApduBody = “Establish-RequestPDU”
		|| FalApduBody = “Establish-Request2PDU”)
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Connection-State-Conflict”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Connection-State-Conflict”
		},
		
		ResetArep
			CLOSED

#	Current state	Event or condition => action	Next state

R51	OPEN	Faulty or unknown AR_FSPM service primitive
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “AR_ASE error”
		},
		
		ResetArep
			CLOSED

R52	OPEN	Not-allowed AR_FSPM service primitive
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “Connection-State-Conflict”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “Connection-State-Conflict”
		},
		
		ResetArep
			CLOSED

R53	OPEN	valid AR_FSPM Send Service primitive (one of CS, US, UCA)
		&& FalApduBody = not-allowed, unknown or faulty FAL PDU
		&& ArAccessSupported = “False”
		=>
		Abort.req {
		Originator := “AP_ASE”,
		ReasonCode := “FAL-PDU-error”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “FAL –PDU-error”
		},
		
		ResetArep
			CLOSED

R54	OPEN	UCA.ind
		&& ArAccessSupported = “True”
		&& (FalApduBody = “UnconfirmedAcknowledgedSend-CommandPDU”
		|| FalApduBody = “UnconfirmedAcknowledgedSend-RequestPDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		=>
		UnconfirmedService.ind {
		}
			OPEN

R55	OPEN	UCA.ind
		&& ArAccessSupported = “True”
		&& (FalApduBody = “UnconfirmedAcknowledgedSend-CommandPDU”
		|| FalApduBody = “UnconfirmedAcknowledgedSend-RequestPDU”)
		&& PDU length > NegotiatedMaxPduSizeReceiving
		=>
		Abort.req {
		Originator := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		ResetArep
			CLOSED

#	Current state	Event or condition => action	Next state
R56	OPEN	AR_ASE service indication => ArFspmService NOTE This state is provided to access the FSPM direct from the FAL User. The function ArFspmService generates an FSPM primitive as defined later in this subclause.	OPEN
R58	OPEN	CS.cnf && (FalApduBody = “ConfirmedSend-AffirmativePDU” || FalApduBody = “ConfirmedSend-NegativePDU” || FalApduBody = “ConfirmedSend-ResponsePDU”) && PDU length ≤ NegotiatedMaxPduSizeReceiving && InvokeIdExistent = “True” && SameService = “True” => ConfirmedService.cnf { }, OutstandingServicesRequestingCounter := OutstandingServicesRequestingCounter-1	OPEN

R59	OPEN	CS.cnf
		&& (FalApduBody = “ConfirmedSend-AffirmativePDU”
		|| FalApduBody = “ConfirmedSend-NegativePDU”
		|| FalApduBody = “ConfirmedSend-ResponsePDU”)
		&& PDU length > NegotiatedMaxPduSizeReceiving
		=>
		Abort.req {
		AbortIdentifier := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “PDU-size”
		},
		
		ResetArep
			CLOSED

R60	OPEN	CS.cnf
		&& (FalApduBody = “ConfirmedSend-AffirmativePDU”
		|| FalApduBody = “ConfirmedSend-NegativePDU”
		|| FalApduBody = “ConfirmedSend-ResponsePDU”)
		&& PDU length ≤ NegotiatedMaxPduSizeReceiving
		&& InvokeIdExistent = “False”
		=>
		Abort.req {
		AbortIdentifier := “FAL”,
		ReasonCode := “InvokeID-error-responding”
		},
		
		Terminate.ind {
		LocallyGenerated := “True”,
		TerminateIdentifier := “FAL”,
		ReasonCode := “InvokeID-error-responding”
		},
		
		ResetArep
			CLOSED

7.4 Functions

Table 5 through Table 20 define internal functions that are used by the AP-Context state machine.

Table 5 – Function ResetArep

Name	ResetArep		
Input	Arep_Id	Output	True or False
Function	Closes the AP AR Context and initializes all elements of the AP attribute *List Of In-Use AR Endpoint Info* to zero (0).		

Table 6 – Function ApContextTest

Name	ApContextTest		
Input	Arep_Id	Output	True or False
Function	Locates the entry for the Selected AREP in the AP attribute *List Of In-Use AR Endpoint Info,* verifies its contents, and ensures that there is a matching AREP defined for the AR_ASE. The way in which the verification is carried out is dependent on implementation.		

Table 7 – Function ServicesSupportedTest

Name	ServicesSupportedTest		
Input	Arep_Id	Output	True or False
Function	Upon receipt of an Initiate-RequestPDU the called AP_ASE shall compare the Local List of Supported Services against those contained in the Initiate PDU. The ServicesSupportedTest fails if either the Local FAL does not support all the services as a responder that the remote FAL supports as a requestor, or the remote FAL does not support all the services as a responder that the local FAL supports as a requestor.		

Table 8 – Function ApExplicitConnection

Name	ApExplicitConnection		
Input	Arep_Id	Output	True or False
Function	Refer to AREP to determine if this AP_ASE supports explicit connection between APs.		

Table 9 – Function ImmediateAcknowledge

Name	ImmediateAcknowledge		
Input	Arep_Id	Output	True or False
Function	Refer to AREP to determine if this AP_ASE requires immediate acknowledge in the underlying layer.		

Table 10 – Function ConfirmedServiceCheck

Name	ConfirmedServiceCheck		
Input	Arep_Id	Output	True or False
Function	Determines if the called FAL service is a confirmed service except for AR ASE services.		

Table 11 – Function UnconfirmedServiceCheck

Name	UnconfirmedServiceCheck		
Input	Arep_Id	Output	True or False
Function	Determines if the called FAL service is an unconfirmed service except AR ASE services.		

Table 12 – Function ArServiceCheck

Name	ArServiceCheck		
Input	**Arep_Id**	**Output**	**True or False**
Function	Determines if the called service is an AR ASE service (FAL service or AR FSPM service).		

Table 13 – Function ArFspmService

Name	ArFspmService		
Input	**Arep_Id**	**Output**	**FAL Service or AR FSPM Service**
Function	Generate an AR ASE service primitive. Relationship between FAL Services and AR FSPM Services shall be as follows: AR-Unconfirmed Send UCS AR-Confirmed Send CS AR-Establish EST AR-Abort Abort		

Table 14 – Function ArAcceeSupported

Name	ArAcceeSupported		
Input	**Arep_Id**	**Output**	**True or False**
Function	Determines if the AP accepts AR ASE Send (ConfirmedSend or UnconfirmedSend) services.		

Table 15 – Function MaxFalPduLengthTest

Name	MaxFalPduLengthTest		
Input	**Arep_Id**	**Output**	**True or False**
Function	Upon receipt of an Initiate-RequestPDU, the called AP_ASE shall check the requested maximum PDU length against its defined context. The following tests are performed: 1. If (ConfiguredMaxPDUSizeSending > MaxPDUSizeReceiving of the Initiate PDU), this test fails; 2. If (ConfiguredMaxPDUSizeReceiving < MaxPDUSizeSending of the Initiate PDU), this test fails.		

Table 16 – Function NegotiateOutstandingServices

Name	NegotiateOutstandingServices		
Input	**Arep_Id**	**Output**	**True or False**
Function	Upon receipt of an Initiate-RequestPDU, the called AP_ASE shall perform the following negotiation: 1. If ConfiguredMaxOustandingServicesRequesting > MaxOutstandingServicesResponding of the Initiate-RequestPDU then NegotiatedMaxOutstandingServicesRequesting = MaxOutstandingServicesResponding of the Initiate-RequestPDU else NegotiatedMaxOutstandingServicesRequesting = ConfiguredMaxOutstandingServicesRequesting; 2. If ConfiguredMaxOutstandingServicesResponding < MaxOutstandingServicesRequesting of the Initiate PDU then NegotiatedMaxOutstandingServicesResponding = ConfiguredMaxOutstandingServicesResponding else NegotiatedMaxOutstandingServicesResponding = MaxOutstandingServicesRequesting of the Initiate PDU;		

Table 17 – Function RequestedServicesSupportedTest

Name	RequestedServicesSupportedTest		
Input	**Arep_Id, Service.primitive**	**Output**	**True or False**
Function	Upon receipt of a service request from FAL user, the called AP_ASE shall compare the Local List of Supported Services against the requested service primitive. This test fails if the service primitive is not contained in the Local List of Supported Services.		

Table 18 – Function IndicatedServicesSupportedTest

Name	IndicatedServicesSupportedTest		
Input	**Arep_Id, service.primitive**	**Output**	**True or False**
Function	Upon receipt of a service indication from AR_ASE, the called AP_ASE shall compare the Local List of Supported Services against the indicated service primitive. This test fails if the service primitive is not contained in the Local List of Supported Services.		

Table 19 – Function InvokeIdExistent

Name	InvokeIdExistent		
Input	**Arep_Id, Invoke_Id**	**Output**	**True or False**
Function	Upon receipt of a service primitive, the called AP_ASE shall 1. compare the local list of invoke IDs in use against the requested Invoke ID if the service primitive is request; 2. compare the local list of invoke IDs in use against the responded invoke ID if the service primitive is response. This test fails if the invoke ID does not exist in the local list of Invoke IDs in use.		

Table 20 – Function SameService

Name	SameService		
Input	**Arep_Id, Invoke_Id**	**Output**	**True or False**
Function	Upon receipt of a service primitive the called AP_ASE shall 1. compare the local list of outstanding services (responding) against the service if the service primitive is response; 2. compare the local list of outstanding services (requesting) against the service if the service primitive is confirmation. This test fails if the service is not the same as that in the local list of outstanding services.		

8 FAL service protocol machine (FSPM)

8.1 Summary

The FAL Service Protocol Machine is common to all the AREP types. Only applicable primitives are different among different AREP types. It has one state called "ACTIVE."

8.2 Primitive definitions

8.2.1 Primitives exchanged between AP-context and FSPM

The primitives exchanged between the AP-Context and the FSPM are described in Table 21 and Table 22.

Table 21 – Primitives issued by AP-context to FSPM

Primitive name	Source	Associated parameters	Functions
EST.req	AP-Context	Arep_Id, Data, Remote_DLCEP_Address	This primitive is used to convey an Establish request primitive from the AP-Context to the FSPM.
EST.rsp(+)	AP-Context	Arep_Id, Data	This primitive is used to convey an Establish response(+) primitive from the AP-Context to the FSPM.
EST.rsp(-)	AP-Context	Arep_Id, Data	This primitive is used to convey an Establish response(-) primitive from the AP-Context to the FSPM.
Abort.req	AP-Context	Arep_Id, Identifier, Reason_Code, Additional_Detail	This primitive is used to convey an Abort request primitive from the AP-Context to the FSPM.
CS.req	AP-Context	Arep_Id, Data	This primitive is used to convey a Confirmed Send (CS) request primitive from the AP-Context to the FSPM.
CS.rsp	AP-Context	Arep_Id, Data	This primitive is used to convey a Confirmed Send (CS) response primitive from the AP-Context to the FSPM.
UCS.req	AP-Context	Arep_Id, Remote_DLSAP_Address, Data	This primitive is used to convey an Unconfirmed Send (UCS) request primitive from the AP-Context to the FSPM.
UCA.req	AP-Context	Arep_Id, Remote_Dlsap_Address, Data	This primitive is used to send an unconfirmed service request.

