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English version

Road transport and traffic telematics - Dedicated Short Range Communication (DSRC) - DSRC data link layer: medium access and logical link control

Télématique de la circulation et du Transport routier - Communication à courte portée - Couche de liaison de contrôle d'accès au média et de contrôle logique de liaison

This European Standard was approved by CEN on 4 December 2002.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This document (EN 12795:2003) has been prepared by Technical Committee CEN TC 278 “Road Transport and Traffic Telematics”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2003, and conflicting national standards shall be withdrawn at the latest by September 2003.

This document supersedes ENV 12795:1997.

The development of this standard was carried out under European Commission Mandate M/018.

This European Standard forms part of a series of European Standards defining the framework of a Dedicated Short Range Communication (DSRC) link in the Road Transport and Traffic Telematics (RTTT) environment.

The communication requirements of many RTTT applications can be fulfilled by DSRC. The DSRC standards enable compliant communication systems to serve multiple RTTT applications in parallel.

The small service areas and severe real-time constraints require a specific protocol architecture leading to the reduced protocol stack shown in Figure A, consisting of the Application Layer, the Data Link Layer, and the Physical Layer. Such architecture is very common for real-time environments.

This European Standard gives the architecture and services offered by the DSRC Data Link Layer.

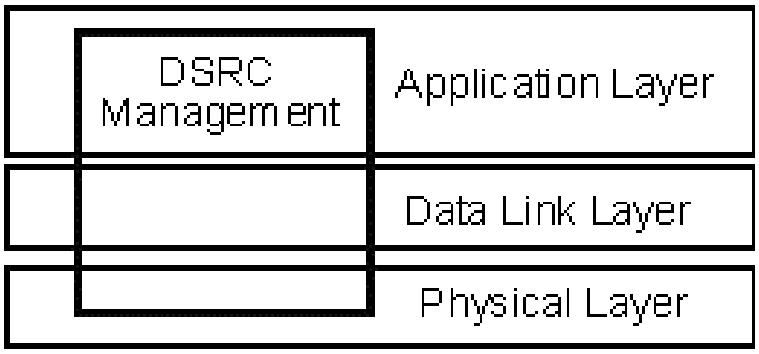


Figure A — DSRC protocol stack

The following set of European Standards for the DSRC link is issued by CEN:

— EN 12253 "DSRC Physical Layer using Microwave at 5.8 GHz”;

— **EN 12795 “DSRC Data Link Layer: MAC and LLC” (this European Standard);**

— EN 12834 "DSRC Application Layer" ;

— EN 13372 "DSRC Profiles for RTTT Applications".

Annex A is normative. Annexes B, C, D and E are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard:

— defines the Data Link Layer of DSRC;

— is positioned with respect to other related standards by the layers defined in OSI Basic Reference Model [EN ISO/IEC 7498-1] as adopted for DSRC;

— supports broadcast and half-duplex transmission modes;

— supports a variety of fixed equipment configurations. It supports configurations where one fixed equipment communicates with one mobile equipment unit, as well as configurations where one fixed equipment can communicate with several mobile equipment units;

— takes into account that the mobile equipment communicates with the fixed equipment while passing through a limited communication zone;

— defines neither any specific configuration nor the layout of the communication zone;

— does not define to what extent different instances of fixed equipment, operating in the vicinity of each other, need to be synchronised with each other;

— defines parameters to be used in negotiation procedures taking place between fixed equipment and mobile equipment.

By defining two distinct sublayers, namely the medium access control sublayer and the logical link control sublayer, this standard defines:

a) medium access control procedures for the shared physical medium;

b) addressing rules and conventions;

c) data flow control procedures;

d) acknowledgement procedures;

e) error control procedures;

f) services provided to application layer.

The MAC sublayer is specific to the DSRC. The LLC services offered are unacknowledged and acknowledged connectionless services based on [ISO/IEC 8802-2].

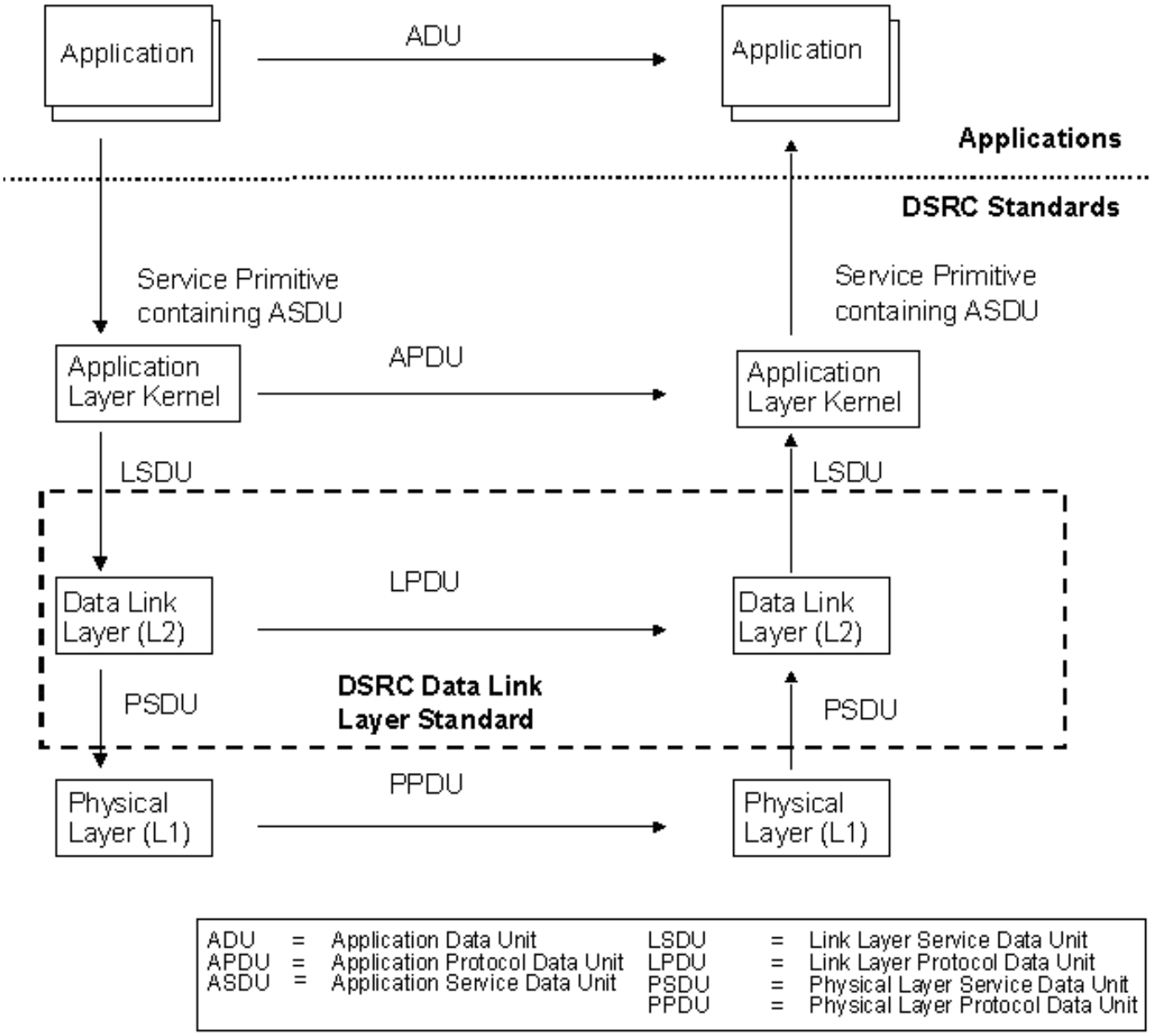


Figure 1 — Architecture and data flow of the DSRC stack

Figure 1 illustrates the global data flow between the elements of the DSRC stack, (Physical, Data Link and Application Layers) and the application.

NOTE For definitions of the terms used in Figure 1 see [EN ISO/IEC 7498-1].

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN ISO/IEC 7498-1:1995, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model (ISO/IEC 7498-1:1994).*

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control.*

ISO/IEC 3309, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure.*

3 Terms and definitions

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

3.1
beacon service table
data structure transmitted by the fixed equipment indicating available services

3.2
downlink
communication channel on which the fixed equipment transmits its information

3.3
fixed equipment
fixed communication facility with one or more downlink channels and, optionally, one or more uplink channels

NOTE Normally the fixed equipment is installed at a fixed location, but it may be installed on a mobile platform.

3.4
link identifier
unique address used for addressing the mobile equipment

3.5
mobile equipment
mobile communication facility capable of receiving information from the fixed equipment on the downlink and, optionally, also capable of transmitting information to the fixed equipment on the uplink

NOTE The mobile equipment normally corresponds to the vehicle’s communication unit.

3.6
profile
unique set of parameter values controlling the behaviour of the DSRC

3.7
service access point
interface point between data link layer and application layer, that has a unique Link Identifier and that allows layers to communicate

[EN ISO/IEC 7498-1:1995]

3.8
uplink
communication channel on which mobile equipment transmits its information

3.9
window
period of time during which the physical medium is allocated either to the fixed equipment or to the mobile equipment

4 Abbreviations and variables

For the purposes of this European Standard, the following abbreviations and variables apply.

4.1 Abbreviations

4.1.1
ACK
ACKnowledge

4.1.2
Can
ACKnowledged command / response

4.1.3
BST
Beacon Service Table

4.1.4
C/R
Command/Response

4.1.5
F
Final

4.1.6
FCS
Frame Check Sequence

4.1.7
FE
Fixed Equipment

4.1.8
HDLC
High-level Data Link Control

4.1.9
LID
Link Identifier

4.1.10
LPDU
Link layer Protocol Data Unit

4.1.11
LLC
Logic Link Control

4.1.12
LSB
Least Significant Bit

4.1.13
LSDU
Link layer Service Data Unit

4.1.14
L1
Layer 1 of DSRC (Physical Layer)

4.1.15
L2
Layer 2 of DSRC (Data Link Layer)

4.1.16
L7
Application Layer Core of DSRC

4.1.17
M
Modifier function bit

4.1.18
MAC
Medium Access Control

4.1.19
ME
Mobile Equipment

4.1.20
MSB
Most Significant Bit

4.1.21
OBU
On-Board Unit, an alternative descriptor to Mobile Equipment

4.1.22
OSI
Open Systems Interconnection

4.1.23
P
Poll

4.1.24
PDU
Protocol Data Unit

4.1.25
P/F
Poll/Final

4.1.26
R
Response

4.1.27
RR
Response Request

4.1.28
RSU
Road Side Unit, an alternative descriptor to Fixed Equipment

4.1.29
SAP
Service Access Point

4.1.30
UI
Unnumbered Information

4.2 Variables

4.2.1
V(RI)
receive state variable (LLC)

4.2.2
V(SI)
transmit state variable (LLC)

5 Frame format

All DSRC transmissions are in frames, and each frame conforms to the structure shown in Figure 2.

Flag	Link Address Field	MAC Control Field	LPDU	Frame Check Sequence	Flag

Figure 2 — Frame structure

Frames containing no LPDU form a special case, see Figure 3.

Flag	Link Address Field	MAC Control Field	Frame Check Sequence	Flag

Figure 3 — Frame structure, no LPDU

NOTE The physical bit stream can also comprise a preamble and / or a trailing bits, see Figure 4.

Preamble	Layer 2 frame (including flags and zero bit insertion between flags)	Optional trailing bits

Figure 4 — Physical layer bit stream

5.1 Flags

All frames shall start and end with a flag. A flag is a zero bit followed by six one bits followed by a zero bit (*0111 1110*). When in receiving state, all stations shall continuously check on a bit-by-bit basis for this sequence. A transmitter shall send only complete eight bit flags.

