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EUROPEAN TELECOMMUNICATION STANDARD

pr **ETS 300 396-3**

July 1996

Source: ETSI TC-RES

Reference: DE/RES-06007-3

ICS: 33.060, 33.060.20

Key words: Radio, air interface, protocol, TETRA

Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 3: Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol

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Contents

Foreword 11

1 Scope 13

2 Normative references 13

3 Definitions and abbreviations 13
3.1 Definitions 13
3.2 Abbreviations 14

4 Overview of protocol 15
4.1 General 15
4.2 The DM channel 16
4.3 DM call procedures 17
4.3.1 Constraints on the frame structure 17
4.3.2 Setting up a call 17
4.3.3 Changeover in a call 19
4.3.4 Pre-emption of a DM call 20
4.3.5 Terminating a call 21
4.4 DM protocol layering 21

5 Layer 3 service description 21
5.1 Introduction 21
5.2 Services offered 21
5.3 Primitive description 22
5.3.1 DMCC-RELEASE primitive 22
5.3.2 DMCC-REPORT primitive 23
5.3.3 DMCC-SDS DATA primitive 23
5.3.4 DMCC-SDS REPORT primitive 23
5.3.5 DMCC-SDS UNITDATA primitive 24
5.3.6 DMCC-SETUP primitive 24
5.3.7 DMCC-TPNI primitive 25
5.3.8 DMCC-TX CEASED primitive 26
5.4 Parameter description 26
5.5 States for DMCC SAP 28

6 Layer 3 protocol 30
6.1 Introduction 30
6.1.1 DMCC protocol states 30
6.1.1.1 IDLE 30
6.1.1.2 CALL SETUP NORMAL 30
6.1.1.3 CALL SETUP PRES_CHECK 30
6.1.1.4 PRE-EMPTION 30
6.1.1.5 CALL ACTIVE TX Occupation 30
6.1.1.6 CALL ACTIVE TX Reservation 30
6.1.1.7 CALL ACTIVE RX Occupation 30
6.1.1.8 CALL ACTIVE RX Reservation 30
6.1.1.9 WAIT RSP Occupation 30
6.1.1.10 WAIT RSP Reservation 31
6.1.1.11 ACK SHORT DATA INITIATED 31
6.1.1.12 UNACK SHORT DATA INITIATED 31
6.2 Circuit mode calls 31
6.2.1 Procedures for call set-up without presence check 31
6.2.1.1 Outgoing call 32

6.2.1.2 Incoming call....33
6.2.1.3 Temporary group address....33
6.2.2 Procedures for call set-up with presence check....33
6.2.2.1 Outgoing call....34
6.2.2.2 Incoming call....35
6.2.3 Procedures for late entry....36
6.2.4 Procedures during occupation....36
6.2.4.1 Master DM-MS....36
6.2.4.2 Slave DM-MS....37
6.2.4.3 Transmitting Party Number Identification (TPNI)....39
6.2.5 Procedures during reservation....39
6.2.5.1 Master DM-MS....39
6.2.5.2 Slave DM-MS....40
6.2.6 Procedures to set up a new call by pre-emption....41
6.3 Short data service procedures....42
6.3.1 Sending short data....43
6.3.1.1 Sending short data on a free channel....43
6.3.1.2 Sending short data by pre-emption....47
6.3.1.3 Sending short data during circuit mode transmission....48
6.3.1.4 Sending short data as a transaction within a circuit mode call....49
6.3.1.4.1 Pre-emption to send short data as a transaction within a circuit mode call....49
6.3.1.4.2 Changeover request to send short data as a transaction within a circuit mode call....49
6.3.1.4.3 Sending the short data as master of the circuit mode call....50
6.3.2 Receiving short data....50
6.3.2.1 Receiving DM-SDS UDATA PDU....50
6.3.2.2 Receiving DM-SDS DATA PDU....50
6.3.3 Additional addressing....51
6.3.4 Extended error protection....51
6.4 Usage of DMA-UNITDATA primitive....51