Table 22 – Primitives issued by FSPM to AP-context

Primitive name	Source	Associated parameters	Functions
EST.ind	FSPM	Arep_Id, Data	This primitive is used to convey an Establish indication primitive from the FSPM to the AP-Context.
EST.cnf(+)	FSPM	Arep_Id, Data	This primitive is used to convey an Establish result(+) primitive from the FSPM to the AP-Context.
EST.cnf(-)	FSPM	Arep_Id, Data	This primitive is used to convey an Establish result(-) primitive from the FSPM to the AP-Context.
Abort.ind	FSPM	Arep_Id, Locally_Generated, Identifier, Reason_Code, Additional_Detail	This primitive is used to convey an Abort indication primitive from the FSPM to the AP-Context.
CS.ind	FSPM	Arep_Id, Data	This primitive is used to convey a Confirmed Send (CS) indication primitive from the FSPM to the AP-Context.
CS.cnf	FSPM	Arep_Id, Data	This primitive is used to convey a Confirmed Send (CS) confirmation primitive from the FSPM to the AP-Context.
UCS.ind	FSPM	Arep_Id, Remote_DLSAP_Address, Duplicate_FAL-SDU, Data, Local_Timeliness, Remote_Timeliness	This primitive is used to convey an Unconfirmed Send (UCS) indication primitive from the FSPM to the AP-Context.
UCA.ind	FSPM	Arep_Id, Remote_DLSAP_Address, Duplicate_FAL-SDU, Data	This primitive is used to convey an unconfirmed service indication.

8.2.2 Parameters of AP-context /FSPM primitives

All the parameters used in the primitives exchanged between the AP-Context and the FSPM are identical to those defined in the “Operational Services” subclause.

8.3 FSPM state tables

8.3.1 General

The FSPM state machines are described in Figure 25, Table 23 and Table 24.

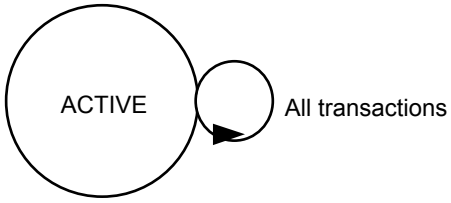


Figure 25 – State transition diagram of FSPM

Table 23 – FSPM state table – sender transactions

#	Current state	Event or condition => action	Next state

S1	ACTIVE	EST.req
		&& SelectArep (Arep_Id) = "True"
		=>
		EST_req {
		user_data := Data,
		remote_dlcep_address := Remote_DLCEP_Address
		}
			ACTIVE

S2	ACTIVE	EST.rsp(+)
		&& SelectArep (Arep_Id) = "True"
		=>
		EST_rsp(+) {
		user_data := Data
		}
			ACTIVE

S3	ACTIVE	EST.rsp(-)
		&& SelectArep (Arep_Id) = "True"
		=>
		EST_rsp(-) {
		user_data := Data
		}
			ACTIVE

S4	ACTIVE	UCS.req
		&& SelectArep (Arep_Id) = "True"
		=>
		UCS_req {
		remote_dlsap_address := Remote_DLSAP_Address,
		user_data := Data
		}
			ACTIVE

S5	ACTIVE	CS.req
		&& SelectArep (Arep_Id) = "True"
		=>
		CS_req {
		user_data := Data
		}
			ACTIVE

S6	ACTIVE	CS.rsp
		&& SelectArep (Arep_Id) = "True"
		=>
		CS_rsp {
		user_data := Data
		}
			ACTIVE

S7	ACTIVE	Abort.req
		&& SelectArep (Arep_Id) = "True"
		=>
		Abort_req {
		identifier := Identifier,
		reason_code := Reason_Code,
		additional_detail := Additional_Detail
		}
			ACTIVE

#	Current state	Event or condition => action	Next state

S12	ACTIVE	UCA.req
		&& SelectArep (Arep_Id) = "True"
		=>
		UCA_req {
		remote_dlsap_address := Remote_DLSAP_Address,
		user_data := Data
		}
			ACTIVE

S14	ACTIVE	Any FSPM.req && SelectArep (Arep_Id) = “False” => (no actions defined by the protocol, see notes 1 and 2.)	ACTIVE

NOTE 1 A primitive generated in the FSPM sender state machine is sent to an appropriate ARPM that is selected by the FSPM using the SelectArep function. The Arep_Id parameter supplied by the AP-Context is the argument of this function.
NOTE 2 If the SelectArep function returns the value of False, it is a local matter to report such instance and the FSPM does not generate any primitives for the ARPM.

Table 24 – FSPM state table – receiver transactions

#	Current state	Event or condition => action	Next state

R1	ACTIVE	EST_ind
		=>
		EST.ind {
		Arep_Id := arep_id,
		Data := user_data
		}
			ACTIVE

R2	ACTIVE	EST_cnf(+)
		=>
		EST.cnf(+) {
		Arep_Id := arep_id,
		Data := user_data
		}
			ACTIVE

R3	ACTIVE	EST_cnf(-)
		=>
		EST.cnf(-) {
		Arep_Id := arep_id,
		Data := user_data
		}
			ACTIVE

R4	ACTIVE	UCS_ind
		=>
		UCS.ind {
		Arep_Id := arep_id,
		Remote_DLSAP_Address := remote_dlsap_address,
		Data := user_data,
		}
			ACTIVE

R5	ACTIVE	CS_ind
		=>
		CS.ind {
		Arep_Id := arep_id,
		Data := user_data
		}
			ACTIVE

R6	ACTIVE	CS_cnf
		=>
		CS.cnf {
		Arep_Id := arep_id,
		Data := user_data
		}
			ACTIVE

R7	ACTIVE	Abort_ind
		=>
		Abort.ind {
		Arep_Id := arep_id,
		Locally_Generated := locally_generated,
		Identifier := identifier,
		Reason_Code := reason_code,
		Additional_Detail := additional_detail
		}
			ACTIVE

R16	ACTIVE	UCA_ind
		=>
		UCA.ind {
		Arep_Id := arep_id,
		Remote_DLSAP_Address := remote_dlsap_address,
		Data := user_data,
		}
			ACTIVE

8.3.2 Functions

The function used in this state machine is as shown in Table 25.

Table 25 – Function SelectArep

Name	**SelectArep**	**Used in**	**FSPM**
Input		Output	
Arep_Id		True || False	
Function			
Looks for the AREP entry that is specified by the Arep_Id parameter. The Arep_Id parameter is provided with the AP-Context service primitives.			

9 Application relationship protocol machines (ARPMs)

9.1 Queued user-triggered bidirectional-flow control (QUB-FC) ARPM

9.1.1 QUB-FCPrimitive definitions

9.1.1.1 Primitives exchanged between ARPM and FSPM

Table 26 and Table 27 list the primitives exchanged between the ARPM and the FSPM.

Table 26 – Primitives issued by FSPM to ARPM

Primitive name	Source	Associated parameters	Functions
EST_req	FSPM	user_data	This is an FAL internal primitive used to convey an Establish request primitive from the FSPM to the ARPM.
EST_rsp(+)	FSPM	user_data	This is an FAL internal primitive used to convey an Establish response(+) primitive from the FSPM to the ARPM.
EST_rsp(-)	FSPM	user_data	This is an FAL internal primitive used to convey an Establish response(-) primitive from the FSPM to the ARPM.
Abort_req	FSPM	identifier, reason_code, additional_detail	This an FAL internal primitive used to convey an Abort request primitive from the FSPM to the ARPM.
CS_req	FSPM	user_data	This is an FAL internal primitive used to convey a Confirmed Send (CS) request primitive from the FSPM to the ARPM.
CS_rsp	FSPM	user_data	This is an FAL internal primitive used to convey a Confirmed Send (CS) response primitive from the FSPM to the ARPM.
UCA_req	FSPM	remote_dlsap_address, user_data	This is an FAL internal primitive used to convey an Unconfirmed Acknowledged Send (UCA) request primitive from the FSPM to the ARPM.

Table 27 – Primitives issued by ARPM to FSPM

Primitive name	Source	Associated parameters	Functions
EST_ind	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey an Establish indication primitive from the ARPM to the FSPM.
EST_cnf(+)	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey an Establish response(+) primitive from the ARPM to the FSPM.
EST_cnf(-)	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey an Establish response(-) primitive from the ARPM to the FSPM.
Abort_ind	ARPM	arep_id, locally_generated, identifier, reason_code, additional_detail	This is an FAL internal primitive used to convey an Abort primitive from the ARPM to the FSPM.
CS_ind	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey a Confirmed Send (CS) indication primitive from the ARPM to the FSPM.
CS_cnf	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey a Confirmed Send (CS) confirmation primitive from the ARPM to the FSPM.
UCA_ind	ARPM	arep_id, remote_dlsap_address, user_data	This is an FAL internal primitive used to convey an Unconfirmed Acknowledged Send (UCA) indication primitive from the ARPM to the FSPM.

9.1.2 Parameters of FSPM/ARPM primitives

The parameters used with the primitives exchanged between the FSPM and the ARPM are described in Table 28.

Table 28 – Parameters used with primitives exchanged between FSPM and ARPM

Parameter name	Description
arep_id	This parameter is used to unambiguously identify an instance of the AREP that has issued a primitive. A means for such identification is not specified by this standard.
User_data	This parameter conveys FAL-User data.
Locally_generated	This parameter conveys value that is used for the Locally_Generated parameter.
Identifier	This parameter conveys value that is used for the Identifier parameter.
Reason_code	This parameter conveys value that is used for the Reason_Code parameter.
Additional_detail	This parameter conveys value that is used for the Additional_Detail parameter.

9.1.3 DLL mapping of QUB-FC AREP Class

This subclause describes the mapping of the QUB-FC AREP class to the Type 8 Data Link Layer defined in IEC 61158-3-8 and IEC 61158-4-8. It does not redefine the DLSAP attributes or DLME attributes that are or will be defined in the Data Link Layer standard; rather, it defines how they are used by this AR class.

NOTE A means to configure and monitor the values of these attributes are not in the scope of this International Standard.

The DLL Mapping attributes and their permitted values and the DLL services used with the QUB-FC AREP class are defined in this subclause.

CLASS: Type 8 QubFC
PARENT CLASS: QueuedUser-TriggeredBidirectional-FlowControlAREP
ATTRIBUTES:

1	(m)	KeyAttribute:	LocalDlcepAddress
2	(m)	Attribute:	RemoteDlcepAddress
3	(m)	Attribute:	QosParameterSet
3.1	(m)	Atribute:	DllPriorityNegotiated
3.2	(m)	Attribute:	MaxConfirmDelay
3.3	(m)	Attribute:	MaxDlsduSizes
3.3.1	(m)	Attribute:	MaxDlsduSizeFromRequestor
3.3.2	(m)	Attribute:	MaxDlsduSizeFromResponder
3.3.3	(m)	Attribute:	MaxDlsduSizeFromRequestorNegotiated
3.3.4	(m)	Attribute:	MaxDlsduSizeFromResponderNegotiated
3.4	(m)	Attribute:	MaxQueueDepth
3.4.1	(m)	Attribute:	MaxSendingQueueDepth
3.4.2	(m)	Attribute:	MaximimReceivingQueueDepth

DLL SERVICES:

1	(m)	OpsService:	DL-Data

9.1.4 Attributes

9.1.4.1 LocalDlcepAddress

This attribute specifies the local DLCEP address and identifies the DLCEP.

The value of this attribute is used as the “DLCEP-address” parameter of the DLL.

9.1.4.2 RemoteDlcepAddress

This attribute specifies the remote DLCEP address and identifies the DLCEP.

9.1.4.3 QosParameterSet

The QosParameterSet attributes specify the DL quality of service that is used by this AREP. These attribute values may be negotiated with the remote AREP.

This attribute specifies the negotiated value of the DLL priority.

9.1.4.4 MaxConfirmDelay

This attribute specifies the maximum confirmation delay of certain DLL connection-oriented services.

9.1.4.5 MaxDlsduSize

MaxDlsduSizeFromRequestor

This attribute specifies the configured value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “True” to the remote AREP.