The flag which ends a frame shall not be used as the start flag for the next frame.

In order to achieve transparency the flag is prevented from accidentally occurring in the link address field, MAC control field, LPDU and frame check sequence via a zero bit insertion procedure described in 5.7.

5.2 Link address field

The link address field carries the Link Identifier (LID). The link address field shall contain either a private LID (contained in 4 octets), a multicast LID (contained in one octet) or a broadcast LID (contained in one octet). The LSB of each octet in the link address field is an extension bit.

5.2.1 Private LID

The private LID is a number in the range of 0 to 268435455. Thus the private LID consists of 28 bits. The private LID is encoded into the link address field as shown in Figure 5.

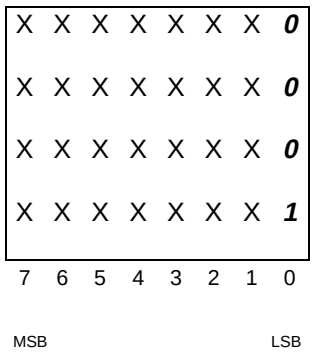


Figure 5 — Private link address field format

The LSB of the first three octets are set to 0 indicating that a further octet of the link address field follows. The LSB of the fourth octet is set to 1 indicating that this is the last octet of the link address field.

5.2.2 Broadcast LID

The broadcast LID equals 127. Thus the broadcast LID consists of 7 bits. The broadcast LID is encoded into the link address field as in Figure 6.

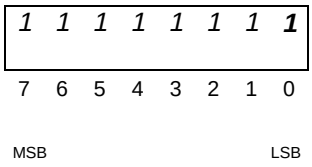
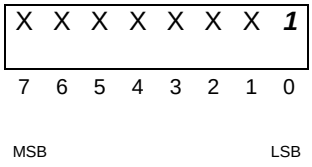


Figure 6 — Broadcast link address field format

The LSB of the link address field in Figure 6 is set to 1 indicating that it consists of one octet only.

5.2.3 Multicast LID

The multicast LID is a number in the range of 0 to 126. Thus the multicast LID consists of 7 bits. The multicast LID 0 is reserved for test purposes and multicast LID in the range 120 to 126 are reserved for private use. The multicast LID is encoded into the link address field as in Figure 7.



X - other than all *1*s

Figure 7 — Multicast link address field format

The LSB of the link address field in Figure 7 is set to 1 indicating that it consists of one octet only.

5.3 MAC Control control field

The MAC control field shall have the encoding as described in 7.3.2.

5.4 LPDU format

The LPDU shall have the encoding as described in 8.3.

5.5 Frame Check Sequence

All frames shall include a 16-bit Frame Check Sequence (FCS) just prior to the end flag for error detection purposes. The contents of the link address field, MAC control field and LPDU shall be included in the calculation of the FCS.

The FCS shall be compliant with 16-bit frame checking sequence as defined in [ISO/IEC 3309] (3.6.2). The generator polynomial shall be $X^{16} + X^{12} + X^5 + 1$, and the initial value used shall be $FFFF_{16}$. The ones complement of the resulting remainder shall be transmitted as the 16-bit FCS.

5.6 Bit order

Flag, Link address, MAC control field, and LPDU shall be transmitted with the LSB first in each octet.

The FCS shall be transmitted with the coefficient of the highest term first.

5.7 Transparency

The occurrence of the flag within a frame other than the start and end flags shall be prevented by a zero bit insertion procedure as follows:

The transmitter shall insert a *0* bit following five contiguous *1* bits anywhere between the start flag and the end flag of the frame. The insertion of the *0* bit thus applies to the contents of the Link address, the MAC control field, the LPDU and the FCS.

The receiver shall continuously monitor the received bit stream; after receiving five contiguous *1* bits, the receiver shall inspect the following bit. If it is a *0*, the five *1* bits are passed as data and the *0* is deleted. If the sixth bit is a *1*, the receiver shall inspect the seventh bit. If this bit is a 0, a valid flag has been received; if it is a *1*, an abort has been received, and the receiving station shall ignore that frame.

6 Address establishment

Each fixed equipment shall contain one broadcast SAP as well as one SAP for each mobile private SAP currently known by the fixed equipment to be in the communications zone.

Each mobile equipment shall contain one broadcast SAP, and if required for uplink transmissions, one private SAP. In addition to that, it may contain one or more multicast SAPs.

The broadcast SAP establishment is defined in 6.1, the mobile private SAP establishment in 6.2 and the fixed private SAP establishment in 6.3.

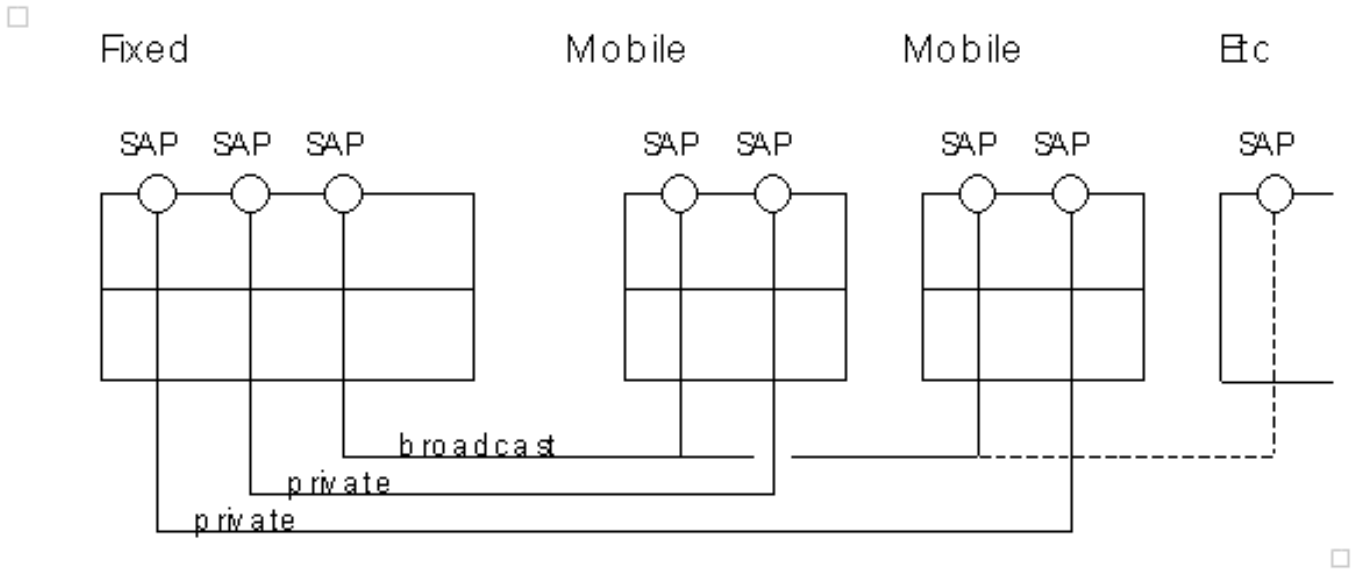


Figure 8 — Link addressing overview

NOTE Mobile equipment arriving in the communication zone is, in many cases, not fully powered, but is in a sleep mode. However, in the following sub-clauses, the mobile equipment is described as if it were always fully powered.

6.1 Broadcast SAP establishment

There shall be a broadcast SAP in every fixed and mobile equipment.

The broadcast SAP shall always be active.

6.2 Mobile private SAP establishment

The mobile private SAP is created by the data link layer on request from the application layer.

The private LID associated with this SAP is generated at the application layer.

The mobile data link entity shall use its private LID in all uplink transmissions.

6.3 Fixed private SAP establishment

When a fixed equipment data link entity receives a frame containing a private LID not known to it, a corresponding SAP shall be created.

NOTE Deletion of fixed private SAPs is under the responsibility of upper layers or applications.

7 Medium Access Control (MAC) sublayer

7.1 Overview

The MAC sublayer is responsible for controlling the use of the physical medium by the MAC sublayer entity residing in the fixed equipment and the MAC sublayer entity residing in the mobile equipment.

The mobile MAC sublayer offers the M-MA-DATA primitives to the mobile LLC sublayer. The fixed MAC sublayer offers the F-MA-DATA primitives to the fixed LLC sublayer.

The medium access control is characterised by:

— half duplex mode;

— asynchronous time division multiple access (TDMA).

The medium access control is unbalanced, in that the fixed equipment is always in control of the physical medium, granting access to the physical medium to either:

— the fixed MAC (downlink window); or

— one mobile MAC exclusively (private uplink window); or

— any mobile MAC, according to certain rules (public uplink window).

The mobile MAC can also request access to the medium.

7.2 MAC Service service primitives

The MAC sublayer offers the following primitives to the LLC sublayer:

— MA-DATA.request;

— MA-DATA.indication.

These are shown in Figure 9.

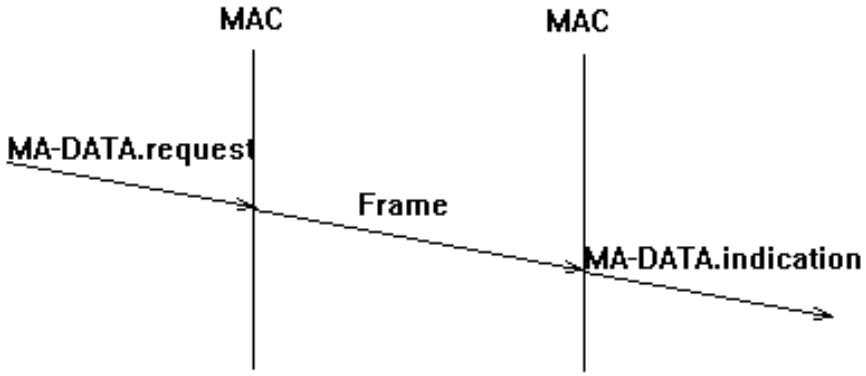


Figure 9 — MAC services and primitives

7.2.1 Fixed MAC service primitives

7.2.1.1 F-MA-DATA.request

The primitive shall be passed from the LLC sublayer to the MAC sublayer to request that an LPDU is transmitted to a mobile SAP in the first available downlink window.

The primitive shall provide the following parameters:

F-MA-DATA.request(LID, LPDU, RR)

The LID shall be the LID of the mobile SAP for which the frame is intended.

It may be a private LID, the broadcast LID or a multicast LID.

The LPDU may be null (in this case no LPDU shall be included in the frame transmitted).

The response request (RR) shall indicate whether or not the fixed equipment shall allocate an uplink window in immediate connection to the downlink frame transmitted.

7.2.1.2 F-MA-DATA.indication

The primitive shall be passed from the MAC sublayer to the LLC sublayer to indicate the successful reception of a valid frame from a mobile SAP.

The primitive shall provide the following parameters

F-MA-DATA.indication (LID, LPDU)

The LID shall be the content of the link address field of the frame received.

The LPDU shall not be null.

7.2.2 Mobile MAC service primitives

7.2.2.1 M-MA-DATA.request

The primitive shall be passed from the LLC sublayer to the MAC sublayer to request that an LPDU is transmitted to the fixed SAP in an uplink window.

The primitive shall provide the following parameters

M-MA-DATA.request(LID, LPDU)

The LID shall be the private LID of the mobile SAP.

The LPDU may be null, in which case no LPDU shall be included in the frame transmitted.

NOTE The uplink window can be public or private, as described in 7.3.4.

7.2.2.2 M-MA-DATA.indication

The primitive shall be passed from the MAC sublayer to the LLC sublayer to indicate the successful reception of a valid frame from a fixed SAP.

The primitive shall provide the following parameters

M-MA-DATA.indication(LID, LPDU)

The LID shall be the content of the link address field of the frame received.