7 Layer 2 service description....52
7.1 Introduction....52
7.2 Layer 2 architecture....52
7.2.1 Lower layer management in layer 2....53
7.3 Service descriptions....53
7.3.1 Services at the DMA-SAP....53
7.3.1.1 Service primitives at the DMA-SAP....54
7.3.1.1.1 DMA-REPORT primitive....55
7.3.1.1.2 DMA-UNITDATA primitive....55
7.3.2 Services at the DMC-SAP....55
7.3.2.1 Service states for the DMC-SAP....56
7.3.2.2 Service primitives at the DMC-SAP....56
7.3.2.2.1 DMC-CONFIGURE primitive....56
7.3.2.2.2 DMC-REPORT primitive....56
7.3.3 Services at the DMD-SAP....56
7.3.3.1 Service primitives at the DMD-SAP....56
7.3.3.1.1 DMD-REPORT primitive....56
7.3.3.1.2 DMD-UNITDATA primitive....57
7.4 Parameter listing....57
7.4.1 Air interface encryption information....57
7.4.2 Air interface encryption state....57
7.4.3 Call release....57
7.4.4 Call set-up after pre-emption or changeover....57
7.4.5 Changeover request held during occupation....58
7.4.6 Circuit mode information....58

7.4.7 Destination address 58
7.4.8 Destination address type 58
7.4.9 DM-SDU 58
7.4.10 DM-SDU length 58
7.4.11 FCS flag 58
7.4.12 Half slot condition 58
7.4.13 Half slot content 58
7.4.14 Half slot importance 58
7.4.15 Half slot position 59
7.4.16 Half slot synchronisation 59
7.4.17 Handle to the request 59
7.4.18 Immediate retransmission 59
7.4.19 Incomplete DM-SDS DATA/ACK received 59
7.4.20 Message type 59
7.4.21 Number of repeats 59
7.4.22 Priority 59
7.4.23 Recent user changeover request 59
7.4.24 Recent user priority 60
7.4.25 Report 60
7.4.26 Reservation time 60
7.4.27 SDS transaction type 60
7.4.28 Source address 60
7.4.29 Source address type 60
7.4.30 Stealing priority 60
7.4.31 Stolen indication 60
7.4.32 Valid addresses 60

8 Layer 2 protocol 60
8.1 Introduction 60
8.1.1 Functions of lower MAC 61
8.1.2 Functions of upper MAC 61
8.2 Interface between lower and upper MAC 61
8.2.1 Logical channels defined at the DMV-SAP 62
8.2.2 Service primitives at the DMV-SAP 63
8.2.3 PDU mapping of the logical channels at the DMV-SAP 63
8.2.4 Scrambling mechanism 64
8.2.5 PDU error detection 64
8.2.6 Modes of operation 64
8.2.6.1 DM-MS modes of operation 64
8.2.6.2 Traffic mode 66
8.2.6.2.1 Normal operation 66
8.2.6.2.2 Stealing mechanism 67
8.2.6.3 Selection of the mode of operation 67
8.3 Basic capabilities of the Physical Layer 68
8.3.1 DM-MS capabilities 68
8.3.1.1 DM only and dual mode capable MS operation 68
8.3.1.2 Dual watch capable MS operation 68
8.4 Usage of DM channel 69
8.4.1 Definition of DM channel 69
8.4.1.1 DM channel A operation 69
8.4.1.2 DM channel B operation 69
8.4.2 DM channel states 70
8.4.2.1 DM channel state definitions 70
8.4.2.2 Determination of DM channel state 70
8.4.2.3 Criteria for occupying a free channel 70
8.4.2.3.1 Signal strength measurement to determine channel free condition 71
8.4.2.4 DM-MS channel surveillance procedures 71
8.4.2.4.1 Signal quality measurement during call transaction 71