This attribute supplies the value for the “Maximum DLSDU sizes from responder” parameter of the DLL.

MaxDlsduSizeFromResponder

This attribute specifies the configured value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “False” to the remote AREP.

This attribute supplies the value for the “Maximum DLSDU sizes from responder” parameter of the DLL.

MaxDlsduSizeFromRequestorNegotiated

This attribute specifies the negotiated value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “True” to the remote AREP.

MaxDlsduSizeFromResponderNegotiated

This attribute specifies the negotiated value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “False” to the remote AREP.

9.1.4.6 MaxQueueDepth

MaxSendingQueueDepth

This attribute specifies the maximum number of FAL-PDUs that can be queued for transmission.

This attribute supplies the value for the “Maximum queue depth” parameter of the DLL for Send queues.

MaxReceivingQueueDepth

This attribute specifies the maximum number of FAL-PDUs that can be queued at reception.

This attribute supplies the value for the “Maximum queue depth” parameter of the DLL for Receive queues.

9.1.5 DLL services

Refer to IEC 61158-3-8 for DLL service descriptions.

9.1.6 QUB-FC ARPM state machine

9.1.6.1 QUB-FC ARPM states

The defined states and their descriptions of the QUB-FC ARPM are shown in Table 29 and Figure 26.

Table 29 – QUB-FC ARPM states

State	Description
CLOSED	The AREP is defined, but not capable of sending or receiving FAL-PDUs. It may send or receive Establish service FAL-PDUs while in this state.
OPEN	The AREP is defined and capable of sending or receiving FAL-PDUs.
REQUESTING (REQ)	The AREP has sent an Establish Request FAL-PDU and is waiting for a response from the remote AREP.
RESPONDING (RSP)	The AREP has received an Establish Request FAL-PDU, delivered an Establish.indication primitive and is waiting for a response from its user.
REPLIED (REPL)	The Server AREP has issued an EST_rsp(+) primitive and is waiting for receiving a "connection-established" indication from the DLL.
SAME	Indicates that the next state is the same as the current state.

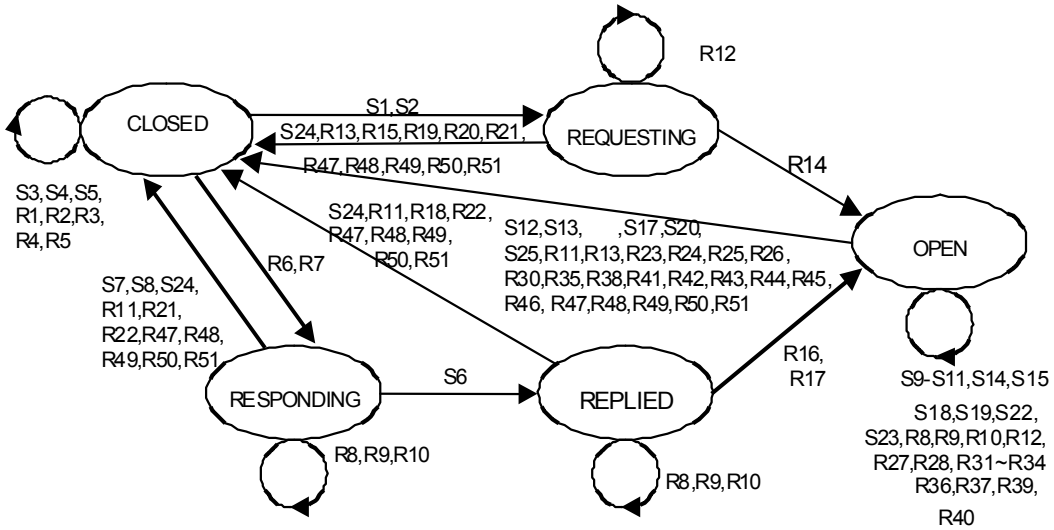


Figure 26 – State transition diagram of QUB-FC ARPM

9.1.6.2 QUB-FC ARPM state table

Table 30 and Table 31 define the state machine of the QUB-FC ARPM.

Table 30 – QUB-FC ARPM state table – sender transactions

#	Current state	Event or condition => action	Next state

S1	CLOSED	EST_req
		&& Initiator = “True”
		&& RemoteAddressConfigurationType := “Free”
		=>
		RemoteDlcepAddress := remote_dlcep_address,
		
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Connect_req”,
		arep_id := GetArepId (),
		called_address := “default dlsap address”,
		calling_address := “default dlsap address”,
		local_dlcep_address := LocalDlcep,
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “EST_ReqPDU”,
		calling_dlcep_address := LocalDlcepAddress,
		called_dlcep_address := RemoteDlcepAddress,
		fal_data := user_data)
		}
			REQ

S2	CLOSED	EST_req
		&& Initiator = “True”
		&& RemoteAddressConfigurationType := “Linked”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Connect_req”,
		arep_id := GetArepId (),
		called_address := “default dlsap address”,
		calling_address := “default dlsap address”,
		local_dlcep_address := LocalDlcep,
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “EST_ReqPDU”,
		calling_dlcep_address := LocalDlcepAddress,
		called_dlcep_address := RemoteDlcepAddress,
		fal_data := user_data)
		}
			REQ

S3	CLOSED	EST_req
		&& Initiator = “False”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Invalid Event for Role”
		}
			CLOSED

S4	CLOSED	unallowed primitive
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Unallowed AREP primitive in connection establishment “
		}
			CLOSED

S5	CLOSED	Abort_req => ignore	CLOSED

S6	RSP	EST_rsp(+)
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Connect_rsp”,
		arep_id := GetArepId (),
		responding_address := “default dlsap address”,
		local_dlcep_address := LocalDlcep,
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “EST_RspPDU”,
		fal_data := user_data)
		}
			REPL

#	Current state	Event or condition => action	Next state

S7	RSP	EST_rsp(-)
		=>
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := "connection rejection-transient condition",
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "EST_ErrPDU",
		fal_data := user_data)
		}
			CLOSED

S8	RSP	unallowed primitive
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Unallowed AREP primitive in connection establishment "
		},
		
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := " Unallowed AREP primitive in connection establishment ",
		dlsdu := "null"
		}
			CLOSED

S9	OPEN	CS_req && Role = “Client” || “Peer” && GetCounterValue(OSCC) < maxOSCC && CIU = 0 => FAL-PDU_req { dmpm_service_name := “DMPM_Data_req”, arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := “CS_ReqPDU”, fal_data := user_data) }, IncrementCounter(OSCC)	OPEN
S10	OPEN	CS_req && Role = “Client” || “Peer” && GetCounterValue(OSCC) < maxOSCC && CIU > 0 => FAL-PDU_req { dmpm_service_name := “DMPM_Data_req”, arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := “CS_ReqPDU”, fal_data := user_data) }, StartTimer(TC) IncrementCounter(OSCC)	OPEN

S11	OPEN	CS_req
		&& Role = “Client” || “Peer”
		=>
		CS_cnf (-) {
		arep_id := GetArepId (),
		user_data := "null"
		}
			OPEN

#	Current state	Event or condition => action	Next state

S12	OPEN	CS_req
		&& Role = “Client” || “Peer”
		&& GetCounterValue(OSCC) ≥ maxOSCC
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Number of parallel services exceeded"
		},
		
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := " Number of parallel services exceeded",
		dlsdu := "null"
		},
		
		StopTimer
		ResetCounters
			CLOSED

S13	OPEN	CS_req
		&& Role = “Server”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Unallowed service as server"
		},
		
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := "Unallowed service as server",
		dlsdu := "null"
		},
		
		StopTimer
		ResetCounters
			CLOSED

S14	OPEN	CS_rsp && Role = “Server” || “Peer” && CIU = 0 => FAL-PDU_req { dmpm_service_name := "DMPM_Data_req", arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := "CS_RspPDU", fal_data := user_data) }, DecrementCounter(OSCS)	OPEN
S15	OPEN	CS_rsp && Role = “Server” || “Peer” && CIU > 0 => FAL-PDU_req { dmpm_service_name := "DMPM_Data_req", arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := "CS_RspPDU", fal_data := user_data) }, StartTimer(TS) DecrementCounter(OSCS)	OPEN

#	Current state	Event or condition => action	Next state

S17	OPEN	CS_rsp
		&& Role = “Client” II "Peer"
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Unallowed service as client"
		},
		
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := " Unallowed service as client",
		dlsdu := "null"
		},
		
		StopTimer
		ResetCounters
			CLOSED

S18	OPEN	UCA_req && Role = "Client" II "Peer" && GetCounterValue(UCC) < maxUCC && CIU = 0 => FAL-PDU_req { dmpm_service_name := "DMPM_Data_req", arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := "UCA_PDU", fal_data := user_data) }, IncrementCounter(UCC)	OPEN
S19	OPEN	UCA_req && Role = "Client" II "Peer" && GetCounterValue(UCC) < maxUCC && CIU > 0 => FAL-PDU_req { dmpm_service_name := "DMPM_Data_req", arep_id := GetArepId (), dlsdu := BuildFAL-PDU (fal_pdu_name := "UCA_PDU", fal_data := user_data) }, StartTimer(TC) IncrementCounter(UCC)	OPEN

S20	OPEN	UCA_req
		&& Role = "Server" II "Peer"
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Unallowed service as server"
		},
		
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := "Unallowed service as server",
		dlsdu := "null"
		},
		
		StopTimer
		ResetCounters
			CLOSED

#	Current state	Event or condition => action	Next state

S22	OPEN	TCTimer expired
		=>
		StartTimer(TC)
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Data_req",
		arep_id := GetArepId (),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "IdlePDU",
		fal_data := "null")
		}
			OPEN

S23	OPEN	TSTimer expired
		=>
		StartTimer(TS)
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Data_req",
		arep_id := GetArepId (),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "IdlePDU",
		fal_data := "null")
		}
			OPEN

S24	NOT CLOSED	Abort_req => FAL-PDU_req { dmpm_service_name := "DMPM_Disconnect_req", arep_id := GetArepId (), reason := "disconnection–normal condition", dlsdu := BuildFAL-PDU (fal_pdu_name := "Abort_PDU", fal_id := identifier, fal_reason_code := reason_code, fal_additional_detail := additional_detail) }, StopTimer, ResetCounters	CLOSED

Table 31 – QUB-FC ARPM state table – receiver transactions

#	Current state	Event or condition => action	Next state

R1	CLOSED	Connect_ind
		&& Initiator = “True”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Multiple Initiators",
		dlsdu := “null”
		}
			CLOSED

R2	CLOSED	Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) <> “EST_ReqPDU”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := “Invalid FAL-PDU”,
		dlsdu := “null”
		}
			CLOSED

R3	CLOSED	Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ReqPDU”
		&& AREPContextCheck (dlsdu) = "False"
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Context Check Negative",
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "Abort_PDU",
		fal_id := identifier,
		fal_reason_code := "Context Check Negative",
		fal_additional_detail := maxOSCC, maxOSCS, maxUCSC, maxUCSS, CI)
		}
			CLOSED

R4	CLOSED	unallowed primitive => (no actions taken)	CLOSED

R5	CLOSED	Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ReqPDU”
		&& RemoteAddressConfigurationType = “Linked”
		&& RemoteDlcepAddress <> calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := “Remote Address Mismatch”,
		dlsdu := “null”
		}
			CLOSED

R6	CLOSED	Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ReqPDU”
		&& AREPContextCheck (dlsdu) = "True"
		&& RemoteAddressConfigurationType = “Linked”
		&& RemoteDlcepAddress = calling_dlcep_address
		=>
		MaxDlsduSizeFromRequestorNegotiated := dlsdu_size_from_requestor,
		MaxDlsduSizeFromResponderNegotiated := dlsdu_size_from_responder,
		