The LPDU shall not be null.

7.3 Window management

7.3.1 Overview

Uplink windows allocated by the fixed equipment are indicated by the MAC control field of the downlink frame and follow immediately after the downlink window containing the frame.

The distinction between allocation of public and private uplink windows is made by the fixed equipment by means of the LID of the frame allocating the uplink window. A public uplink window is allocated if the link address field contains a broadcast LID while a private uplink window is allocated if the link address field contains a private LID.

Figure 10 gives an overview of window management.

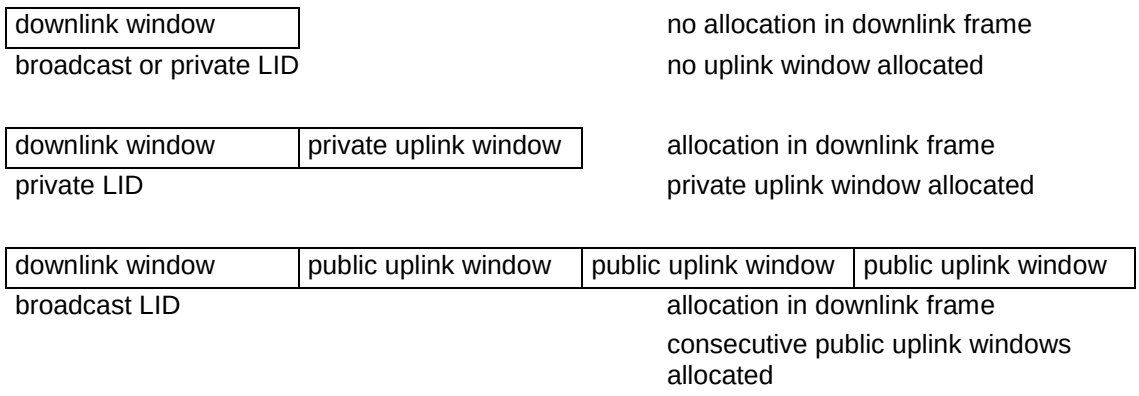


Figure 10 — Window management overview

7.3.2 MAC control field

The MAC control field is used to:

— indicate whether the frame contains an LPDU;

— indicate the transmission direction;

— allocate public and private windows;

— request for private windows;

— specify type of LPDU.

The MAC control field has the length of one octet. The content of the MAC control field is different on the downlink and on the uplink. Bits that are not specified are reserved for future use.

7.3.2.1 MAC control field of the downlink

The MAC control field of the downlink shall be used by frames transmitted by the fixed equipment. The format is described in Figure 11.

L The LPDU Existence bit shall be used to indicate whether the frame contains an LPDU.

0 = frame contains no LPDU
1 = frame contains LPDU

NOTE: Minimum LPDU consists of a LLC control field only.

D The Direction Identifier bit shall be used to identify the link direction

0 = downlink direction.

A The Medium Allocation bit shall be used to allocate medium (see 7.3.4).

0 = no uplink window is allocated by the fixed equipment
1 = uplink window is allocated by the fixed equipment

NOTE The allocation may be a private uplink window or N5 public uplink windows

C/R The LLC Command/Response bit shall be used to identify the LPDU as command or response. The LLC Command/Response bit shall be ignored if the LPDU Existence bit is set to *0.* (For the use of the C/R bit see 8.3.1)

0 = command LPDU
1 = response LPDU

S The MAC Sequence bit shall be used to distinguish between first allocation of a private uplink window and reallocation of a private uplink window. (see 7.4.2)

X Reserved, shall be set to *0.*

Figure 11 — MAC control field of the downlink

7.3.2.2 MAC control field of the uplink

The MAC control field of the uplink shall be used by frames transmitted by the mobile equipment. The format is described in Figure 12.

L The LPDU Existence bit shall be used to indicate whether the frame contains an LPDU.
0 = frame contains no LPDU
1 = frame contains LPDU

D The Direction Identifier bit shall be used to identify the link direction
1 = uplink direction

R The Medium Request bit shall be used to request uplink window (see 7.4.3).
0 = no window is requested by mobile equipment
1 = window is requested by the mobile equipment

C/R The LLC Command/Response bit shall be used to identify the LPDU as command or response. The LLC Command/Response bit shall be ignored if the LPDU existence bit is set to *0.* (For the use of the C/R bit see 8.3.1)
0 = command LPDU
1 = response LPDU

X Reserved, shall be set to *0.*

Figure 12 — MAC control field of the uplink

7.3.3 Downlink windows

The fixed equipment allocates a downlink window simply by transmitting a frame.

A downlink window starts at the start of the first bit of the preamble and ends at the end of the last bit of the end flag of the downlink layer 2 frame transmitted.

NOTE Trailing bits defined at the physical layer are not part of the window.

A downlink window shall not start before T1 after the end of the previous window if the previous window is an uplink window.

A downlink window shall not start before T2 after the end of the previous window if the previous window is a downlink window.

A layer 2 frame transmitted in a downlink window shall consist of not more than N2 octets.

See Figure 13 and Figure 14 for the timing of the downlink window.

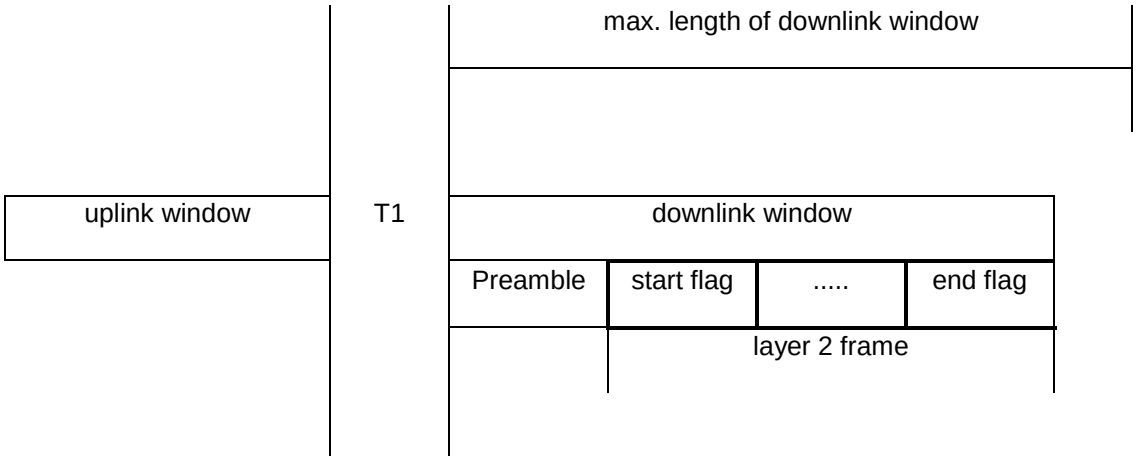


Figure 13 — Timing of downlink window after uplink window

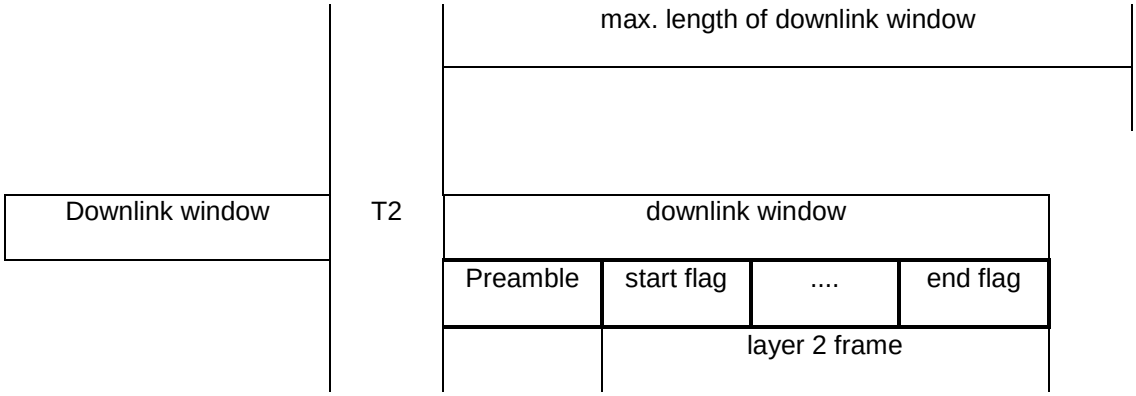


Figure 14 — Timing of downlink window after downlink window

NOTE From N2 the maximum duration in time of the downlink window can be calculated, taking bit rate and zero bit insertion into account.

7.3.4 Uplink windows

The fixed equipment allocates one or more uplink windows immediately following a downlink frame by setting the A bit of the MAC control field of the downlink frame to 1.There are two kinds of uplink windows, private uplink windows and public uplink windows.

A private uplink window may only be used by one mobile equipment, while public uplink windows may be used by any mobile equipment according to certain rules described in 7.3.4.3.

If the LID of the allocating downlink frame is a private LID, the allocated uplink window is a private uplink window. If the LID of the allocating downlink frame is a broadcast LID, the allocated uplink windows are public uplink windows.

Each allocating downlink frame may thus allocate either:

a) one private uplink window; or

b) N5 consecutive public uplink windows.

7.3.4.1 Private uplink windows

A private uplink window may only be used by the mobile equipment having a private LID equal to the LID of the frame allocating the window.

A private uplink window starts T3 after the end of the downlink window containing the frame allocating the uplink window.

A private uplink window ends:

a) T4a after the start of the window, if no mobile equipment has started transmitting before that time; or

b) at the end of the last bit of the end flag of the uplink layer 2 frame transmitted; and

c) no later than the maximum time of private uplink windows, defined by N3.

Figure 15 shows the timing for the private uplink window.

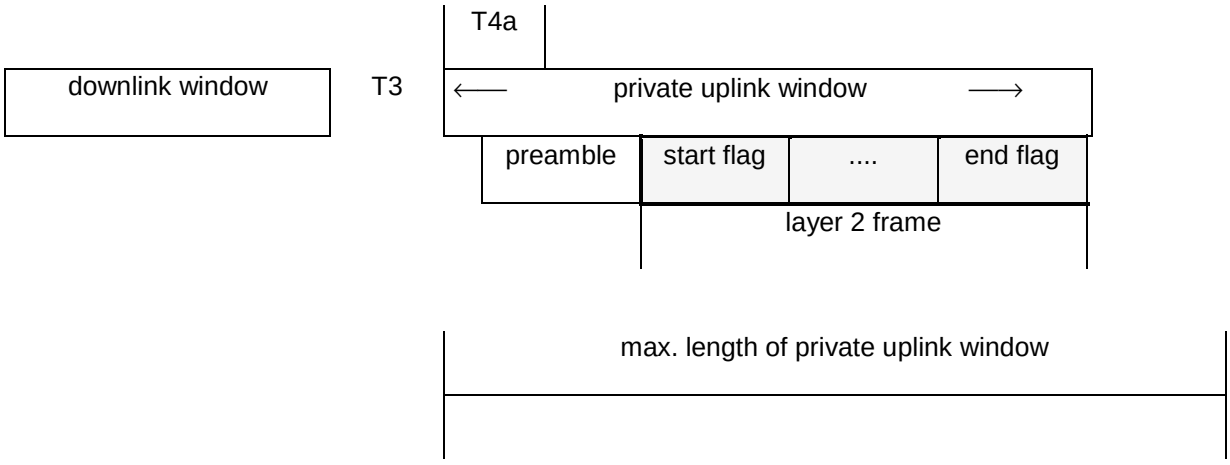


Figure 15 — Private uplink window timing

7.3.4.2 Public uplink windows

Each downlink frame can simultaneously allocate N5 public uplink windows.