8.4.3 DM-MAC states....72
8.4.3.1 DM-MAC state definitions....72
8.4.3.2 Criteria for changing DM-MAC state....72
8.4.4 DM-MS monitoring requirements....73
8.4.4.1 Free DM channel....73
8.4.4.2 DM channel in occupation during call set-up....73
8.4.4.3 DM channel in occupation during a circuit mode call....73
8.4.4.4 DM channel in reservation during a circuit mode call....73
8.4.4.5 DM channel in occupation during a SDS call....73
8.4.4.6 DM channel usage during pre-emption signalling....74
8.4.4.7 DM channel usage during timing change request signalling....74
8.4.4.8 Channel B master MS monitoring procedures....74
8.4.5 Transmission of layer 3 messages by DM-MAC....74
8.4.5.1 Transmission of DMCC message by DM-MAC....74
8.4.5.2 Transmission of U-plane messages by DM-MAC....77
8.4.6 Transmission of layer 2 messages generated by DM-MAC....77
8.4.7 Transmission of messages by DM-MAC....79
8.4.7.1 DM-MAC repeat transmissions....79
8.4.7.2 DM-MAC frame count down procedure....79
8.4.7.3 Timers....79
8.4.7.4 Linearisation....79
8.4.7.5 Fragmentation....79
8.4.7.6 Fill bit indication....79
8.4.7.7 Selection of pseudo address....79
8.4.7.8 Slot flag indication....80
8.4.7.9 Change over requests bit map....80
8.4.7.10 Dual watch operation....80
8.4.7.11 Air interface encryption....80
8.4.7.12 Channel A or B operation....80
8.4.7.13 SDS time remaining....80
8.4.7.14 Timing change procedure....80
8.4.7.15 Timing change at changeover or pre-emption....81
8.5 MAC Procedures for transfer of signalling messages....82
8.5.1 Formation of MAC PDU....82
8.5.2 Addressing....83
8.5.2.1 Transmission of message....83
8.5.2.1.1 Addressing in synchronisation burst....83
8.5.2.1.2 Addressing in normal burst....84
8.5.2.2 Reception of message....84
8.5.3 Use of air interface encryption....85
8.5.4 Fragmentation and reconstruction....85
8.5.4.1 Fragmentation....86
8.5.4.2 Reconstruction....87
8.5.5 Fill bit addition and deletion....88
8.5.5.1 Fill bit addition....88
8.5.5.2 Fill bit deletion....88
8.5.5.3 Null PDU....88
8.5.6 Transmission and reception of messages by layer 2 unacknowledged service....89
8.5.6.1 Transmission of message....89
8.5.6.2 Reception of message....90
8.5.7 Random access protocol....92
8.5.7.1 Introduction....92
8.5.7.2 Procedures for master DM-MS....92
8.5.7.2.1 Indicating frames available for requests....92
8.5.7.2.2 Monitoring frames available for requests....92
8.5.7.2.3 Response to pre-emption or changeover request....92

8.5.7.2.4 Response to timing change request.....93
8.5.7.3 Procedures for requesting DM-MS.....94
8.5.7.3.1 Preparing for random access.....94
8.5.7.3.2 First transmission of request.....94
8.5.7.3.3 Waiting for response.....95
8.5.7.3.4 Subsequent transmission of request.....95
8.5.7.3.5 Abandoning random access attempt.....96
8.6 MAC procedures in traffic mode.....97
8.6.1 Introduction.....97
8.6.2 Criteria for transmission and reception of traffic.....97
8.6.3 Change of U-plane mode.....98
8.6.3.1 Set-up without presence check.....98
8.6.3.2 Set-up with presence check.....98
8.6.3.3 Late entry.....99
8.6.3.4 End of traffic transmission.....99
8.6.4 Exchange of information at the DMD-SAP.....99
8.6.4.1 Interface at transmitting DM-MS.....101
8.6.4.2 Interface at receiving DM-MS.....102
8.6.5 Stealing from circuit mode capacity.....103
8.6.5.1 Transmission on STCH.....103
8.6.5.2 Criteria for C-plane stealing.....103
8.6.5.3 Reception on STCH.....104