		EST_ind {
		arep_id := GetArepId (),
		user_data := dls_user_data
		}
			RSP

#	Current state	Event or condition => action	Next state

R7	CLOSED	Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ReqPDU”
		&& AREPContextCheck (dlsdu) = "True"
		&& RemoteAddressConfigurationType = “Free”
		=>
		RemoteDlcepAddress := calling_dlcep_address,
		MaxDlsduSizeFromRequestorNegotiated := dlsdu_size_from_requestor,
		MaxDlsduSizeFromResponderNegotiated := dlsdu_size_from_responder,
		
		EST_ind {
		arep_id := GetArepId (),
		user_data := dls_user_data
		}
			RSP

R8	RSP
	REPL
	OPEN
		Connect_ind
		&& Initiator = “False”
		&& RemoteAddressConfigurationType = “Linked”
		&& RemoteDlcepAddress <> calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Remote Address Mismatch",
		dlsdu := “null”
		}
			SAME

R9	RSP
	REPL
	OPEN
		Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ReqPDU”
		&& RemoteAddressConfigurationType = “Free”
		&& RemoteDlcepAddress <> calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "AREP Busy",
		dlsdu := “null”
		}
			SAME

R10	RSP
	REPL
	OPEN
		Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) <> “EST_ReqPDU”
		&& RemoteAddressConfigurationType = “Free”
		&& RemoteDlcepAddress <> calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		}
			SAME

R11	RSP
	REPL
	OPEN
		Connect_ind
		&& Initiator = “False”
		&& FAL_Pdu_Type (dls_user_data) = "EST_ReqPDU"
		&& RemoteDlcepAddress = calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Invalid FAL-PDU"
		}
			CLOSED

#	Current state	Event or condition => action	Next state

R12	REQ OPEN	Connect_ind
		&& Initiator = “True”
		&& RemoteDlcepAddress <> calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Multiple Initiators",
		dlsdu := “null”
		}
			SAME

R13	REQ OPEN	Connect_ind
		&& Initiator = “True”
		&& RemoteDlcepAddress = calling_dlcep_address
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		dlcep_dl_id := dlcep_dl_id (from Connect_ind),
		reason := "Multiple Initiators",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Multiple Initiators"
		}
			CLOSED

R14	REQ	Connect_cnf
		&& FAL_Pdu_Type (dls_user_data) = “EST_RspPDU”
		=>
		MaxDlsduSizeFromRequestorNegotiated := dlsdu_size_from_requestor,
		MaxDlsduSizeFromResponderNegotiated := dlsdu_size_from_responder,
		DllPriorityNegotiated := dll_priority,
		
		EST_cnf(+) {
		arep_id := GetArepId (),
		user_data := dls_user_data
		}
			OPEN

R15	REQ	Connect_cnf
		&& FAL_Pdu_Type (dls_user_data) <> “EST_RspPDU”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Invalid FAL-PDU"
		}
			CLOSED

R16	REPL	FAL-PDU_ind && dmpm_service_name = “DMPM_Connection_Established_ind” &&CIU=0 => (no actions taken)	OPEN
R17	REPL	FAL-PDU_ind && dmpm_service_name = “DMPM_Connection_Established_ind” &&CIU>0 => StartTimer(RS)	OPEN

#	Current state	Event or condition => action	Next state

R18	REPL	FAL-PDU_ind
		&& ((dmpm_service_name <> “DMPM_Disconnect_ind”)
		&& (dmpm_service_name <>“DM_Connection_Established_ind”))
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid DL-Event",
		dlsdu := “null”
		},
		
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid DL-Event”,
		additional_detail := “null”
		}
			CLOSED

R19	REQ	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& FAL_Pdu_Type (dls_user_data) = “EST_ErrPDU”
		=>
		EST_cnf(-) {
		arep_id := GetArepId (),
		user_data := dls_user_data
		}
			CLOSED

R20	REQ	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu <> “null”
		&& ((FAL_Pdu_Type (dls_user_data) <> “Abort_PDU”)
		&& (FAL_Pdu_Type (dls_user_data) <> “EST_ErrPDU”))
		=>
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := “null”
		}
			CLOSED

R21	REQ
	RSP
		FAL-PDU_ind
		&& dmpm_service_name <> “DMPM_Disconnect_ind”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid DL-Event",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := "FAL",
		reason_code := "Invalid DL-Event"
		}
			CLOSED

R22	REPL RSP	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu <> “null” && FAL_Pdu_Type (dls_user_data) <> “Abort_PDU” => Abort_ind{ arep_id := GetArepId (), locally_generated := "True", identifier := “FAL”, reason_code := “Invalid FAL-PDU”, additional_detail := “null” }, StopTimer, ResetCounters	CLOSED

#	Current state	Event or condition => action	Next state
R23	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu <> “null” && FAL_Pdu_Type (dls_user_data) <> “Abort_PDU” && Role = "Client" II "Peer" => Abort_ind{ arep_id := GetArepId (), locally_generated := "True", identifier := “FAL”, reason_code := “Invalid FAL-PDU”, additional_detail := “null” }, StopTimer, ResetCounters	CLOSED
R24	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu <> “null” && FAL_Pdu_Type (dls_user_data) <> “Abort_PDU” && Role = "Server" II "Peer" => Abort_ind{ arep_id := GetArepId (), locally_generated := "True", identifier := “FAL”, reason_code := “Invalid FAL-PDU”, additional_detail := “null” }, StopTimer, ResetCounters	CLOSED

R25	OPEN	FAL-PDU_ind
		&& ((dmpm_service_name <> “DMPM_Disconnect_ind”)
		II (dmpm_service_name <> “DMPM_Data_ind”))
		&& Role = "Client" II "Peer"
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid DL-Event",
		dlsdu := “null”
		},
		
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid DL-Event”,
		additional_detail := “null”
		},
		
		StopTimer,
		ResetCounters
			CLOSED

#	Current state	Event or condition => action	Next state

R26	OPEN	FAL-PDU_ind
		&& ((dmpm_service_name <> “DMPM_Disconnect_ind”)
		II (dmpm_service_name <> “DMPM_Data_ind”))
		&& Role = "Server" II "Peer"
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid DL-Event",
		dlsdu := “null”
		},
		
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid DL-Event”,
		additional_detail := “null”
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R27	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && Role = “Peer” || “Server” && FAL_Pdu_Type (dls_user_data) = “CS_ReqPDU” && GetCounterValue(OSCS) < maxOSCS && CIU = 0 => CS_ind { arep_id := GetArepId (), user_data := fal_pdu }, IncrementCounter(OSCS)	OPEN
R28	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && Role = “Peer” || “Server” && FAL_Pdu_Type (dls_user_data) = “CS_ReqPDU” && GetCounterValue(OSCS) < maxOSCS && CIU > 0 => CS_ind { arep_id := GetArepId (), user_data := fal_pdu }, IncrementCounter(OSCS) , StartTimer(RS)	OPEN

R30	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& Role = “Server” ||“Peer”
		&& FAL_Pdu_Type (dls_user_data) = “CS_ReqPDU”
		&& GetCounterValue(OSCS) ≥ maxOSCS
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Number of parallel services exceeded",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Number of parallel services exceeded”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

#	Current state	Event or condition => action	Next state
R31	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && Role = “Client” || “Peer” && FAL_Pdu_Type (dls_user_data) = “CS_RspPDU” && CIU = 0 => CS_cnf { arep_id := GetArepId (), user_data := fal_pdu }, DecrementCounter(OSCC)	OPEN
R32	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && Role = “Client” || “Peer” && FAL_Pdu_Type (dls_user_data) = “CS_RspPDU” && CIU > 0 => CS_cnf { arep_id := GetArepId (), user_data := fal_pdu }, DecrementCounter(OSCC) , StartTimer(RC)	OPEN

R33	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& FAL_Pdu_Type (dls_user_data) = “UCA_ReqPDU”
		&& Role = "Server" II "Peer"
		&& CIU = 0
		=>
		UCA_ind {
		arep_id := GetArepId (),
		user_data := fal_pdu
		},
		
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Data_req”,
		arep_id := GetArepId (),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "UCA_AckPDU),
		fal_data := "null")
		}
			OPEN

R34	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& FAL_Pdu_Type (dls_user_data) = “UCA_ReqPDU”
		&& Role = "Server" II "Peer"
		&& CIU > 0
		=>
		UCA_ind {
		arep_id := GetArepId (),
		user_data := fal_pdu
		},
		
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Data_req”,
		arep_id := GetArepId (),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := "UCA_AckPDU),
		fal_data := "null")
		},
		
		StartTimer(RS)
			OPEN

#	Current state	Event or condition => action	Next state

R35	OPEN	FAL-PDU_ind
		&& dmpm_service_name = DMPM_Data_ind"
		&& FAL_Pdu_Type (dls_user_data) = “UCA_ReqPDU”
		&& Role = "Client" II "Peer"
		=>
		FAL-PDU_req {
		dmpm_service_name := "DMPM_Disconnect_req",
		arep_id := GetArepId (),
		reason := "Invalid Event for Role",
		dlsdu := "null"
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid Event for Role”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R36	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && FAL_Pdu_Type (dls_user_data) = “UCA_AckPDU” && Role = "Client" II "Peer" && GetCounterValue(UCC) > 0 && CIU = 0 => DecrementCounter(UCC)	OPEN
R37	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && FAL_Pdu_Type (dls_user_data) = “UCA_AckPDU” && Role = "Client" II "Peer" && GetCounterValue(UCC) > 0 && CIU > 0 => DecrementCounter(UCC) , StartTimer(RC)	OPEN

R38	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& FAL_Pdu_Type (dls_user_data) = “UCA_AckPDU”
		&& Role = "Client" II "Peer"
		&& GetCounterValue(UCC) = 0
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "UCA_AckPDU received and UCC=0",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “ UCA_AckPDU received and UCC=0”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R39	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && FAL_Pdu_Type (dls_user_data) = “IdlePDU” && CIU > 0 && Role = "Client" II "Peer" => StartTimer(RC)	OPEN

#	Current state	Event or condition => action	Next state
R40	OPEN	FAL-PDU_ind && dmpm_service_name = “DMPM_Data_ind” && FAL_Pdu_Type (dls_user_data) = “IdlePDU” && CIU > 0 && Role = "Server" II "Peer" => StartTimer(RS)	OPEN

R41	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& FAL_Pdu_Type (dls_user_data) = “IdlePDU”
		&& CIU = 0
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R42	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& Role = "Client"
		&& ((FAL_Pdu_Type (dls_user_data) <> “CS_RspPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> "UCA_AckPDU)
		II (FAL_Pdu_Type (dls_user_data) <> "IdlePDU"))
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

#	Current state	Event or condition => action	Next state

R43	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& Role = "Server"
		&& ((FAL_Pdu_Type (dls_user_data) <> “CS_ReqPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> “UCA_ReqPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> "IdlePDU"))
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R44	OPEN	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& Role = "Client"
		&& ((FAL_Pdu_Type (dls_user_data) <> “CS_ReqPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> “CS_RspPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> “UCA_ReqPDU”)
		II (FAL_Pdu_Type (dls_user_data) <> "UCA_AckPDU)
		II (FAL_Pdu_Type (dls_user_data) <> "IdlePDU"))
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "Invalid FAL-PDU",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R45	OPEN	RCTimer expired
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "RCTimer expired",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := "RCTimer expired",
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

#	Current state	Event or condition => action	Next state

R46	OPEN	RSTimer expired
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := "RSTimer expired",
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := "RSTimer expired",
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