A public uplink window may be used by any mobile equipment according to certain rules given in 7.3.4.3.

A public uplink window starts:

a) T3 after the end of the downlink window containing the frame allocating the window if the public uplink window is the first window after the downlink window; or

b) immediately after the end of the previous window if that window is a public uplink window.

A public uplink window ends T5 after the start of that window.

The transmission of the first bit of the preamble of the layer 2 frame in a public uplink window shall start before T4b after the start of that window.

A layer 2 frame transmitted in a public uplink window shall consist of not more than N4 octets.

See Figure 16 for the timing of the public uplink window.

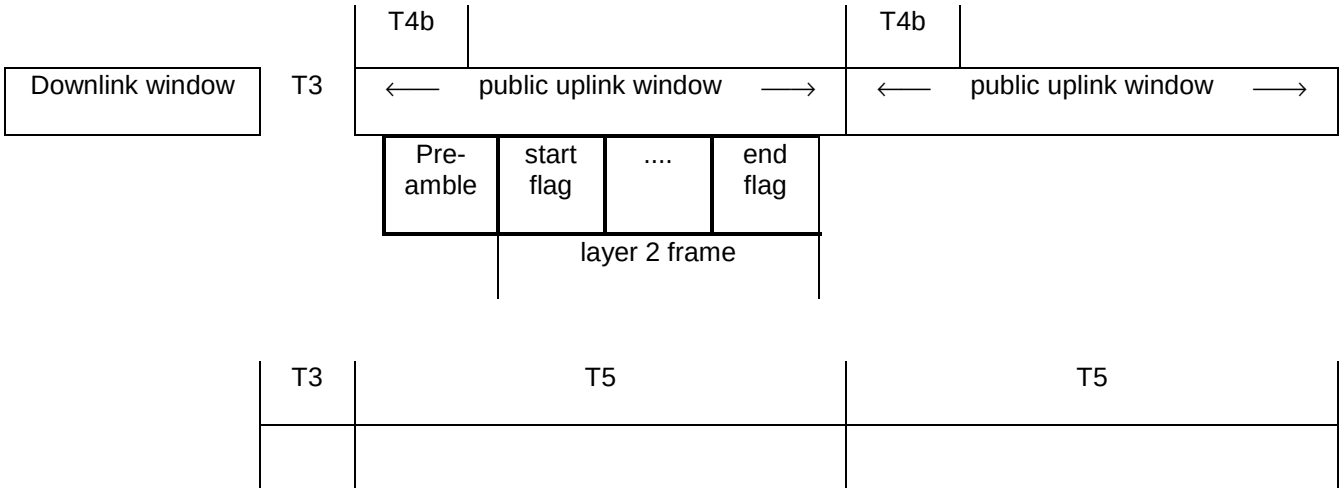


Figure 16 — Public uplink window timing

7.3.4.3 Public uplink window selection

The public uplink window selection mechanism is a (pseudo-)random mechanism. The probability of selecting one out of N5 public uplink windows shall be 1/N5. If a pseudo-random mechanism is used, an appropriate seeding of the algorithm has to be taken into account.

7.4 MAC elements of procedure

7.4.1 Private medium response flag

In each mobile equipment there is a private medium response flag. It shall be set to zero each time a private uplink window is requested and incremented for each public uplink window allocation received.

After a private uplink window request, the corresponding private uplink window allocation and subsequent reallocations by the fixed equipment, shall take place before the private medium response flag reaches the value 1.

7.4.2 Fixed equipment MAC procedures

7.4.2.1 Frame reception

7.4.2.1.1 Validity of frame

The MAC sublayer shall inspect all received frames to assess their validity.

A received frame shall be considered valid if:

a) the frame is correctly delimited by start and end flags according to 5.1; and

b) the frame (after deletion of zero bits inserted for transparency) contains a number of bits corresponding exactly to an integer number of octets;

c) the frame contains a valid link address field according to 5.2 containing the private LID of an SAP; and

d) the frame contains a MAC control field according to 7.3.2; and

e) the frame does not consist of too many octets (parameters N3 and N4 respectively); and

f) the frame contains a valid FCS field according to 5.5.

If the frame received is not valid it shall be discarded. If a non-valid frame is received in a private uplink window, reallocation may be undertaken according to 7.4.2.2.3.

7.4.2.1.2 Information transfer

If the L bit of a received valid frame is set to *1* this shall indicate that the frame contains an LPDU. The start and end flags, the FCS, the link address field and the MAC control field shall be removed from the frame. The LPDU and the contents of the link address field shall then be passed to the LLC sublayer in an F-MA-DATA.indication.

7.4.2.1.3 Private uplink window request

If the R bit of a received valid frame is set to *1* this shall indicate that the remote mobile SAP indicated by the link address field is requesting a private uplink window to be allocated to it. The fixed equipment shall allocate a private uplink window to that SAP before the private medium response flag (see 7.4.1) has reached the value 1.

7.4.2.2 Frame transmission

7.4.2.2.1 Information transfer

As a result of an *F*-MA-DATA.request an LPDU may be pending. The fixed equipment shall then construct a frame according to the frame format in 5.

The L bit of the MAC control field shall be set to *1* and the D bit to *0*.

The A bit and the S bit shall be set according to 7.4.2.2.2 and 7.4.2.2.3.

The frame shall then be passed to the lower layer.

7.4.2.2.2 Private uplink window allocation

The fixed equipment shall allocate a private uplink window to a remote mobile SAP if an outgoing LPDU contains a command to that SAP, which requires an immediate response.

The fixed equipment may allocate a private uplink window to a remote mobile SAP if a private uplink window has been requested from (but not yet granted to) that SAP.

The fixed equipment may allocate a private uplink window to a remote mobile SAP if a private uplink window previously allocated to that SAP contained no valid uplink frame (reallocation).

When a private uplink window is allocated, the A bit of the allocating frame shall be set to *1*. The link address field of the allocating frame shall contain the private LID of a remote SAP to which the private uplink window is allocated.

In the first private uplink allocation for a new SAP the S bit shall be set to 0. If a private uplink window allocation to a mobile equipment is either the first response to a private uplink window request from that mobile equipment, or is the result of an *F*-MA-DATA.request, then the value of the S bit transmitted shall be the complement of the value of the S bit of the previous private uplink window allocation.

7.4.2.2.3 Private uplink window reallocation

Each time a private uplink window is allocated by the fixed equipment, a transmission is expected from the mobile equipment, to which the window is allocated.

If no valid frame was received by the fixed equipment it may reallocate the private uplink window as long as the corresponding private medium response flag has not reached the value 1.

The S bit of the MAC control field shall then have the same value as it had on the first occasion that that window was allocated.

7.4.2.2.4 Public uplink window allocation

When public uplink windows are allocated, the A bit of the allocating frame shall be set to *1*. The link address field of the allocating frame shall contain the broadcast LID. The number of consecutive public uplink windows simultaneously allocated shall be N5.

7.4.3 Mobile equipment MAC procedures

7.4.3.1 Frame reception

7.4.3.1.1 Validity of frame

The MAC sublayer shall inspect all received frames to assess their validity.

A received frame shall be considered valid if:

a) the frame is correctly delimited by start and end flags according to 5.1; and

b) the frame contains a valid link address field according to 5.2 which contains either the LID of the private SAP of this mobile equipment, or the broadcast LID, or a multicast LID known by this mobile equipment; and

c) the frame contains an MAC control field according to 7.3.2; and

d) the frame does not consist of more octets than are given by parameter N2; and

e) the frame contains a valid FCS field according to 5.5.

If the frame received is not valid it shall be discarded.

7.4.3.1.2 Information transfer

If the L bit of a received valid frame is set to *1* this shall indicate that the frame contains an LPDU. The start and end flags, the FCS, the link address field and the MAC control field shall be removed from the frame. The LPDU and the contents of the link address field shall then be passed to the LLC sublayer in an M-MA-DATA.indication.

7.4.3.1.3 Private uplink window allocation

If the A bit of the received frame equals *1* and the LID is private, a private uplink window is allocated by the received frame.

If the L-bit of the received frame equals *0*, indicating that no LPDU is present, the value of the S-bit shall be used to distinguish between allocation and reallocation.

If the allocation is a new allocation, i.e. not a reallocation, the private uplink window shall be used for transmitting a pending LPDU.

If the allocation is a reallocation the mobile equipment shall use the private uplink window for retransmitting the frame transmitted in the previous private uplink window.

7.4.3.1.4 Public uplink window allocation

If the A bit of the received frame equals *1* and the LID is the broadcast LID a public uplink window is allocated by the received frame. The number of simultaneously allocated consecutive public uplink windows is indicated by parameter N5.

The mobile equipment may transmit in the public uplink window selected as described in 7.3.4.3.

7.4.3.2 Frame transmission

7.4.3.2.1 Information transfer

As a result of an M-MA-DATA.request an LPDU may be pending.

The mobile equipment shall then construct a frame according to the frame format of clause 5.

The L bit and the D bit of the MAC control field shall be set to *1*.

The R bit shall be set according to 7.4.3.2.2.

The mobile equipment shall then transmit the frame according to the following rules:

a) if the LPDU contains an LLC command and if a private uplink window is allocated before, the mobile equipment shall transmit the frame in the private uplink window. If the FE sends a private window reallocation the previously sent frame shall be transmitted. If the fixed equipment sends a private window allocation the pending frame shall be transmitted;

b) if the LPDU contains an LLC response the mobile equipment shall transmit the frame in the first private uplink window allocated.

If the frame is transmitted in a private uplink window it shall be kept pending at least until the private medium response flag has reached the value 1.

7.4.3.2.2 Private uplink window request

The mobile equipment can request that a private uplink window be allocated to it by the fixed equipment.

There are three cases:

a) if the mobile equipment has a command frame to transmit and has not requested a private uplink window for that frame, it shall request a private uplink window by transmitting a frame with the L bit of the MAC control field set to 0 and the R bit set to 1;

b) if the mobile equipment has a frame to transmit and has already requested a private uplink window for that frame it shall retransmit the request after the private medium response flag has reached the value 1;

c) if the mobile equipment has a frame to transmit in a private uplink window and still has an LPDU pending it shall request (another) private uplink window by setting the R bit of the MAC control field of the transmitted frame to 1.

8 Logical Link Control sublayer

8.1 Overview

The LLC generates command PDUs and response PDUs for transmission and interprets received command PDUs and response PDUs. Specific responsibilities assigned to an LLC include:

a) initiation of control signal interchange;

b) organisation of data flow;

c) interpretation of received command PDUs and generation of appropriate response PDUs; and

d) actions regarding error control and error recovery functions in the LLC sublayer.

To satisfy a broad range of potential applications, two types of data link control operation are included.

1. Unacknowledged connectionless-mode service.

The unacknowledged connectionless-mode data transfer service provides the means by which application layer entities can exchange link service data units (LSDUs) without the establishment of a data link level connection on an unacknowledged base. The data transfer can be point-to-point, multicast, or broadcast**.**

Unacknowledged operation provides an unacknowledged connectionless-mode service across a data link with minimum protocol complexity. This type of operation may be useful when higher layers provide any essential recovery and sequencing services so that these do not need replicating in the data link layer. In addition, this type of operation may prove useful in applications where it is not essential to guarantee the delivery of every data link layer data unit and for some initial data transfer.

2. Acknowledged connectionless-mode services.

The acknowledged connectionless-mode data unit exchange services provide the means by which application layer entities can exchange link service data units (LSDUs) which are acknowledged at the LLC sublayer, without the establishment of a data link connection. The services provide a means by which an application layer entity at one station can transmit a data unit to another station, request a previously prepared data unit from another station, or exchange data units with another station. The data unit transfer is point-to-point.