9 PDU descriptions.....105
9.1 Layer 2 PDUs sent in DSB.....105
9.1.1 DMAC-SYNC PDU.....105
9.2 Layer 2 PDUs sent in DNB.....106
9.2.1 DMAC-DATA PDU.....107
9.2.2 DMAC-FRAG PDU.....107
9.2.3 DMAC-END PDU.....108
9.2.4 DMAC-U SIGNAL PDU.....108
9.2.5 DMAC-TRAFFIC PDU.....108
9.3 Layer 2 information element coding.....108
9.3.1 A/B channel usage.....109
9.3.2 Air interface encryption state.....109
9.3.3 Communication type.....109
9.3.4 Destination address.....109
9.3.5 Destination address type.....109
9.3.6 DM-SDU.....110
9.3.7 Encryption key number.....110
9.3.8 Fill bit indication.....110
9.3.9 Fragmentation flag.....110
9.3.10 Frame countdown.....110
9.3.11 Frame number.....110
9.3.12 Key Stream Generator (KSG) number.....111
9.3.13 MAC PDU subtype.....111
9.3.14 MAC PDU type.....111
9.3.15 Message dependent elements.....111
9.3.16 Message type.....111
9.3.17 Mobile Network Identity (MNI).....112
9.3.18 Null PDU flag.....112
9.3.19 Number of SCH/F slots.....112
9.3.20 Repeater flag.....113
9.3.21 Repeater or gateway address.....113
9.3.22 Second half slot stolen flag.....113
9.3.23 Slot number.....113
9.3.24 Source address.....113
9.3.25 Source address type in DATA.....113
9.3.26 Source address type in SYNC.....113
9.3.27 SYNC PDU type.....114

9.3.28 System code 114
9.3.29 Time Variant Parameter (TVP) 114
9.3.30 Timestamp flag 114
9.3.31 U-plane DM-SDU 114
9.4 Messages generated by layer 2 114
9.4.1 DM-RESERVED 114
9.4.2 DM-SDS OCC 115
9.4.3 DM-TIMING REQUEST 115
9.4.4 DM-TIMING ACK 115
9.5 Layer 3 PDUs 115
9.5.1 DM-SETUP 116
9.5.2 DM-SETUP PRES 116
9.5.3 DM-CONNECT 117
9.5.4 DM-DISCONNECT 117
9.5.5 DM-OCCUPIED 117
9.5.6 DM-RELEASE 118
9.5.7 DM-TX CEASED 118
9.5.8 DM-TX REQUEST 118
9.5.9 DM-TX ACCEPT 118
9.5.10 DM-PREEMPT 119
9.5.11 DM-PRE ACCEPT 119
9.5.12 DM-REJECT 119
9.5.13 DM-INFO 120
9.5.14 DM-SDS UDATA 120
9.5.15 DM-SDS DATA 120
9.5.16 DM-SDS ACK 121
9.6 Message dependent elements coding 121
9.6.1 Changeover requests bitmap 121
9.6.2 FCS flag 122
9.6.3 LCH in frame 3 122
9.6.4 Perceived channel state 122
9.6.5 Pre-emption flag 122
9.6.6 Priority level 123
9.6.7 Recent user priority flag 123
9.6.8 Requests flag 123
9.6.9 Reservation time remaining 123
9.6.10 SDS time remaining 123
9.6.11 SDS transaction type 124
9.6.12 Timing acceptance flag 124
9.6.13 Timing advance element 124
9.6.14 Timing change announcement flag 124
9.6.15 Timing change request flag 124
9.6.16 Timing flag 125
9.7 DM-SDU elements coding 125
9.7.1 Acknowledgement type 125
9.7.2 Additional address type(s) 125
9.7.3 Basic service information 125
9.7.4 Calling party TSI 125
9.7.5 Cease cause 126
9.7.6 Disconnect cause 126
9.7.7 FCS 126
9.7.8 Information type 126
9.7.9 Length indicator 126
9.7.10 New call pre-emption 127
9.7.11 Pre-coded status 127
9.7.12 Reject cause 127
9.7.13 Release cause 127
9.7.14 Short Data Type Identifier (SDTI) 127
9.7.15 Type of pre-emption 128
9.7.16 User Defined Data (UDD) type 1 128