R47	NOT CLOSED	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu <> “null” && FAL_Pdu_Type (dls_user_data) = “Abort_PDU” => Abort_ind{ arep_id := GetArepId (), locally_generated := "False", identifier := AbortIdentifier (fal_pdu), reason_code := AbortReason (fal_pdu), additional_detail := AbortDetail (fal_pdu) }, StopTimer, ResetCounters	CLOSED
R48	NOT CLOSED	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu = "null" && originator = "remote_dls_provider" => Abort_ind{ arep_id := GetArepId (), locally_generated := "False", identifier := “Data Link Layer”, reason_code := reason, additional_detail := "null" }, StopTimer, ResetCounters	CLOSED
R49	NOT CLOSED	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu = "null" && originator = "remote_dls_user" => Abort_ind{ arep_id := GetArepId (), locally_generated := "False", identifier := “FAL”, reason_code := reason, additional_detail := "null" }, StopTimer, ResetCounters	CLOSED

#	Current state	Event or condition => action	Next state
R50	NOT CLOSED	FAL-PDU_ind && dmpm_service_name = “DMPM_Disconnect_ind” && fal_pdu = "null" && originator = "local_dls_provider" => Abort_ind{ arep_id := GetArepId (), locally_generated := "True", identifier := “Data Link Layer”, reason_code := reason, additional_detail := "null" }, StopTimer, ResetCounters	CLOSED

R51	NOT CLOSED	ErrorToARPM
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := reason,
		dlsdu := “null”
		},
		
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := "True",
		identifier := “FAL”,
		reason_code := reason,
		additional_detail := "null"
		},
		
		StopTimer,
		ResetCounters
			CLOSED

9.1.6.3 Functions used by QUB-FC ARPM

Table 32 through Table 44 define the functions used by this state machine.

Table 32 – Function GetArepId ()

Name	GetArepId ()	Used in	ARPM
Input		Output	
(none)		AREP Identifier	
Function			
Returns a value that can unambiguously identify the current AREP.			

Table 33 – Function BuildFAL-PDU

Name	BuildFAL-PDU	Used in	ARPM
Input		Output	
fal_pdu_name, calling_dlcep_address, called_dlcep_address, fal_data, fal_id, fal_reason_code, fal_additional_detail		dlsdu	
Function			
Builds an FAL-PDU out of the parameters given as input variables.			

Table 34 – Function FAL_Pdu_Type

Name	FAL_Pdu_Type	Used in	ARPM
Input		Output	
dls_user_data		One of the FAL-PDU types defined in the FAL-PDUs subclause.	
Function			
This function decodes the FAL-PDU that is conveyed in the dls_user_data parameter and retrieves one of the FAL-PDU types.			

Table 35 – Function AREPContextCheck()

Name	AREPContextCheck()	Used in	ARPM
Input		Output	
dl_sdu		Boolean value.	
Function			

This function checks the AREP context parameters that are received with establish service. The compatibility of the remote to the local context is shown in the following table:

Local Context		Remote Context
Type	=	Type
maxOSCC	≤	maxOSCS
maxOSCS	≤	maxUCSS
maxUCSC	≥	maxOSCC
maxUCSS	≥	maxUCSC
CI	=	CIU

Explanation:
≤: local value smaller than or equal to remote value
≥: local value larger than or equal to remote value
=: local value equal to remote value

Table 36 – Function AbortIdentifier

Name	AbortIdentifier	Used in	ARPM
Input		Output	
fal_pdu		The Identifier parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Identifier parameter.			

Table 37 – Function AbortReason

Name	AbortReason	Used in	ARPM
Input		Output	
fal_pdu		The Reason Code parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Reason Code parameter.			

Table 38 – Function AbortDetail

Name	AbortDetail	Used in	ARPM
Input		Output	
fal_pdu		The Additional Detail parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Additional Detail parameter.			

NOTE The following two functions make use of persistent protocol timers that are able to issue the local events 'TSTimer expired', 'TCTimer expired', 'RCTimer expired' and 'RSTimer expired' to notify the expiration of the appropriate time interval to the ARPM.

Table 39 – Function StartTimer

Name	StartTimer	Used in	ARPM
Input		Output	
identifier			
Function			
This function starts the selected persistent protocol timer as follows: If identifier is TS then function starts the TSTimer with the value of CIU/3. If identifier is TC then function starts the TCTimer with the value of CIU/3. If identifier is RS then function starts the RSTimer with the value of CIU. If identifier is RC then function starts the RCTimer with the value of CIU.			

NOTE The appropriate timer is restarted if it was still running.

Table 40 – Function StopTimer

Name	StopTimer	Used in	ARPM
Input		Output	
Function			
This function stops all local persistent protocol timers of the ARPM.			

NOTE The following functions make use of local persistent variables OSCC (current value of outstanding services at client), UCC (current value of unconfirmed services at client) and OSCS (current value of outstanding services at server) that supports counting of outstanding services. The initial values of OSCC, UCC, OSCS are 0.

Table 41 – Function ResetCounters

Name	ResetCounters	Used in	ARPM
Input		Output	
Function			
This function sets OSCC, UCC, OSCS to zero.			

Table 42 – Function IncrementCounter

Name	IncrementCounter	Used in	ARPM
Input		Output	
identifier			
Function			
This function increments the selected counter.			

Table 43 – Function DecrementCounter

Name	DecrementCounter	Used in	ARPM
Input		Output	
identifier			
Function			
This function decrements the selected counter.			

Table 44 – Function GetCounterValue

Name	GetCounterValue	Used in	ARPM
Input		Output	
identifier		value	
Function			
This function returns the current value of the selected counter.			

9.2 Buffered network-scheduled unidirectional (BNU) ARPM

9.2.1 Primitive definitions

9.2.1.1 Primitives exchanged between ARPM and FSPM

Table 45 and Table 46 list the primitives exchanged between the FSPM and the ARPM.

Table 45 – Primitives issued by FSPM to ARPM

Primitive name	Source	Associated parameters	Functions
EST_req	FSPM	user_data	This is an FAL internal primitive used to convey an Establish request primitive from the FSPM to the ARPM.
Abort_req	FSPM	identifier, reason_code, additional_detail	This an FAL internal primitive used to convey an Abort request primitive from the FSPM to the ARPM.
UCS_req	FSPM	user_data	This is an FAL internal primitive used to convey an Unconfirmed Send (UCS) request primitive from the FSPM to the ARPM.

Table 46 – Primitives issued by ARPM to FSPM

Primitive name	Source	Associated parameters	Functions
EST_cnf(+)	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey an Establish response(+) primitive from the ARPM to the FSPM.
EST_cnf(-)	ARPM	arep_id, user_data	This is an FAL internal primitive used to convey an Establish response(-) primitive from the ARPM to the FSPM.
Abort_ind	ARPM	arep_id, locally_generated, identifier, reason_code, additional_detail	This is an FAL internal primitive used to convey an Abort primitive from the ARPM to the FSPM.
UCS_ind	ARPM	arep_id, duplicate_fal_sdu, user_data, local_timeliness, remote_timeliness	This is an FAL internal primitive used to convey an Unconfirmed Send (UCS) indication primitive from the ARPM to the FSPM.

9.2.1.2 Parameters of FSPM/ARPM primitives

The parameters used with the primitives exchanged between the FSPM and the ARPM are described in Table 47.

Table 47 – Parameters used with primitives exchanged between FSPM and ARPM

Parameter name	Description
arep_id	This parameter is used to unambiguously identify an instance of the AREP that has issued a primitive. A means for such identification is not specified by this standard.
user_data	This parameter conveys FAL-User data.
locally_generated	This parameter conveys value that is used for the Locally_Generated parameter.
identifier	This parameter conveys value that is used for the Identifier parameter.
reason_code	This parameter conveys value that is used for the Reason_Code parameter.
additional_detail	This parameter conveys value that is used for the Additional_Detail parameter.

9.2.2 DLL mapping of BNU AREP class

9.2.2.1 BNU AREP class formal model

This subclause describes the mapping of the BNU AREP class to the Fieldbus Data Link Layer. It does not redefine the DLSAP attributes or DLME attributes that are or will be defined in the Data Link Layer standard; rather, it defines how they are used by this AR class.

The DLL mapping attributes and their permitted values and the DLL services used with the BNU AREP class are defined in this subclause.

CLASS: **Bnu**
PARENT CLASS: **BufferedNetworkScheduledUnidirectionalAREP**
ATTRIBUTES:

1	(m)	KeyAttribute:	PublisherDlcepAddress
3	(m)	Attribute:	QosParameterSet
3.1	(m)	Attribute:	DlcepClass (Publisher, Subscriber)
3.7	(m)	Constraint:	DlcepClass = Publisher
3.7.2	(m)	Attribute:	MaxDlsduSizeFromRequestor
3.8	(m)	Constraint:	DlcepClass = Subscriber
3.8.2	(m)	Attribute:	MaxDlsduSizeFromResponder

DLL SERVICES:

1	(c)	Constraint:	DlcepClass (Publisher)
1.1	(m)	OpsService:	DL-Put
1.2	(o)	OpsService:	DL-Get
2	(c)	Constraint:	DlcepClass (Subsciber)
2.1	(o)	OpsService:	DL-Put
2.2	(m)	OpsService:	DL-Get
3	(m)	OpsService:	DL-Buffer-Received

9.2.2.2 Attributes

9.2.2.2.1 PublisherDlcepAddress

This attribute specifies the Publisher's DLCEP address and identifies the DLCEP.

The value of this attribute is used as the "DLCEP-address" parameter of the DLL.

This attribute contains the following three subattributes: Link Address, Node Address, and Selector.

NOTE Since the local Link and Node addresses are set by the Network Management, only the Selector portion of the LocalDlsapAddress attribute is a configurable attribute of the FAL.

9.2.2.2.2 DlcepClass

This attribute specifies the behavior of the DLCEP which is attached to the AREP.

This attribute supplies the value for the "DLCEP class" parameter of the DLL. The possible value of this attribute is either Publisher or Subscriber and corresponds to PUBLISHER and SUBSCRIBER defined by the DLL, respectively.

9.2.2.2.3 MaxDlsduSizeFromRequestor

This attribute is used if the Role attribute has a value of "PushPublisher" and specifies the maximum length of an FAL-PDU that can be sent from this AREP.

9.2.2.2.4 MaxDlsduSizeFromResponder

This attribute is used if the Role attribute has a value of "PushSubscriber" and specifies the maximum length of an FAL-PDU that can be received by this AREP.

9.2.2.3 DLL services

Refer to IEC 61158-3-8 for DLL service descriptions.

9.2.3 BNU AREP state machine

9.2.3.1 BNU ARPM states

The defined states together with their descriptions of the BNU ARPM are listed in Table 48 and Figure 27.

Table 48 – BNU ARPM states

State	Description
CLOSED	The AREP is defined, but not capable of sending or receiving FAL-PDUs.
REQUESTING	The AREP has issued an EST_req and waiting for an EST_cnf primitive.
OPEN	The AREP is defined and capable of sending or receiving FAL-PDUs.