Acknowledged operation provides an acknowledged connectionless-mode data unit exchange service, which permits a station both to transmit data and to request the return of data at the same time. Although the exchange service is connectionless, in-sequence delivery is guaranteed for data transmitted by the initiating station.

8.2 LLC service primitives

This sub-clause specifies the services required of the LLC sublayer by the DSRC application layer, as viewed from the application layer, to allow an application layer entity to exchange packets with remote peer application layer entities. The services are described in an abstract way and do not imply any particular implementation or any exposed interface.

Two forms of service are provided

1) unacknowledged connectionless-mode;

2) acknowledged connectionless-mode.

8.2.1 Unacknowledged connectionless data transfer

The primitives associated with unacknowledged connectionless-mode data transfer are:

DL-UNITDATA.request
DL-UNITDATA.indication

The DL-UNITDATA.request primitive is passed from the application layer to the LLC sublayer to request that a LSDU be transmitted using unacknowledged connectionless-mode procedures. The DL-UNITDATA.indication primitive is passed from the LLC sublayer to the application layer to indicate the arrival of a LSDU.

Table 1 shows a list of LLC service primitives offered by the LLC sublayer to the application layer for unacknowledged connectionless-mode data transmission.

Table 1 — LLC service primitives offered by the LLC sublayer to the application layer for unacknowledged connectionless-mode data transmission

Name	Description
DL-UNITDATA.request (LID, data, RR)	Passed from the application layer to the LLC sublayer to request transmission of a LSDU The LID either shall be a private LID, a multicast LID or a broadcast LID. Multicast and broadcast LID are only possible at the FE. The response request RR shall be passed directly to the FE-MAC and shall be used to enable a direct response from the ME-LLC by setting the A bit of the MAC control field. Thus RR is not available at the ME.
DL-UNITDATA.indication (LID, data)	Passed from the LLC sublayer to the application layer to indicate the arrival of a LSDU. The LID shall be equal to the LID received in the corresponding DL-UNITDATA.request frame.

8.2.2 Acknowledged connectionless data transfer

The primitives associated with the acknowledged connectionless-mode data unit transmission service are:

DL-DATA-ACK.request
DL-DATA-ACK.indication
DL-DATA-ACK-STATUS.indication

The DL-DATA-ACK.request primitive is passed from the application layer to the LLC sublayer to request that a LSDU be transmitted to a remote LLC using acknowledged connectionless-mode data unit transmission procedures. The DL-DATA-ACK.indication primitive is passed from the LLC sublayer to the application layer to indicate the arrival of a command PDU except in the case where this PDU is used only for Data Link Echo. The DL-DATA-ACK-STATUS.indication primitive is passed from the LLC sublayer to the application layer to convey the results of the previous associated DL-DATA-ACK.request primitive.

Table 2 shows a list of LLC service primitives offered by the LLC sublayer to the application layer for acknowledged connectionless mode data transmission.

Table 2 — LLC service primitives offered by the LLC sublayer to the application layer for acknowledged connectionless mode data transmission

Name	Description
DL-DATA-ACK.request (LID, data)	Passed from the FE application layer to the FE-LLC sublayer to request transmission of a LSDU to the specified ME. The LID shall be a private LID of an ME.
DL-DATA-ACK.indication (LID,data)	Passed from the ME-LLC sublayer to the ME application layer to indicate the arrival of a non-null and non-duplicate LSDU from the FE. The LID shall be the private LID of the ME.
DL-DATA-ACK-STATUS.indication (LID, status)	Passed from the FE-LLC sublayer to the FE application layer to indicate the success or failure of the previous associated acknowledged connectionless-mode data unit transmission request. The LID shall be a private LID of an ME. The status parameter indicates success or failure.

8.2.3 Acknowledged connectionless data exchange

The primitives associated with the acknowledged connectionless-mode data unit exchange service are:

DL-REPLY.request
DL-REPLY.indication
DL-REPLY-STATUS.indication

The DL-REPLY.request primitive is passed from the application layer to the LLC sublayer to request that a LSDU be returned from a remote station or that LSDUs be exchanged between stations using acknowledged connectionless-mode data unit exchange procedures. The DL-REPLY.indication primitive is passed from the LLC sublayer to the application layer to indicate the arrival of a command PDU. The DL-REPLY-STATUS.indication primitive is passed from the LLC sublayer to the application layer to convey the results of the previous associated DL-REPLY.request primitive.

The primitives associated with reply data unit preparation are:

DL-REPLY-UPDATE.request
DL-REPLY-UPDATE-STATUS.indication

The DL-REPLY-UPDATE request primitive is passed from the application layer to the LLC sublayer with a LSDU to be held by LLC and transmitted at a later time when requested to do so by some other station. The DL-REPLY-UPDATE-STATUS.indication primitive is passed from the LLC sublayer to the application layer to convey the results of the previous associated DL-REPLY-UPDATE request primitive.

Table 3 shows a list of LLC service primitives offered by the LLC sublayer to the application layer for acknowledged connectionless mode data exchange.

Table 3 — LLC service primitives offered by the LLC sublayer to the application layer for acknowledged connectionless mode data exchange

Name	Description
DL-REPLY.request (LID, data)	Passed from the FE application layer to the FE-LLC sublayer to request transmission of a previously prepared data unit from the specified ME (in case of null data parameter) or to exchange data units with the specified ME. The LID shall be a private LID of an ME.
DL-REPLY.indication (LID, data)	Passed from the ME-LLC sublayer to the ME application layer to indicate either a request of a LSDU from the FE or an exchange of LSDUs with the FE. The LID shall be the private LID of the ME. Every new request of a LSDU from the FE will delete any previously prepared data.
DL-REPLY-STATUS.indication (LID, data, status)	Passed from the FE-LLC sublayer to the FE application layer to indicate the success or failure of the previous acknowledged connectionless-mode data unit exchange request and to pass data if available. The LID shall be a private LID of an ME. The status parameter indicates success or failure.
DL-REPLY-UPDATE.request (LID,data)	Passed from the ME application layer to the ME-LLC sublayer to request preparation of a LSDU for future access. A subsequent DL-REPLY-UPDATE.request service primitive serves to replace the currently associated LSDU with a new LSDU. The LID shall be the private LID of the ME. The data parameter specifies the link service data unit to be held by the LLC sublayer in preparation for transfer at a later time when requested.
DL-REPLY-UPDATE-STATUS.indication (LID, status) (not mandatory)	Passed from the ME-LLC sublayer to the ME application layer to indicate the success or failure of the previous associated data unit preparation request (DL-REPLY-UPDATE.request). The LID shall be the private LID of the ME. The status parameter indicates success or failure. The effect of receipt of this primitive by the ME-L7 is not specified. Thus this indication is not mandatory.

NOTE A data link layer request containing a valid command is considered to be successful even if the requested data cannot be provided within link turn around time. In this case a late response will occur. A failure would occur if the command was not understood by the ME.

8.3 LPDU format

All LPDUs shall conform to the format shown in Figure 17.

LLC Control Field	Information Field
8 bits	N × 8 bits

LLC Control Field (see 8.3.2)

N =Number of octets; an integer value equal to or greater than *0*
(upper limit of N is given by N2, N3 or N4)

Figure 17 — LPDU format

8.3.1 C/R bit

The Command/Response bit shall be handled according to 7.3.2.

8.3.2 LLC control field

The LLC control field shall consist of one octet that shall be used to designate command and response.

The format defined for the control field is described in Figure 18.

M	M	M	P/F	M	M	*1*	*1*
7	6	5	4	3	2	1	0
MSB							LSB

M Modifier function bits

P/F Poll bit – used in command LPDU transmission,

P=1=Poll, P=0=no Poll

Final bit – used in response LPDU transmission,

F=1=Final, F=0=no Final

The two least significant bits are set to *1*.

Figure 18 — LLC control field

NOTE The control field shown in Figure 18 utilises a subset of the LLC control field format of [ISO/IEC 8802-2].

8.3.2.1 Unacknowledged connectionless

The LLC control field encoding for unacknowledged connectionless operation is shown in Figure 19:

0	*0*	*0*	P	*0*	*0*	*1*	*1*	*UI COMMAND*
7	6	5	4	3	2	1	0	
MSB							LSB	

Figure 19 — UI command, LLC control field

8.3.2.2 Acknowledged connectionless

The LLC control field encoding for acknowledged connectionless operation is shown in Figure 20:

0	*1*	*1*	P	*0*	*1*	*1*	*1*	AC0 COMMAND
1	*1*	*1*	P	*0*	*1*	*1*	*1*	AC1 COMMAND
0	*1*	*1*	F	*0*	*1*	*1*	*1*	AC0 RESPONSE
1	*1*	*1*	F	*0*	*1*	*1*	*1*	AC1 RESPONSE
7	6	5	4	3	2	1	0	
MSB							LSB	

Figure 20 — ACn command and response, control field

The MSB of the LLC control field for ACn commands and responses is the N bit.

8.3.3 LLC Status Subfield

Every ACn response PDU shall contain a Status Subfield in its information field. The remainder of the information field may be either null or non-null; if non-null it shall contain a LSDU as shown in Figure 21.

LLC Control Field	← ACn Response Information Field→	
	Status Subfield, 1 octet	LSDU Subfield, 0 or more octets
	R R R R C C C C	Link-Service-Data-Unit
	7 6 5 4 3 2 1 0	
	MSB LSB	

Figure 21 — ACn response information field format

The code returned in the CCCC part of the status subfield indicates the success or failure of information passage in the command PDU. The code returned in the RRRR part of the status subfield indicates the success or failure of information passage in the response PDU.

Table 4 — ACn response status subfield RRRRCCCC values

R	R	R	R	C	C	C	C	MNEMONIC	Hex	DESCRIPTION
0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	OK_OK	0	Command accepted / Response LSDU present
0	*0*	*1*	*1*	*0*	*0*	*0*	*0*	NE_OK	30	Command accepted / Response LSDU not yet available
0	*1*	*0*	*0*	*0*	*0*	*0*	*0*	NR_OK	40	Command accepted / Response LSDU not requested

NOTE All other RRRRCCCC code combinations are reserved for future use.

8.3.4 Information field

The information field shall consist of any integral number (including zero) of octets.

8.3.5 Invalid LPDU

An invalid LPDU shall be defined as one which meets at least one of the following conditions:

a) it is identified as invalid by the MAC sublayer;

b) it is not an integral number of octets in length;

c) its length is *0* (no control field);

d) it does not contain a valid command or response control field as defined by this standard;

e) it does contain an acknowledged connectionless LLC command or response control field, and the Link ID is multi- or broadcast;

f) it does contain an acknowledged connectionless response control field, and no ACn response status subfield in its information field.

Invalid LPDUs shall be ignored.

8.4 LLC elements of procedure

8.4.1 Overview

This sub-clause defines the commands and associated responses. 8.4.2 and 8.4.3 contain the definitions of the set of commands and responses (listed below) for each of the control field formats for unacknowledged and acknowledged operation, respectively. The C/R bit, located in bit four of the MAC control field, is used to distinguish between commands and responses. Table 5 shows the commands and responses.

Table 5 — Commands and responses

Commands	Responses
UI - Unnumbered Information	
AC0 - Acknowledged Connectionless Information, Seq. 0	AC0 - Acknowledged Connectionless Acknowledge, Seq. 0
AC1 - Acknowledged Connectionless Information, Seq. 1	AC1 - Acknowledged Connectionless Acknowledge, Seq. 1

8.4.2 Unacknowledged commands

On the downlink, the UI command PDU shall be used to transmit information to one or more mobile SAP(s) (private, multicast or broadcast LID). On the uplink, the UI command PDU shall be used to transmit information to one fixed SAP (private LID).