9.7.17 UDD 2 128
9.7.18 UDD 3 128
9.7.19 UDD 4 128

Annex A (normative): Timers and constants in DM-MS 129

A.1 Layer 3 timers 129

A.2 Layer 3 constants 129

A.3 Layer 2 timers 129

A.4 Layer 2 constants 130

A.5 Maximum number of frame transmissions 130

Annex B (normative): Mathematical definition of Frame Check Sequence (FCS) 131

Annex C (informative): DMC-SAP boundary state model illustrations 132

History 134

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Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Public Enquiry phase of the ETSI standards approval procedure.

This ETS is a multi-part standard and will consist of the following parts:

Part 1: "General network design";

Part 2: "Radio aspects";

Part 3: "Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol";

Part 4: "Repeaters ", (DE/RES-06007-4);

Part 5: "Gateways", (DE/RES-06007-5);

Part 6: "Security", (DE/RES-06007-6).

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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1 Scope

This ETS defines the Trans-European Trunked RAdio system (TETRA) Direct Mode Operation (DMO). It specifies the basic air interface, the inter-working between Direct Mode (DM) groups via repeaters, and inter-working with the TETRA Voice plus Data (V+D) system via gateways. It also specifies the security aspects in TETRA DMO, and the intrinsic services that are supported in addition to the basic bearer and teleservices.

This part applies to the TETRA DMO Mobile Station - Mobile Station (MS-MS) Air Interface (AI) and contains the specifications of the Data Link Layer (DLL) and the network layer according to the ISO model.

It establishes the services, messages and protocols used for voice and circuit mode data calls and short data transfer, starting with the upper layers:

- it defines and specifies the protocol used by the layer 3 entity to communicate across the air interface;

- it defines and specifies the services and protocol used in the DLL.

The normative annexes mainly specify the parameter values used in the protocol.

The informative annexes refer mainly to the description of more general layer 3 to layer 1 mechanisms.

2 Normative references

This ETS incorporates by dated and 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 ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] prETS 300 396-1 (1996): "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 1: General network design".

[2] prETS 300 396-2 (1996): "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 2: Radio aspects".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

call: There are two types of call, individual call or group call. An individual call is a complete sequence of related call transactions between two DM-MSs. There are always two participants in an individual call. A group call is a complete sequence of related call transactions involving two or more DM-MSs. The number of participants in a group call is not fixed, but shall be at least two. Participants may join (late entry) and leave an ongoing group call.

call transaction: All of the functions associated with a complete unidirectional transmission of information during a call. A call is made up of one or more call transactions. In a simplex call these call transactions are sequential.

called user application: The user application which receives an incoming call.

calling user application: The user application which initiates an outgoing call.

changeover: Within a call, the process of effecting a transfer of the master role (and hence transmitting MS) at the end of one call transaction so that another can commence.

Direct Mode (DM): A mode of simplex operation where mobile subscriber radio units may communicate using radio frequencies which may be monitored by but which are outside the control of the TETRA V+D network. DM is performed without intervention of any base station.

DM Call Control (DMCC): The layer 3 entity responsible for setting up and maintaining a call in DMO.

DM channel (and physical channel): A specific grouping of timeslots in the DM multiplex structure related to a particular DM frequency (carrier). The grouping may not always be fixed, but in DMO when operating in frequency efficient mode as an example, there are two DM channels, identified by the letters A and B.