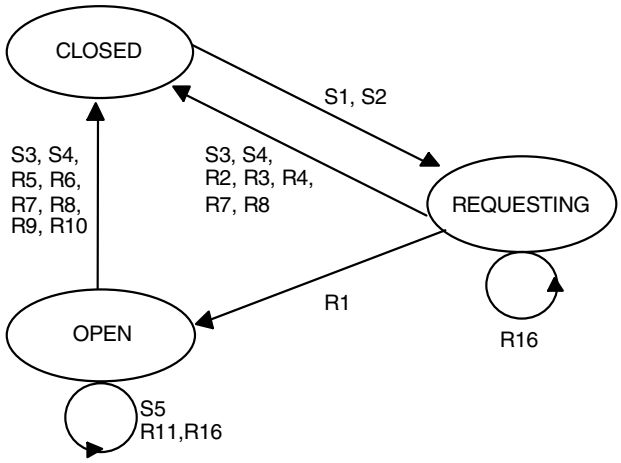


Figure 27 – State transition diagram of the BNU ARPM

9.2.3.2 BNU ARPM state table

Table 49 and Table 50 define the BNU ARPM state machine.

Table 49 – BNU ARPM state table – sender transactions

#	Current state	Event or condition => action	Next state

S1	CLOSED	EST_req
		&& Role = “PushPublisher”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Connect_req”,
		arep_id := GetArepId (),
		called_address := “null”,
		calling_address := “default dlsap address”,
		local_dlcep_address := PublisherDlcepAddress,
		dlsdu := “null”
		}
			REQ

S2	CLOSED	EST_req
		&& Role = “PushSubscriber”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Connect_req”,
		arep_id := GetArepId (),
		called_address := PublisherDlcepAddress,
		calling_address := “default dlsap address”,
		local_dlcep_address := “default subscriber dlcep address”,
		dlsdu := “null”
		}
			REQ

#	Current state	Event or condition => action	Next state

S3	NOT CLOSED	Abort_req
		&& Role = “PushPublisher”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := “disconnection–normal condition”,
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “Abort_PDU”,
		fal_id := identifer,
		fal_reason_code := reason_code,
		fal_additional_detail := additional_detail)
		}
			CLOSED

S4	NOT CLOSED	Abort_req
		&& Role = “PushSubscriber”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := “disconnection–normal condition”,
		dlsdu := “null”
		}
			CLOSED

S5	OPEN	UCS_req
		&& Role = “PushPublisher”
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Put_req”,
		arep_id := GetArepId (),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “UCS_PDU”,
		fal_data := user_data)
		}
			OPEN

Table 50 – BNU ARPM state table – receiver transactions

#	Current state	Event or condition => action	Next state

R1	REQ	Connect_cnf
		=>
		EST_cnf(+) {
		arep_id := GetArepId (),
		user_data := “null”
		}
			OPEN

R2	REQ	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu = “null”
		&& originator = “local_dls_provider”
		=>
		EST_cnf(-) {
		arep_id := GetArepId (),
		user_data := “null”
		}
			CLOSED

R3	REQ	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu = “null”
		&& originator = “remote_dls_provider”
		=>
		EST_cnf(-) {
		arep_id := GetArepId (),
		user_data := “null”
		}
			CLOSED

#	Current state	Event or condition => action	Next state

R4	REQ	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name <> “DMPM_Disconnect_ind”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Invalid DI Event”,
		additional_detail := “null”
		}
			CLOSED

R5	OPEN	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu = “null”
		&& originator = “local_dls_provider”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “Data Link Layer”,
		reason_code := reason,
		additional_detail := “null”
		}
			CLOSED

R6	OPEN	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu = “null”
		&& originator = “remote_dls_provider”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “False”,
		identifier := “Data Link Layer,”
		reason_code := reason,
		additional_detail := “null”
		}
			CLOSED

R7	NOT CLOSED	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& Fal_Pdu_Type (fal_pdu) = “Abort_PDU”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “False”,
		identifier := AbortIdentifier (fal_pdu),
		reason_code := AbortReason (fal_pdu),
		additional_detail := AbortDetail (fal_pdu)
		}
			CLOSED

R8	NOT CLOSED	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Disconnect_ind”
		&& fal_pdu <> “null”
		&& Fal_Pdu_Type (fal_pdu) <> “Abort_PDU”
		=>
		Abort_ind {
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := “null”
		}
			CLOSED

#	Current state	Event or condition => action	Next state

R9	OPEN	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& ((dmpm_service_name <> “DMPM_Buffer_Received_ind”)
		&& (dmpm_service_name <> “DMPM_Disconnect_ind”)
		&& (dmpm_service_name <> “DMPM_Get_cnf”)
		&& (dmpm_service_name <> “DMPM_Buffer_Sent_ind”))
		=>
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Invalid DI Event”,
		additional_detail := “null”
		},
		
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := “Invalid DL-Event”,
		dlsdu := “null”
		}
			CLOSED

R10	OPEN	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Buffer_Received_ind”
		&& FAL_pdu_type <> “UCS_PDU”
		=>
		Abort_ind{
		arep_id := GetArepId (),
		locally_generated := “True”,
		identifier := “FAL”,
		reason_code := “Invalid FAL-PDU”,
		additional_detail := “null”
		},
		
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Disconnect_req”,
		arep_id := GetArepId (),
		reason := “Invalid FAL-PDU”,
		dlsdu := “null”
		}
			CLOSED

R11	OPEN	FAL-PDU_ind
		&& Role = “PushSubscriber”
		&& dmpm_service_name = “DMPM_Buffer_Received_ind”
		&& FAL_Pdu_Type (fal_pdu) = “UCS_PDU”
		=>
		UCS_ind {
		arep_id := GetArepId (),
		duplicate_fal_sdu := duplicate_dlsdu,
		user_data := fal_pdu,
		local_timeliness := local_dle_timeliness,
		remote_timeliness := remote_dle_timeliness
		}
			OPEN

R16	NOT CLOSED	ErrorToARPM => (no actions taken) NOTE It is a local matter to report this error status to network management entities. The ARPM does not abort the existing connections. The FAL user may issue an Abort request to disconnect the current connection, depending on the type of status information conveyed by the ErrorToARPM primitive.	SAME

9.2.3.3 Functions used by BNU ARPM

Table 51 through Table 56 define the functions used by this state machine.

Table 51 – Function GetArepId ()

Name	GetArepId ()	Used in	ARPM
Input		Output	
(none)		AREP Identifier	
Function			
Returns a value that can unambiguously identify the current AREP.			

Table 52 – Function BuildFAL-PDU

Name	BuildFAL-PDU	Used in	ARPM
Input		Output	
fal_pdu_name, calling_dlcep_address, called_dlcep_address, fal_data, fal_id, fal_reason_code, fal_additional_detail		dlsdu	
Function			
Builds an FAL-PDU out of the parameters given as input variables.			

Table 53 – Function FAL_Pdu_Type

Name	FAL_Pdu_Type	Used in	ARPM
Input		Output	
fal_pdu		One of the FAL-PDU types defined in the clause 4.	
Function			
This function decodes the FAL-PDU that is conveyed in the fal_pdu parameter and retrieves one of the FAL-PDU types.			

Table 54 – Function AbortIdentifier

Name	AbortIdentifier	Used in	ARPM
Input		Output	
fal_pdu		The Identifier parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Identifier parameter.			

Table 55 – Function AbortReason

Name	AbortReason	Used in	ARPM
Input		Output	
fal_pdu		The Reason Code parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Reason Code parameter.			

Table 56 – Function AbortDetail

Name	AbortDetail	Used in	ARPM
Input		Output	
fal_pdu		The Additional Detail parameter of the Abort service.	
Function			
This function decodes the Abort_PDU that is conveyed in the fal_pdu parameter and extracts the Additional Detail parameter.			

9.3 Queued user-triggered bidirectional – transparent mode (QUB-TM) ARPM

9.3.1 QUB-TM Primitive definitions

9.3.1.1 Primitives exchanged between ARPM and FAL

The primitives exchanged between ARPM and FAL are shown in Table 57 and Table 58

Table 57 – Primitives issued by FAL to ARPM

Primitive name	Source	Associated parameters	Functions
DSA_req	FAL	user_data	This is a primitive used to convey a Data-Send-Acknowlegde request primitive from the FAL to the ARPM.

Table 58 – Primitives issued by ARPM to FAL

Primitive name	Source	Associated parameters	Functions
DSA_cnf(+)	ARPM	arep_id, user_data	This is a primitive used to convey a Data-Send-Acknowledge confirmation(+) primitive from the ARPM to the FAL.
DSA_cnf(-)	ARPM	arep_id, user_data	This is a primitive used to convey a Data-Send-Acknowledge confirmation(-) primitive from the ARPM to the FAL
DSA_ind	ARPM	arep_id, user_data	This is a primitive used to convey a Data-Send-Acknowledge indication from the ARPM to the FAL.

9.3.1.2 Parameters of FAL/ARPM primitives

The parameters used with the primitives exchanged between the FAL and the ARPM are described in Table 59.

Table 59 – Parameters used with primitives exchanged between FAL and ARPM

Parameter name	Description
Arep_id	This parameter is used to unambiguously identify an instance of the AREP that has issued a primitive. A means for such identification is not specified by this standard.
User_data	This parameter conveys FAL-User data.

9.3.2 DLL mapping of QUB-TM AREP Class

This subclause describes the mapping of the QUB-TM AREP class to the Type 8 Data Link Layer defined IEC 61158-3-8 and IEC 61158-4-8. It does not redefine the DLSAP attributes or DLME attributes that are or will be defined in the Data Link Layer standard; rather, it defines how they are used by this AR class.

NOTE A means to configure and monitor the values of these attributes are not in the scope of this standard.

The DLL Mapping attributes and their permitted values and the DLL services used with the QUB-TM AREP class are defined in this subclause.

CLASS: **Type 8 QubTM**
PARENT CLASS: **QueuedUser-TriggeredBidirectional-FlowControlAREP**
ATTRIBUTES:

1	(m)	KeyAttribute:	LocalDlcepAddress
2	(m)	Attribute:	RemoteDlcepAddress
3	(m)	Attribute:	QosParameterSet
3.3	(m)	Attribute:	MaxDlsduSizes
3.3.1	(m)	Attribute:	MaxDlsduSizeFromRequestor
3.3.2	(m)	Attribute:	MaxDlsduSizeFromResponder
3.3.3	(m)	Attribute:	MaxDlsduSizeFromRequestorNegotiated
3.3.4	(m)	Attribute:	MaxDlsduSizeFromResponderNegotiated
3.4	(m)	Attribute:	MaxQueueDepth
3.4.1	(m)	Attribute:	MaxSendingQueueDepth
3.4.2	(m)	Attribute:	MaximimReceivingQueueDepth

DLL SERVICES:

1	(m)	OpsService:	DL-Data

9.3.3 Attributes

9.3.3.1 LocalDlcepAddress

This attribute specifies the local DLCEP address and identifies the DLCEP.

The value of this attribute is used as the “DLCEP-address” parameter of the DLL.

9.3.3.2 RemoteDlcepAddress

This attribute specifies the remote DLCEP address and identifies the DLCEP.

9.3.3.3 QosParameterSet

9.3.3.3.1 General

The QosParameterSet attributes specify the DL quality of service that is used by this AREP. These attribute values may be negotiated with the remote AREP.

9.3.3.3.2 MaxDlsduSize

MaxDlsduSizeFromRequestor

This attribute specifies the configured value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “True” to the remote AREP.

This attribute supplies the value for the “Maximum DLSDU sizes from requestor” parameter of the DLL.

MaxDlsduSizeFromResponder

This attribute specifies the configured value of the maximum length of an FAL-PDU that can be sent from the AREP whose Initiator attribute has a value of “False” to the remote AREP.

This attribute supplies the value for the “Maximum DLSDU sizes from responder” parameter of the DLL.

9.3.3.3.3 MaxQueueDepth

MaxSendingQueueDepth

This attribute specifies the maximum number of FAL-PDUs that can be queued for transmission.

This attribute supplies the value for the “Maximum queue depth” parameter of the DLL for Send queues.

MaxReceivingQueueDepth

This attribute specifies the maximum number of FAL-PDUs that can be queued at reception.