The use of the UI command PDU is not dependent on the existence of a data link connection between the destination and source LLCs, and its use will not affect the state variables of the acknowledged operation. There is no LLC response PDU to the UI command PDU.

8.4.2.1 Transmitting UI commands

Upon being passed a DL-UNITDATA.request primitive from the application layer, the LLC shall transmit an UI command PDU which contains the LSDU and which has the P bit set to *0*.

The C/R bit in the MAC control field shall be used to identify that a command is contained in the PDU.

8.4.2.2 Receiving UI commands

If the received LPDU is valid and not null then the LSDU shall be passed to the application layer in a DL-UNITDATA.indication primitive.

Reception of the UI command PDU shall not be acknowledged by the logical data link procedures. The data contained in an UI PDU may be lost if a logical data link exception occurs during the transmitting of the command PDU.

8.4.3 Acknowledged commands/responses

The ACn command PDU shall be used to transmit information or to request information, without the prior establishment of a data link connection. Use of the ACn command PDU is not dependent upon the existence of a data link connection between the destination and source. Reception of an ACn command PDU shall be acknowledged by an ACn response PDU at the earliest opportunity. The information field in the ACn command PDU may be either null (having zero length) or non-null, and if non-null shall contain a link service data unit. The ACn command shall have a private LID.

The ACn response PDU shall be used to reply to an ACn command PDU. Responses shall be made at the earliest opportunity. The ACn response PDU shall identify the responding LLC and shall be transmitted to the originating LLC. The ACn response PDU shall always contain a status subfield in its information field (see 8.3.3).

The source LLC may retransmit an acknowledged command PDU for recovery purposes but it shall not transmit a new acknowledged command PDU while waiting for an acknowledgement of a previous PDU with the same LID. Acknowledged connectionless information exchange shall not interfere with any unacknowledged connectionless operation.

The N bit in successive PDUs provides a one-bit sequence number, which allows the LLC which receives a command PDU to distinguish between a new PDU and a retransmission of the previous PDU.

Further, the LLC that receives an acknowledgement PDU can ensure that the acknowledgement refers to the last transmitted command PDU. A previously received acknowledgement, which incurred excessive delay, is thus ignored.

8.4.3.1 State variables

Acknowledged operation defines state information which shall be maintained at the stations involved in the information exchange. Each station shall maintain for each SAP, a one-bit sequence number for transmitting and another for receiving.

Therefore mobile equipment has to maintain one pair of send / receive sequence numbers if using acknowledged connectionless operation.

A fixed equipment has to maintain, for each mobile equipment using acknowledged connectionless operation in the communication zone, one pair of send / receive sequence numbers.

8.4.3.1.1 Transmit sequence state variable V(SI).

The LLC shall be able to maintain one transmit sequence state variable V(SI) for each unique SAP used for transmitting acknowledged connectionless command PDUs. This variable shall take on the values of *0* and *1.* The V(SI) variables permit the LLC to insure that a received acknowledgement applies to the currently outstanding transmission and allows the receiver to detect duplicate frames. V(SI) shall be created with the establishment of a new private LID.

8.4.3.1.2 Receive sequence state variable V(RI).

The LLC shall be able to maintain one receive sequence state variable V(RI) for each unique SAP associated with received acknowledged connectionless command PDUs. This variable contains the complement of the N bit of the last received acknowledged command with the associated LID. V(RI) allows the LLC to differentiate between an acknowledged connectionless command PDU received for the first time, and a received PDU which is a retransmission of a previously received PDU. V(RI) shall be created with the establishment of a new private LID.

8.4.3.1.3 Procedure for link set-up

The transmit sequence state variable V(SI) and the receive state variable V(RI) shall be created and deleted together with the creation and deletion of the corresponding SAP.

The transmit sequence state variable V(SI) shall be created with a value of *0*. The receive sequence state variable V(RI) shall be created with an undefined value.

NOTE No sequence number resynchronisation is defined since it is assumed that the state variables are not deleted (e.g. by power down, reset) in one communication zone.

8.4.3.2 Procedure for the use of the P/F bit

LLC shall set the P bit in an ACn command PDU to *0* if the command PDU is not a request for the remote LLC to return a LSDU in its acknowledgement. Thus the P bit is set to *0* when data is to be passed only from the transmitting station to the receiving station, or when the command PDU is to be passed only for the purpose of the Data Link Echo command.

LLC shall set the P bit in an ACn command PDU to *1* if the command PDU is a request for the remote LLC to return a LSDU in its acknowledgement. Setting the P bit to *1* allows data to be passed in both directions.

When transmitting an ACn response PDU, LLC shall set the F bit equal to the P bit in the received ACn command PDU and include a non-null LSDU subfield only if the F bit is a *1*.

Table 6 and Table 7 summarise the functions performed by ACn command and response PDUs according to the state of the P/F bit and the presence of a non-null LSDU.

Table 6 — Summary of ACn command functionality

Commands

P	LSDU	Function
0	null	Data Link Echo
0	non-null	Transmitting data
1	null	(Not allowed)
1	non-null	Exchanging data

Table 7 — Summary of ACn response functionality

Responses:

F	LSDU	Function
0	null	Acknowledgement, no data requested
0	non-null	(Not allowed)
1	null	Acknowledgement, requested data unavailable
1	non-null	Acknowledgement with requested data

8.4.3.3 Transmitting ACn commands

Information transfer from an initiating LLC to a responding LLC shall be accomplished by transmitting the ACn command. Transmitting an ACn command is allowed at any time to any receiving LLC provided that the transmitting LLC is not currently awaiting an ACn response PDU from that LLC.

Upon being passed a DL-DATA-ACK.request primitive from the application layer, the LLC shall transmit an ACn command PDU containing the LSDU and with the P bit set to *0*.

Upon being passed a DL-REPLY.request primitive from the application layer, the LLC shall transmit an ACn command PDU containing the LSDU and with the P bit set to *1*.

When an ACn command PDU is constructed the value of V(SI) shall be used to select the LLC control field code of the PDU. When V(SI) is *0* the LLC control field code shall be AC0, and when V(SI) is *1* the LLC control field code shall be AC1.

When the LLC transmits a command PDU, it shall start an acknowledgement timer for that transmission and increment an internal transmission count variable. If no ACn response PDU is received before the acknowledgement timer expires, the transmitting LLC shall retransmit the command, increment the internal transmission count variable, and reset and restart the acknowledgement timer.

If a response is still not received, the retransmission procedure shall be repeated until the value of the internal transmission count variable is equal the value of the logical link parameter N11, as described in 7.6.3, at which time an unsuccessful status shall be reported to the application layer using the related STATUS.indication primitive.

The acknowledgement timer and the internal transmission count shall be maintained separately for each Acknowledged connectionless information exchange between a pair of transmitting and receiving LLCs.

The maximum value for the acknowledgement timer is N13.

The maximum value for the internal transmission count variable is N11.

8.4.3.4 Receiving ACn commands

Upon receipt of an ACn command PDU, the LLC shall compare the V(RI) receive state variable with the N bit of the received LPDU from that SAP.

If the comparison shows equality the received PDU is recognised to be a non-duplicate, otherwise the received PDU is recognised to be a duplication of the most recently received ACn command PDU.

8.4.3.4.1 Non-duplicate ACn command

If the received LPDU is valid and not null and the P bit is *0* then the LSDU shall be passed to the application layer in a DL-DATA-ACK.indication primitive.

If the P bit is *1*, the LSDU shall be passed to the application layer in a DL-REPLY.indication primitive.

The state variable V(RI) of the SAP associated with the received command PDU shall be set equal to the complement of the N bit of the received PDU.

LLC shall acknowledge the receipt of a non-duplicate ACn command PDU by transmitting to the originator of the command an ACn response PDU which has the N bit set to the (new) value of the V(RI).

If the P bit in the received command PDU is *0*, the response PDU shall be transmitted with the F bit set to *0* and with only a status subfield in the information field.

If the P bit in the command PDU is *1*, the response PDU shall be transmitted with the F bit set to *1*, and with the information field containing the LSDU previously associated with the SAP, if it is available.

If the LSDU is not available, it may be transmitted later (see EN 13372).

8.4.3.4.2 Duplicate ACn commands

The LLC-procedures upon the reception of a duplicate ACn command PDU are the same as those for the non-duplicate PDU with the following exceptions.

The V(RI) state variable is not affected by the reception of a duplicate command PDU.

The DL-DATA-ACK.indication primitive is not issued, regardless of the P bit in the command PDU.

If a LSDU is received in the command PDU, it shall not be passed to the application layer.

8.4.3.5 Transmitting ACn responses

An AC0 response PDU shall be transmitted only upon the reception of an AC1 command.

An AC1 response PDU shall be transmitted only upon the reception of an AC0 command.

The response shall be transmitted to the transmitter of the associated command PDU.

The ACn status subfields shall be set according to 8.3.3.

8.4.3.6 Receiving acknowledgement

After transmitting an ACn command PDU to a remote LLC, the transmitting LLC shall expect to receive an acknowledgement in the form of an ACn PDU from the LLC to which the command PDU was transmitted.

AC0 commands shall receive an AC1 acknowledgement and vice versa.

Upon receiving such a response PDU, the LLC shall compare the N bit in the response PDU with the current value of the transmit sequence state variable V(SI).

If the comparison shows inequality, the response is considered valid and the LLC shall stop the acknowledgement timer associated with the transmission for which the acknowledgement was received, and reset the internal transmission count to zero. The V(SI) state variable shall be complemented.

The LLC shall pass a DL-DATA-ACK-STATUS.indication primitive or a DL-REPLY-STATUS.indication primitive to the application layer, depending on which request primitive is being confirmed. In the case that a LSDU was returned in the ACn response PDU, the LSDU shall be passed to the application layer.

LLC shall pass the status to the application layer based on the status subfield in the response PDU.

If the comparison of the N bit in the response PDU with the current value of the transmit sequence state variable V(SI) shows equality, the ACn response PDU shall be considered invalid. The LLC shall take no further action, and shall continue to expect to receive a valid ACn response PDU. The acknowledgement timer shall not be affected.

8.4.3.7 Maximum number of transmissions, N11

N11 is a logical link parameter that indicates the maximum number of times that an ACn command PDU is transmitted by LLC when trying to accomplish a successful information exchange. Normally, N11 is set large enough to overcome the loss of a PDU due to link error conditions. The value of N11 may be set to *1* so that LLC does not itself re-queue a PDU to the MAC sublayer, but the application layer may initiate retransmissions.

8.4.3.8 Acknowledgement time, N13

The acknowledgement time is a logical link parameter that determines the period of the acknowledgement timers, and as such shall define the time interval during which the LLC shall expect to receive an ACn response PDU from a specific LLC from which the LLC is awaiting a response PDU. The acknowledgement time shall take into account any delay introduced by the MAC sublayer and whether the timer is started at the beginning or at the end of the transmitting of the ACn command PDU by the LLC. The proper operation of the procedure shall require that the acknowledgement time shall be greater than the normal time between the transmitting of an ACn command PDU and the reception of the corresponding ACn response PDU.

The unit for the acknowledgement time is defined MAC specific. The public uplink windows allocated are used for this timing purpose.

8.4.4 Bit order

Commands and responses shall be delivered to or received from the MAC sublayer with least significant bit first (i.e., the first bit of an octet that is delivered or received shall have the weight 2^0).

The information field shall be delivered to the MAC sublayer in the same bit order as received from the application layer.

The information field shall be delivered to the application layer in the same bit order as received from the MAC sublayer.