DM Mobile Station (DM-MS): A physical grouping that contains all of the mobile equipment that is used to obtain TETRA DM services. By definition, a MS contains at least one Mobile Radio Stack (MRS). For synchronisation purposes, DM-MSs can have one of two status levels:

- **Master:** if the DM-MS is either active in a call transaction transmitting traffic or control data, or is reserving the channel by means of channel reservation signalling and hence is providing synchronisation information to the channel;

- **Slave:** if the DM-MS is receiving traffic and/or signalling and hence is deriving synchronisation information from the channel.

Dual Watch Mobile Station (DW-MS): A MS that can operate either in TETRA DMO or TETRA V+D mode. Only one mode can be selected at any given time but it is capable of monitoring the V+D control channel while in DMO or a DM channel while in V+D mode.

DM GATEway (DM-GATE): A device which provides gateway connectivity between a DM-MS and the TETRA V+D network. The gateway provides the interface between TETRA DMO and TETRA V+D mode.

DM REPeater (DM-REP): A device that operates in TETRA DMO and provides a repeater function to enable two or more DM-MSs to extend their coverage range.

frequency efficient mode: Mode of operation where two independent DM communications are supported on a single radio carrier frequency. In frequency efficient mode the two DM channels are identified as channel A and channel B.

logical channel: A generic term for any distinct data path. Logical channels are considered to operate between logical endpoints.

Medium Access Control (MAC) block: The unit of information transferred between the upper MAC and lower MAC for a particular logical channel (e.g. SCH/F or STCH). The lower MAC performs channel coding for insertion into the appropriate physical slot or halfslot.

simplex: A mode of single or dual frequency working in which information can be transferred in both directions but not at the same time.

surveillance: The process of monitoring the quality of the radio link.

V+D operation: A mode of operation where MSs may communicate via the TETRA V+D air interface which is controlled by the TETRA Switching and Management Infrastructure (SwMI).

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

CRC	Cyclic Redundancy Check

DCC	Direct Mode Colour Code
DLB	Direct Mode Linearisation Burst
DLL	Data Link Layer
DMA	A layer 2 Service Access Point (DMA-SAP)
DMC	A layer 2 Service Access Point (DMC-SAP)
DMD	A layer 2 Service Access Point (DMD-SAP)
DM-primitive	TETRA MAC primitive of service
DM-SDU	SDU from layer 3
DMV-primitive	TETRA MAC virtual primitive of service
DM-GATE	Direct Mode Gateway.
DM-MS	Direct Mode Mobile Station
DM-REP	Direct Mode Repeater.
DMCC	Direct Mode Call Control entity
DMO	Direct Mode Operation
DNB	Direct Mode Normal Burst
DO-MS	Direct Mode Only Mobile Station
DSB	Direct Mode Synchronisation Burst
DTX	Discontinuous Traffic Transmission
DU-MS	Dual Mode (V+D / Direct Mode) Switchable Mobile Station
DW-MS	Dual Watch Mobile Station
FCS	Frame Check Sequence
FN	Frame Number
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
ISSI	Individual Short Subscriber Identity
ITSI	Individual TETRA Subscriber Identity
LCH	Linearisation CHannel
MAC	Medium Access Control
MNI	Mobile Network Identity
mod	modulo (base for counting)
MS	Mobile Station
PACQ	Probability of synchronisation burst acquisition
PDU	Protocol Data Unit
PL	Physical Layer designates the whole layer 1
QN	Quarter Symbol Number
RDC	Radio Downlink Counter
RSSI	Radio Signal Strength Indication
SAP	Service Access Point
SCH	Signalling Channel
SCK	Static Cipher Key
SDS	Short Data Service
SDU	Service Data Unit
SN	Symbol Number
SSI	Short Subscriber Identity
STCH	Stealing Channel
SwMI	Switching and Management Infrastructure
TCH	Traffic Channel
TN	Timeslot Number
TPNI	Transmitting Party Number Identification
TSI	TETRA Subscriber Identity
TVP	Time Variant Parameter
V+D	Voice plus Data