This attribute supplies the value for the “Maximum queue depth” parameter of the DLL for Receive queues.

9.3.4 DLL services

Refer to IEC 61158-3-8 for DLL service descriptions.

9.3.5 QUB-TM AREP state machine

9.3.5.1 QUB-TM ARPM states

The defined states and their description of the QUB-TM are shown in Table 60 and Figure 28.

Table 60 – QUB-TM ARPM states

State name	Description
ACTIVE	The QUB-TM in the ACTIVE state is ready to transmit or receive primitives to or from the FAL and the ARPM.

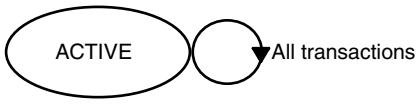


Figure 28 – State transition diagram of QUB-TM AREP

9.3.5.2 QUB-TM ARPM state table

The sender transactions are shown in Table 61 and the receiver transactions are shown in Table 62.

Table 61 – QUB-TM state table - sender transactions

#	Current state	**Event** or **condition** **=> action**	Next state

S1	ACTIVE	DSA_req
		=>
		FAL-PDU_req {
		dmpm_service_name := “DMPM_Data_req”,
		arep_id := GetArepId(),
		dlsdu := BuildFAL-PDU (
		fal_pdu_name := “ DataSendAcknowledge-PDU”,
		fal_data := user_data;
		}
			ACTIVE

Table 62 – QUB-TM state table - receiver transactions

#	Current state	Event or condition => action	Next state

R1	ACTIVE	FAL-PDU_ind
		&& dmpm_service_name = “DMPM_Data_ind”
		&& FAL_pdu_type(fal_pdu) = “ DataSendAcknowledge-PDU”
		=>
		DSA_ind {
		arep_id := GetArepID(),
		user_data = fal_pdu;
		}
			ACTIVE

R2	ACTIVE	DL_Data.cnf
		&& dl_status = “success”
		=>
		DSA_cnf(+) {
		arep_id := GetArepID(),
		}
			ACTIVE

R3	ACTIVE	DL_Data.cnf
		&& dl_status <> “success”
		=>
		DSA_cnf(-) {
		arep_id := GetArepID(),
		reason := dl_status
		}
			ACTIVE

NOTE In state S2 and S3 the Data Link Layer confirmation is used to build the DSA_cnf. The DataSendAcknowledge Service has no FAL response PDU.			

9.3.5.3 Functions used by QUB-TM ARPM

The functions used by the QUB-TM ARPM are show in Table 63 through Table 69.

Table 63 – Function GetArepId ()

Name	GetArepId ()	Used in	ARPM
Input		Output	
(none)		AREP Identifier	
Function			
Returns a value that can unambiguously identify the current AREP.			

Table 64 – Function BuildFAL-PDU

Name	BuildFAL-PDU	Used in	ARPM
Input		Output	
fal_pdu_name, calling_dlcep_address, called_dlcep_address, fal_data, fal_id,		dlsdu	
Function			
Builds an FAL-PDU out of the parameters given as input variables.			

Table 65 – Function FAL_Pdu_Type

Name	FAL_Pdu_Type	Used in	ARPM
Input		Output	
dls_user_data		One of the FAL-PDU types defined in the FAL-PDUs section.	
Function			
This function decodes the FAL-PDU that is conveyed in the dls_user_data parameter and retrieves one of the FAL-PDU types.			

Table 66 – Function ResetCounters

Name	ResetCounters	Used in	ARPM
Input		Output	
Function			
This function sets OSCC, UCC, OSCS to zero.			

Table 67 – Function IncrementCounter

Name	IncrementCounter	Used in	ARPM
Input		Output	
identifier			
Function			
This function increments the selected counter.			

Table 68 – Function DecrementCounter

Name	DecrementCounter	Used in	ARPM
Input		Output	
identifier			
Function			
This function decrements the selected counter.			

Table 69 – Function GetCounterValue

Name	GetCounterValue	Used in	ARPM
Input		Output	
identifier		value	
Function			
This function returns the current value of the selected counter.			

10 DLL mapping protocol machine

10.1 Overview

The DLL Mapping Protocol Machine is common to all the AREP types. Only applicable primitives are different among different AREP types.

Remarks about dl identifiers:

The Data Link Layer (see IEC 61158-3-8) defines two types of identifiers to distinguish each DL-primitive or to match one DL outgoing primitive with its mate incoming primitive. They are suffixed as dl-identifier or DLS-user-identifier. In a real implementation of an FAL-DL interface, these identifications may be achieved by means of a pointer to memory location or a return value of a function call, or something else. Since they are purely a local matter, it is not testable over the Fieldbus network. For this reason, they are not included as parameters of the DMPM primitives.

“dl-identifiers” or “dls-user-identifiers“are mandatory in the DL-services. The FAL assumes that the values of these parameters are provided from DLSAPs or DLCEPs by a local means.

A remark about DLS-user identification:

It is assumed that a connection between one ARPM instance and one DMPM instance is established locally other than a protocol means. Therefore, DLS-user identification parameters are not used in the DMPM primitives.

A remark about buffer or queue identifiers:

The Data Link Layer standard uses parameters to identify a buffer that are shared between the Data Link Layer and the DLS-user. Although they are useful to clarify the operations of the Data Link Layer, none of them affects protocol behavior of the FAL and DL. In a real implementation, these parameters are implementation dependent. Therefore, this standard does not include parameters that directly correspond to these buffer identifiers. A means for identifying the buffers between the FAL and the DL is a local matter.

A remark about initialization of the Data Link Layer:

The FAL assumes that the initialization procedures of the Data Link Layer have been executed prior to the operations of the FAL state machines. Therefore, DL-services to deal with such initialization procedures are not listed in IEC 61158-3.

A remark about DLC establishment:

The FAL assumes that all DLCs have been established prior to the operation of the FAL state machine. Therefore, DL-services to deal with such establishment procedures are not listed.

10.2 Primitive definitions

10.2.1 Primitives exchanged between DMPM and ARPM

Table 70 shows the primitives issued by ARPM to DMPM.

Table 70 – Primitives issued by ARPM to DMPM

Primitive names	Source	Associated parameters	Functions
FAL-PDU_req	ARPM	dmpm_service_name, arep_id, called_address*), calling_address*), responding_address*), local_dlcep_address*), reason, action_class*), dlsdu	This primitive is used to request the DMPM to transfer an FAL-PDU, or to request an abort without transferring an FAL-PDU. It passes the FAL-PDU to the DMPM as a DLSDU. It also carries some of the Data Link Layer parameters that are referenced there.
NOTE These parameters are issued by the ARPM state machines but they are not used by the Data Link Layer.			

Table 71 shows the primitives issued by DMPM to ARPM.

Table 71 – Primitives issued by DMPM to ARPM

Primitive names	Source	Associated parameters	Functions
FAL-PDU_ind	DMPM	dmpm_service_name, originator, reason, duplicate_dlsdu, calling_address, fal_pdu, local_dle_timeliness, remote_dle_timeliness	This primitive is used to pass an FAL-PDU received as a Data Link Layer service data unit to a designated ARPM. It also carries some of the Data Link Layer parameters that are referenced in the ARPM.
Connect_ind	DMPM	calling_dlcep_address, dlsdu_size_from_requestor, dlsdu_size_from_responder, dls_user_data	This primitive is used to convey a DL_Connect.ind primitive to the ARPM to process connection establishment. All the parameters that are associated with the DL_Connect.ind primitive are carried with this primitive.
Connect_cnf	DMPM	dll_priority, dlsdu_size_from_requestor, dlsdu_size_from_responder, dls_user_data	This primitive is used to convey a DL_Connect.cnf primitive to the ARPM. All the parameters that are associated with the DL_Connect.cnf are carried with this primitive.
ErrorToARPM	DMPM	originator, reason	This primitive is used to convey selected communication errors reported by the Type8 Data Link Layer to a designated ARPM.

10.2.2 Parameters of ARPM/DMPM primitives

The parameters used with the primitives exchanged between the ARPM and the DMPM are described in Table 72.

Table 72 – Parameters used with primitives exchanged between ARPM and DMPM

Parameter name	Description
arep_id	This parameter carries a local identifier to specify the associated AR instance.
action_class	This parameter conveys the value of the dl_action_class parameter.
calling_address	This parameter conveys the value of the dl_calling_address.
calling_dlcep_address	This parameter conveys the value of the RequestingAREP parameter supplied with the EST_ReqPDU.
called_address	This parameter conveys the value of the dl_called_address parameter.
dmpm_service_name	This parameter conveys a Type8 Data Link Layer service name. Possible values are all the DL-X.yyy primitives defined in this section and are represented as DMPM_X_yyy.
local_dlcep_address	This parameter conveys the value of the dl_dlcep_address parameter.
duplicate_dlsdu	As duplicate_dlsdu detection is not supported by the Data Link Layer this attribute is always set to "False".
dll_priority	As no different priorities are supported by the Data Link Layer this attribute is always set to "normal".
dlsdu_size_from_requestor	This parameter conveys the value of the dl_dlsdu_size_from_requestor parameter.
dlsdu_size_from_responder	This parameter conveys the value of the dl_dlsdu_size_from_responder parameter.
dls_user_data	This parameter conveys the value of the dl_dls_user_data parameter.
dlsdu	This parameter conveys the value of the dl_dls_user_data parameter.
fal_pdu	This parameter conveys the value of the dl_dls_user_data parameter.
remote_dle_timeliness	As timeliness is not supported by the Data Link Layer this attribute is always set to "False".
local_dle_timeliness	As timeliness is not supported by the Data Link Layer this attribute is always set to "False".
originator	This parameter conveys the value of the dl_originator parameter.
reason	This parameter conveys the value of the dl_reason parameter.
responding_address	This parameter conveys the value of the dl_responding_address parameter.

10.2.3 Primitives exchanged between data-link layer and DMPM

NOTE The DLL primitives (see Table 73) and their parameters are defined in IEC 61158-3-8.

Table 73 – Primitives exchanged between data-link layer and DMPM

Primitive names	Source	Associated parameters
DL_Data.ind	Data Link Layer	dl_dls_user_data
DL_Data.cnf	Data Link Layer	dl_status
DL_Buffer_Received.ind	Data Link Layer	dl_status
DL_Get.cnf(+)	Data Link Layer	dl_dls_user_data
DL_Get.cnf(-)	Data Link Layer	dl_error_type
DL_Put.cnf(+)	Data Link Layer	(none)
DL_Put.cnf(-)	Data Link Layer	dl_error_type
DL_Data.req	DMPM	dl_dls_user_data
DL_Get.req	DMPM	(none)
DL_Put.req	DMPM	dl_dls_user_data

10.2.4 Parameters of DMPM/data-link layer primitives

The parameters used with the primitives exchanged between the DMPM and the data-link layer are defined in the DLL Service definition (see IEC 61158-3-8). They are prefixed by "dl_" to indicate that they are used by the FAL.

10.3 DMPM state machine

10.3.1 DMPM states

The defined state of the DMPM together with its description listed in Table 74 and Figure 29 shows the corresponding state transition diagram.

Table 74 – DMPM state descriptions

State name	Description
ACTIVE	The DMPM in the ACTIVE state is ready to transmit or receive primitives to or from the Data Link Layer and the ARPM.

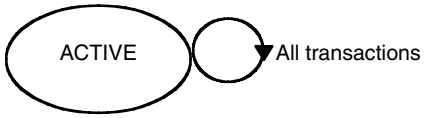


Figure 29 – State transition diagram of DMPM

10.3.2 DMPM state table

NOTE 1 Although each primitive contains all the available parameters, only those applicable to particular ARPM are relevant.