Annex A
(normative)

Data link layer parameters

N1	not used		
N2	maximum number of octets in frame in downlink window	128	octets
N3	maximum number of octets in frame in private uplink window	128	octets
N4	maximum number of octets in frame in public uplink window	9	octets
N5	number of simultaneously allocated public uplink windows	3	
N6	not used		
N7	not used		
N8	not used		
N9	not used		
N10	not used		
N11	maximum number of retransmissions	--	see 8.4.3.7
N12	maximum private medium response time	1	
N13	maximum value for acknowledgement timer	1	see 8.4.3.8
T1	minimum uplink to downlink turn around time	32	µs
T2	min downlink to downlink window time	0	µs
T3	downlink to uplink turn around time	160	µs
T4a	maximum time to start of transmission in private uplink window	320	µs
T4b	maximum time to start of transmission in public uplink window	32	µs
T5	time duration of public uplink window	448	µs

NOTE The numbering used in ENV 12795:1997 has been kept.

Annex B
(informative)

Data link layer overhead

Table B.1 indicates, for the different command and response frames, the amount of overhead introduced by the data link layer. The overhead is in number of octets.

For the calculations a 4 octet length of private LID has been assumed.

Zero bit insertion, as described in 5.7, is excluded.

Table B.8 — Data link layer overhead

	pure MAC frame		frame containing UI command PDU		ACn	ACn
	broadcast LID	Private LID	Broadcast LID	private LID	command	response
Framing (Flag / FCS)	4	4	4	4	4	4
Link Address Field	1	4	1	4	4	4
MAC Control Field	1	1	1	1	1	1
LLC Control Field	-	-	1	1	1	1
Status Subfield	-	-	-	-	-	1
Layer 2 overhead	6	9	7	10	10	11

Annex C
(informative)

Evolution of the MAC sequence bit

The following example shows how lost frames can be handled and how the MAC sequence bit S evolves. (The arrow → stands for downlink, ← for uplink; a shaded field stands for „frame lost on the link“. S=u stands for S bit unchanged against previous value for the same LID, S=t for S bit is toggled).

Table C.1 — Behaviour of MAC sequence bit – Example 1

FE		**ME**	**FE**		**ME**	Remarks
BST, S=0	→					
BST, S=0	→					
.....						
BST, S=0	→					
	←	PrWRq				MAC Ctrl = 60 Hex
BST, S=0	→					
	←	PrWRq	*Variant:*			Variant: PrWA does not come through before the next BST transmission
PrWA, S=0	→		PrWA, S=0	→		S=0 since first allocation to a new LID
PrWA, S=0	→		PrWA, S=0	→		
			.....			
			PrWA, S=0	→		
			BST	→		
				←	PrWRq	
			PrWA, S=1	→		
	←	VST (UI)		←	VST (UI)	Mac Ctrl = C0, LLC Ctrl = 03
PrWA, S=u	→					S remains unchanged to previous value
PrWA, S=u	→					
.....						
BST, S=0	→					
	←	PrWRq				
PrWA, S=t	→					
	←	VST (UI)	*Variant:*			Variant: Unknown EFC application
			UI (release)	→		
			BST	→		
				←	PrWRq	
			UI (release)	→	(END)	ME released. End of transaction.
AC0 (GET1), PrWA, S=t	→					When ME receives no AC Cmd before the next BST, it reconnects with PrWRq
AC0 (GET1), PrWA, S=u	→					ME has received an application command and stops reconnecting

The following example shows responses when ME asks for a private window to send pending data.

Table C.2 — Behaviour of MAC sequence bit – Example 2

	←	AC1, no LSDU		LLC status = 30, APDU requested but not yet available
BST	→			
	←	PrWRq		
PrWA, S=t	→			
	←	UI (X.resp)		Application data received by FE

If after the AC1 frame from the ME the FE receives nothing for a long time, the AC command is reissued. (Still AC0, since it is no new command - there was no application layer response yet. The S bit is toggled since it is a new allocation).

Table C.3 — Behaviour of MAC sequence bit – Example 3

AC0 (GET 1) PrWA, S=t	→			
	←	AC1 (X.resp)		Application data received by FE

The following example shows responses when ME waits for FE retry to send pending data.

Table C.4 — Behaviour of MAC sequence bit – Example 4

	←	AC1 (X.resp= Processing)		
AC1 (GET1), PrWA, S=t	→			AC1 since an application layer response was already received.
	←	AC0 (X.resp=data)		Application data received by FE

Annex D
(informative)

Address establishment

This annex deals with an example of how a communications session between a fixed equipment and a mobile equipment unit could be set up and initialised.

The basic underlying assumptions are that the fixed side periodically broadcasts a beacon service table, BST, containing information on communication parameters, communication profiles and available applications. The BST is transmitted as unnumbered information, UI, with the broadcast address. The frame containing the BST also contains an uplink window allocation, and, since the address is broadcast, it is a public uplink window allocation.

The mobile unit waits, until it hears the BST. The BST is addressed to the data link user, the application layer, and it is interpreted there. The first action in the application layer is to generate a new link address if the interpretation of the BST indicates that the mobile has arrived at a new beacon. The next action is to read or generate a vehicle service table, VST, containing information on communication parameters, communication profiles and available applications in the mobile, and to issue a DL-UNITDATA.request containing the VST.

The interpretation of the BST has also provided the mobile interlayer management with the necessary information on number of, and length of, public uplink windows etc.

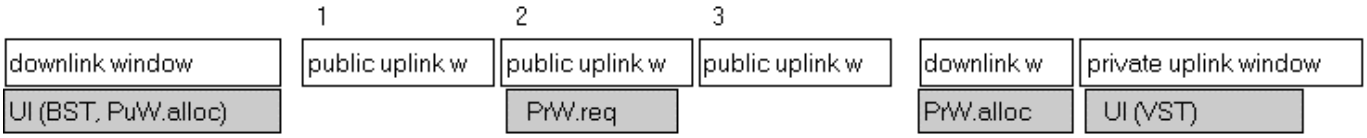
The LLC sublayer discards any state information relating to the earlier SAP and creates a new SAP with the new link address and new state information. The LLC sublayer then issues an MA-DATA.request containing the VST to the MAC sublayer.

The MAC sublayer constructs the frame containing the VST, realises that the frame is too long for the public uplink window that is available and constructs a request for private window using the new link address. It then selects a public uplink window according to the random delay counter and transmits the request for private window in this public uplink window.

The fixed equipment MAC responds to the request for private window by allocating a private uplink window to the mobile with the indicated link address. In that private uplink window the mobile transmits the pending frame containing the VST.

When the frame is correctly received in the fixed MAC the result will be an MA-DATA.indication to the fixed LLC. The fixed LLC will study the link address and find that it is new, create a new SAP for that link address and issue a DL-UNITDATA.indication.

The sequence of frames/windows can be depicted as in Figure D.1.



number of simultaneously allocated public windows = 3
random delay counter = 2
maximum random delay counter = 3

Figure D.22 — BST – VST exchange for newly arrived mobile equipment - Windows

The sequence of service primitives and frames can also be depicted as in Figure D.2.

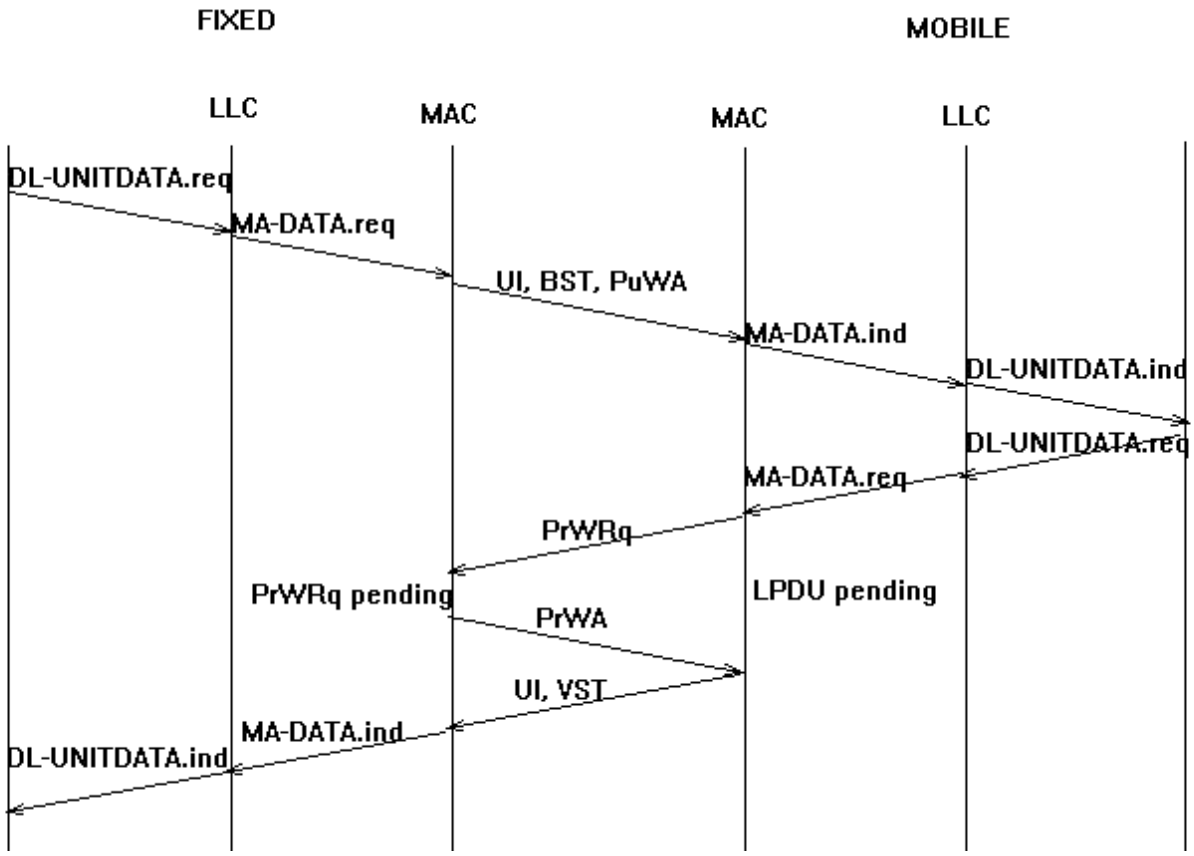


Figure D.23 — BST – VST exchange for newly arrived mobile equipment - Primitives

In any DSRC communication the unreliability of the link should be taken into account. It is therefore necessary to investigate the possibilities to recover from loss of frames also in the early phases of communication.

If the frame transmitted on the uplink in the public uplink window is lost (due to contention or for other reasons) the mobile equipment will not know until the private uplink window allocation timer has expired. Since the maximum value of the timer is 1, the mobile will expect a private window allocation before the next public window allocation, which occurs at the next transmission of the BST (see Figure D.3).