NOTE 2 Parameters starting with a capital letter, "DlcepClass" for instance, refer to those defined in the attribute list of each ARPM. Therefore, they are not conveyed by the service primitives defined here.

Table 75 shows the sender transaction state table:

Table 75 – DMPM state table – sender transactions

#	Current state	**Event** or **condition** **=> action**	Next state

S1a1	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = "Unlinked"
		&& (DMPM_service_name = "DMPM_Connect_req"
		|| DMPM_service_name = "DMPM_Connect_rsp"
		|| DMPM_service_name = "DMPM_Data_req"
		|| DMPM_service_name = "DMPM_Put_req")
		=>
		PickArep (arep_id),
		
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Disconnect_ind",
		originator := local_dls_provider,
		reason := "Unlinked",
		fal_pdu := "null"
		}
			ACTIVE

S1a2	ACTIVE	FAL-PDU_req && DlLinkStatus() = "Unlinked" && DMPM_service_name = "DMPM_Disconnect_req" && (ArepRole(arep_id) = "Client" || ArepRole(arep_id) = "Server" || ArepRole(arep_id) = "Peer") => (no actions taken)	ACTIVE

#	Current state	Event or condition => action	Next state

S1b1	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Connect_req"
		&& (ArepRole(arep_id) = “Client”
		|| ArepRole(arep_id) = “Peer”)
		=>
		PickArep (arep_id),
		
		DL_Data.req {
		dl_dls_user_data := dlsdu
		}
			ACTIVE

S1b2	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Connect_req"
		&& ArepRole(arep_id) = “PushPublisher”
		=>
		PickArep (arep_id),
		
		Connect_cnf {
		dlsdu_size_from_requestor := MaxDlsduSizeFromRequestor,
		dlsdu_size_from_responder := “null”,
		dls_user_data := “null”
		}
			ACTIVE

S1b3	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Connect_req"
		&& ArepRole(arep_id) = “PushSubscriber”
		=>
		PickArep (arep_id),
		
		Connect_cnf {
		dlsdu_size_from_requestor := "null",
		dlsdu_size_from_responder := MaxDlsduSizeFromResponder,
		dls_user_data := “null”
		}
			ACTIVE

S2	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Connect_rsp"
		=>
		PickArep (arep_id),
		
		DL_Data.req {
		dl_dls_user_data := dlsdu
		}
		FAL-PDU_ind {
		dmpm_service_name := "DMPM_Connection_Established_ind",
		fal_pdu := "null"
		}
			ACTIVE

S3a	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Disconnect_req"
		&& (ArepRole(arep_id) = “Client”
		|| ArepRole(arep_id) = “Server”
		|| ArepRole(arep_id) = “Peer”
		=>
		PickArep (arep_id),
		
		DL_Data.req {
		dl_dls_user_data := dlsdu
		}
			ACTIVE

S3b	ACTIVE	FAL-PDU_req && DMPM_service_name = "DMPM_Disconnect_req" && (ArepRole(arep_id) = “PushPublisher” || ArepRole(arep_id) = “PushSubscriber”) => (no actions taken)	ACTIVE

#	Current state	Event or condition => action	Next state

S4	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Data_req"
		=>
		PickArep (arep_id),
		
		DL_Data.req {
		dl_dls_user_data := dlsdu
		}
			ACTIVE

S6a	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Put_req"
		&& ArepRole(arep_id) <> "PushPublisher"
		=>
		PickArep (arep_id),
		
		DL_Put.req {
		dl_dls_user_data := dlsdu
		}
		
		DL_Put.cnf(+) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Put_cnf”,
		reason := “success”
		}
		
		DL_Put.cnf(-) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Put_cnf”,
		reason := dl_error_type
		}
		
		ErrorToARPM {
		originator := “local_dls_provider”,
		reason := dl_error_type
		}
			ACTIVE

S6b	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = "DMPM_Put_req"
		&& ArepRole(arep_id) = "PushPublisher"
		=>
		PickArep (arep_id),
		
		DL_Put.req {
		dl_dls_user_data := RemoveUcsPduHeader(dlsdu)
		}
		
		DL_Put.cnf(+) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Put_cnf”,
		reason := “success”
		}
		
		DL_Put.cnf(-) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Put_cnf”,
		reason := dl_error_type
		}
		
		ErrorToARPM {
		originator := “local_dls_provider”,
		reason := dl_error_type
		}
			ACTIVE

#	Current state	Event or condition => action	Next state

S7a	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = “DMPM_Get_req”
		&& ArepRole(arep_id) <> "PushSubscriber"
		=>
		PickArep (arep_id),
		
		DL_Get.req {
		}
		
		DL_Get.cnf(+) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Get_cnf",
		reason :=”success”,
		fal_pdu := dl_dls_user_data
		}
		
		DL_Get.cnf(-) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Get_cnf",
		reason :=dl_error_type
		}
			ACTIVE

S7b	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = “DMPM_Get_req”
		&& ArepRole(arep_id) = "PushSubscriber"
		=>
		PickArep (arep_id),
		
		DL_Get.req {
		}
		
		DL_Get.cnf(+) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Get_cnf",
		reason :=”success”,
		fal_pdu := AddUcsPduHeader(dl_dls_user_data)
		}
		
		DL_Get.cnf(-) -- This is an immediate response.
		=>
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Get_cnf",
		reason :=dl_error_type
		}
			ACTIVE

S8a	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Unlinked”
		&& DMPM_service_name = “DMPM_Compel_req”
		=>
		PickArep (arep_id),
		
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Compel_Service_cnf",
		reason := "failure-inappropriate request”
		}
			ACTIVE

S8b	ACTIVE	FAL-PDU_req
		&& DlLinkStatus() = “Linked”
		&& DMPM_service_name = “DMPM_Compel_req”
		=>
		PickArep (arep_id),
		
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Compel_Service_cnf",
		reason := "failure-inappropriate request”
		}
			ACTIVE

Table 76 shows the receiver transaction state table:

Table 76 – DMPM state table – receiver transactions

#	Current state	Event or condition => action	Next State
R15a	ACTIVE	DL_Data.ind && FindArep() <> "True" => (no actions taken)	ACTIVE

R16a	ACTIVE	DL_Data.ind
		&& FindArep() = "True"
		&& FalArHeader (dl_dls_user_data) = “Establish-Request-PDU”
		=>
		Connect_ind {
		calling_dlcep_address :=RemoteDlcepAddress,
		dlsdu_size_from_requestor := MaxDlsduSizeFromRequestor,
		dlsdu_size_from_responder := MaxDlsduSizeFromResponder,
		dls_user_data := dl_dls_user_data
		}
			ACTIVE

R16b	ACTIVE	DL_Data.ind
		&& FindArep() = "True"
		&& FalArHeader (dl_dls_user_data) = “Establish-Response-PDU”
		=>
		Connect_cnf {
		dll_priority := "normal",
		dlsdu_size_from_requestor := MaxDlsduSizeFromRequestor,
		dlsdu_size_from_responder := MaxDlsduSizeFromResponder,
		dls_user_data := dl_dls_user_data
		}
			ACTIVE

R16c	ACTIVE	DL_Data.ind
		&& FindArep() = "True"
		&& (FalArHeader (dl_dls_user_data) = “Establish-Error-PDU”
		|| FalArHeader(dl_dls_user_data) = ”Abort-PDU”)
		=>
		FAL-PDU_ind{
		DMPM_service_name = ”DMPM_Disconnect_ind”,
		fal_pdu := LSDU
		}
			ACTIVE

R16d	ACTIVE	DL_Data.ind
		&& FindArep() = "True"
		&& FalArHeader(dl_dls_user_data) <> “Establish-Request-PDU”
		&& FalArHeader(dl_dls_user_data) <> “Establish-Response-PDU”
		&& FalArHeader(dl_dls_user_data) <> “Establish-Error-PDU”
		&& FalArHeader(dl_dls_user_data) <> “Abort-PDU”
		=>
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Data_ind",
		fal_pdu := LSDU
		}
			ACTIVE

R18	ACTIVE	DL_Data.cnf && dl_status = “OK” => (no actions taken)	ACTIVE
R19a	ACTIVE	DL_Data.cnf && dl_status <> “OK” && FindArep() = "False" => (no actions taken)	ACTIVE

R19b	ACTIVE	DL_Data.cnf
		&& dl_status <> “OK”
		&& FindArep() = "True"
		=>
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Data_cnf”,
		reason := dl_status
		}
		ErrorToARPM {
		originator := “local_dls_provider”,
		reason := dl_status
		}
			ACTIVE

#	Current state	Event or condition => action	Next State

R21	ACTIVE	DL_Buffer_Received.ind
		=>
		--loop through all AREPs
		
		arep_id := SelectNextArep()
		
		if (ArepRole(arep_id) = “PushSubscriber”)
		DL_Get.req {
		}
		
		DL_Get.cnf(+)
		
		FAL-PDU_ind {
		DMPM_service_name := "DMPM_Buffer_Received_ind",
		duplicate_dlsdu := "False",
		fal_pdu := AddUcsPduHeader(dl_dls_user_data),
		local_dle_timeliness := "False",
		remote_dle_timeliness := "False"
		}
		
		DL_Get.cnf(-)
		
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Get_cnf”,
		reason := dl_error_type
		}
		ErrorToARPM {
		originator := “local_dls_provider”,
		reason := dl_error_type
		}
		endif
		
		if (ArepRole(arep_id) = “PushPublisher”)
		FAL-PDU_ind {
		DMPM_service_name := “DMPM_Buffer_Sent_ind”
		}
		endif
			ACTIVE

10.3.3 Functions used by DMPM

Table 77 through Table 84 show the functions used by the DMPM

Table 77 – Function PickArep

Name	PickArep	Used in	DMPM
Input		Output	
arep_id		(all the attributes of the specified AREP)	
Function			
Selects the attributes for the AREP specified by the arep_id parameter. After this function is executed, the attributes of the selected AREP are available to the state machine.			

Table 78 – Function FindAREP

Name	FindAREP	Used in	DMPM
Input		Output	
(local mapping)		True || False	
Function			
This function identifies the AREP that shall be bound with an active DMPM. True means the AREP exists. If it does, this function also returns a means to send a DMPM primitive to that AREP.			

Table 79 – Function SelectNextArep

Name	SelectNextAREP	Used in	DMPM
Input		Output	
(none)		arep_id	
Function			
Returns the arep_id parameter of the next existing AREP, starting with the first one.			

Table 80 – Function ArepRole

Name	ArepRole	Used in	DMPM
Input		Output	
arep_id		(the value of the Role attribute of the specified AREP)	
Function			
This function returns the Role attribute of the AREP specified by the arep_id parameter.			

Table 81 – Function FalArHeader

Name	FalArHeader	Used in	DMPM
Input		Output	
dl_dls_user_data		(the FAL header)	
Function			
This function decodes the dlsdu conveyed by the dl_dls_user_data argument and returns the FAL-PDU type.			

Table 82 – Function AddUcsPduHeader

Name	AddUcsPduHeader	Used in	DMPM
Input		Output	
dl_dls_user_data		fal_pdu	
Function			
Adds the UCS-PDU header to the dl_dls_user_data received from the DLE.			

Table 83 – Function RemoveUcsPduHeader

Name	FalArHeader	Used in	DMPM
Input		Output	
fal_pdu		dlsdu	
Function			
Removes the UCS-PDU header from the FAL-PDU received from an AREP			

Table 84 – Function DlLinkStatus

Name	DlLinkStatus	Used in	DMPM
Input		Output	
(none)		Linked || Unlinked	
Function			
This function returns whether or not the local Dls-provider is synchronized at the moment.			

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