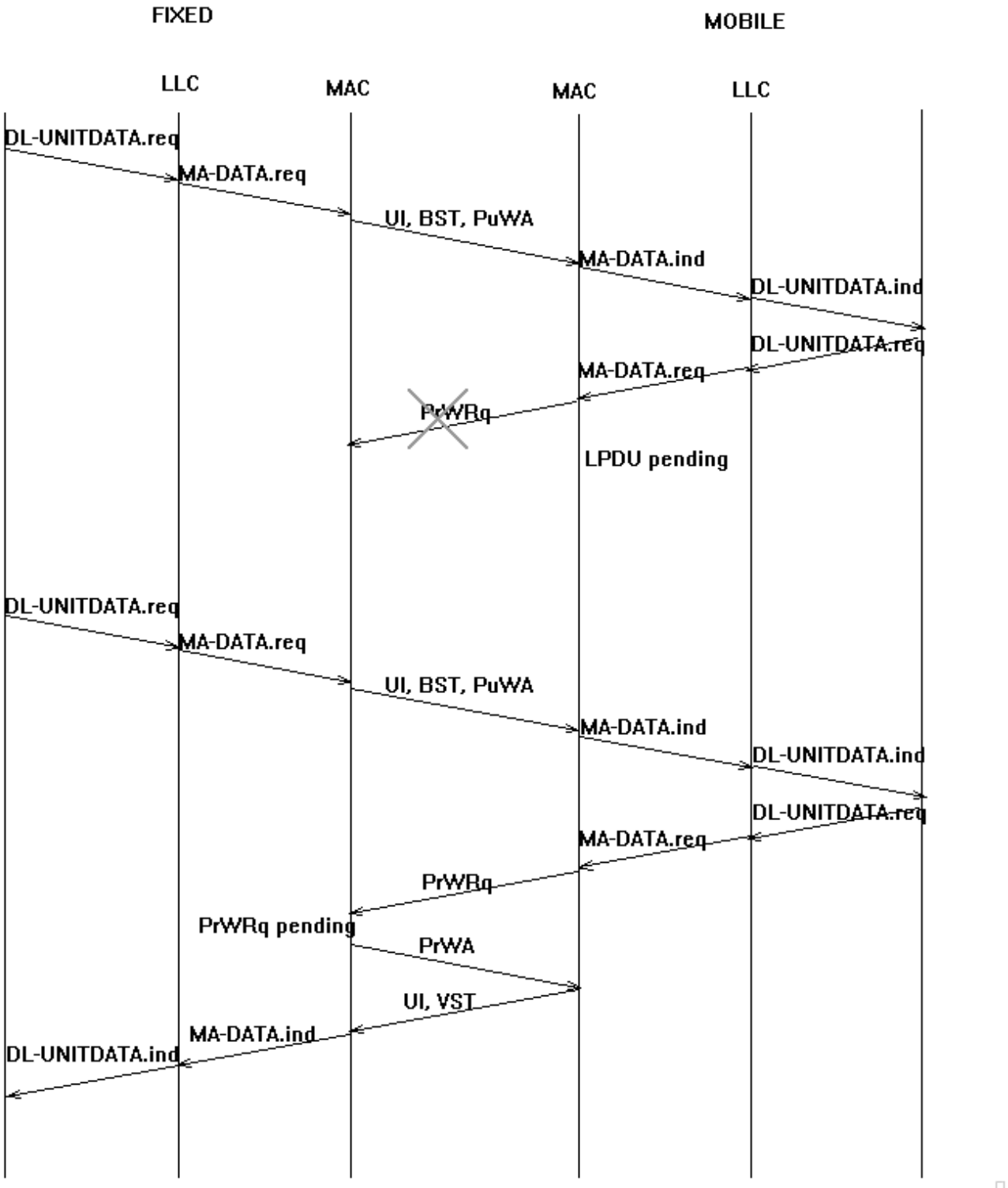


Figure D.24 — BST – VST exchange when private window request is lost

If the frame transmitted on the downlink allocating the private uplink window is lost, the mobile will not transmit in the private window allocated and the fixed side can reallocate the private uplink window to increase the probability of getting the data (see Figure D.4).

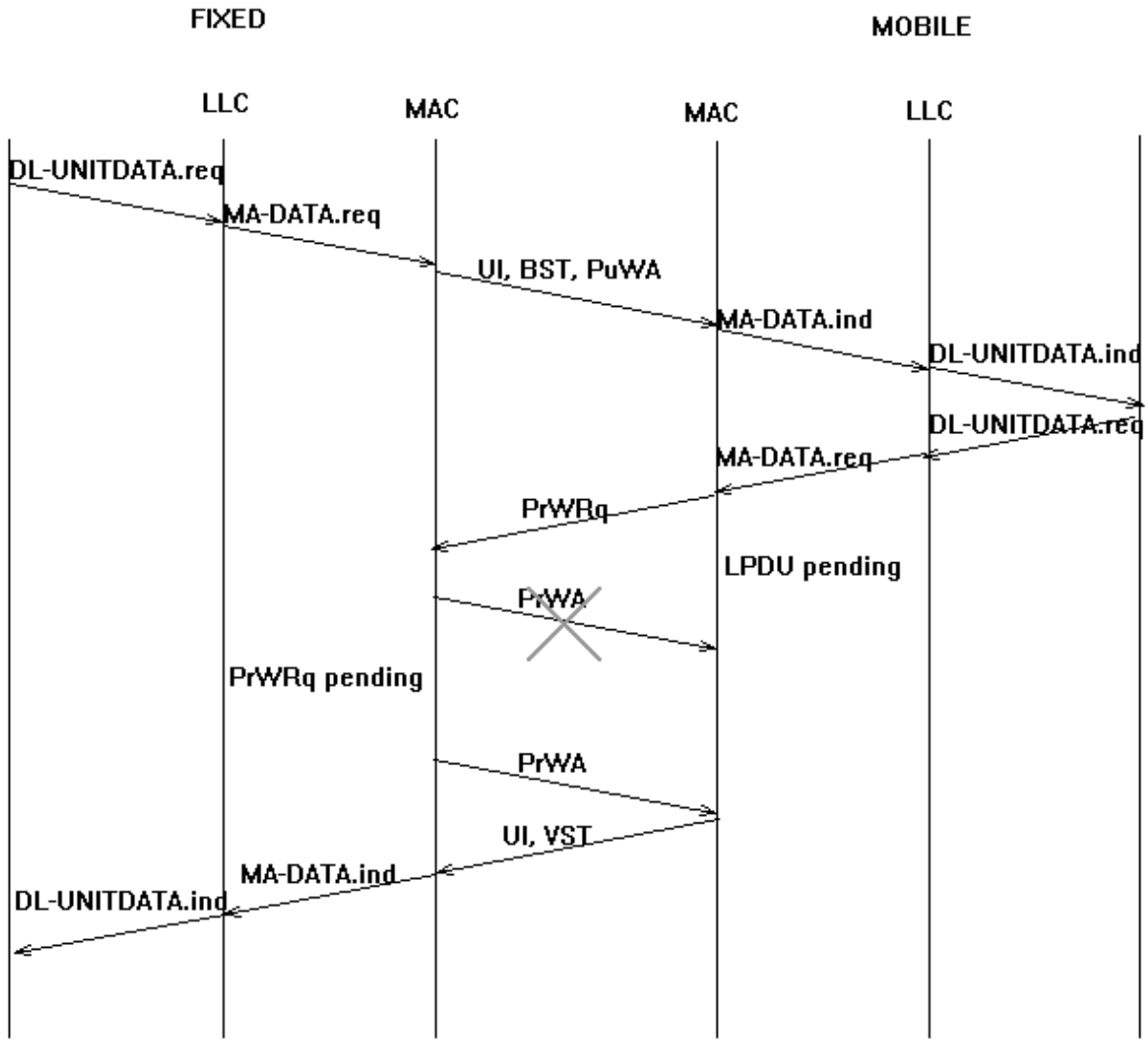


Figure D.25 — BST – VST exchange when a private window allocation is lost

If the UI frame containing the VST, transmitted on the uplink is lost, the fixed side will not receive a valid frame in the private window allocated and it can then reallocate the private uplink window (see Figure D.5).

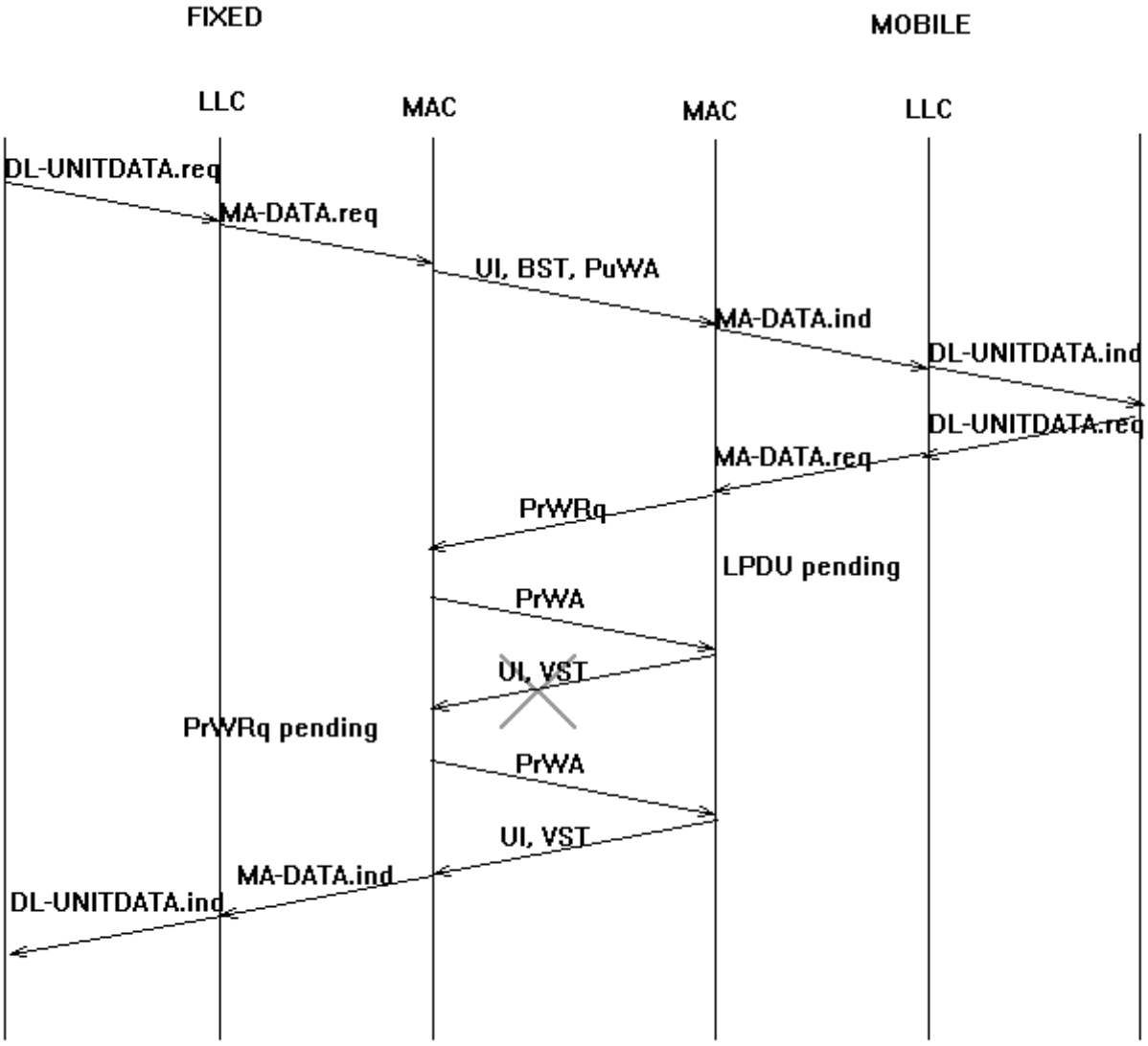


Figure D.26 — BST – VST exchange when VST is lost

Annex E
(informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

This European Standard does not fall under any Directive of the EC.

In the relevant CEN/CENELEC countries these A-deviations are valid instead of the provisions of the European Standard until they have been removed.

Clause	Deviation
All	**Italy** Decreto del Presidente della repubblica, 22 giugno 1999, n. 250; Regolamento recante norme per l'autorizzazione alla installazione e all'esercizio di impianti per la rilevazione degli accessi di veicoli ai centri storici e alle zone a traffico limitato, a norma dell'articolo 7, comma 133-*bis*, della legge 15 maggio 1997, n.127 This Italian regulation prescribes the use of UNI 10607, which specifies a DSRC system that is incompatible with this European Standard.