4 Overview of protocol

4.1 General

TETRA DMO offers the possibility of direct communication between MSs, e.g. without the need of an intervening base station. A major criteria in the development of TETRA DMO is to provide a simple but robust system which will allow communication using parameters as close to the TETRA V+D system as

possible, but in areas where there may be no V+D coverage. TETRA DMO is not intended to replace TETRA V+D and will not offer the capability or resource efficiency of the V+D system.

Due to the absence of a controlling infrastructure, TETRA DMO has specific requirements in terms of timing, synchronisation and protocol robustness in order that the DM system can operate effectively. Requirements for timing and synchronisation are outlined in ETS 300 396-2 [2], clause 7 and this part of the ETS provides detail of the DMO protocol, which has been developed in order to support the basic mode of operation for TETRA DMO, which is direct communication between MSs.

Specific variants of the basic TETRA DMO protocol to support communication via DM Repeaters (DM-REPs) and DM Gateways (DM-GATEs), and these are addressed in other parts of this ETS.

TETRA DMO will operate within a pre-assigned portion of the radio spectrum allocated to TETRA on frequencies specifically allocated to DMO. The radio parameters of DMO are given in ETS 300 396-2 [2], clause 6. The process of selection of an appropriate radio channel is not standardized within this ETS, but in TETRA DMO it is wholly controlled by the MS, e.g. it may be as simple as by manual selection by a channel select switch.

In DMO a radio channel is not allocated to a MS by an infrastructure and therefore it is possible to access a DM radio channel at any time by any user.

In DMO, group and individual addresses are used within the protocol as a means of controlling the use of the channel and are applied in a similar way to those used in V+D, see ETS 300 396-1 [1], clause 6. In addition, in a similar manner to V+D, DM Normal Bursts (DNBs) are scrambled using a colour code. The colour code is designed to prevent inadvertent decoding of traffic from another call operating on the same DM channel.

4.2 The DM channel

A DM channel can be in one of three states:

- free, where there is no activity on the channel;

- occupied, where a call transaction is in progress on the channel;

- reserved, where a "channel reservation" signal is present on the channel.

The actions and procedures followed by a MS wishing to make a call on a DM channel will vary depending on the state of the channel.

When the channel is free, it is available for use by any DM-MS which can tune to that channel.

When a channel is occupied, it is in active use in a group or individual call. A master DM-MS will be providing synchronisation for the channel in frames 6, 12, and 18, and transmitting traffic in DNBs in other frames.

When a channel is reserved, it has been in use for an individual or group call. The master DM-MS for that call transaction transmits DSBs in frames 6, 12, and 18 with parameters indicating the fact that the channel is reserved, for which group or individual it is being reserved, and for how long the channel will continue to be reserved. A DM channel will become reserved after the conclusion of each call transaction, and stay reserved until either a changeover of the master role has been successfully achieved, or until the channel reservation timer of the master DM-MS has expired.

In TETRA DMO, the absence of a base station requires that special procedures have to be followed in order to achieve synchronisation between mobiles participating in a call. The procedures vary depending on the state of the selected DM channel.

4.3 DM call procedures

The procedures and sequences given in the following subclauses are intended to illustrate possible scenarios and the mechanisms which the protocol may take in those circumstances. The procedures are not exhaustive and are not intended to show every possible scenario.

The frame and slot timing diagrams which follow assume only single occupancy of a DM channel.

Abbreviations are used in the diagrams to represent Packet Data Units (PDUs) sent within the protocol. The actual message types are as follows:

cak ≡ DM-TX ACCEPT;
crq ≡ DM-TX REQUEST;
Pak ≡ DM-RELEASE + DM-PRE ACCEPT (sent in DNB);
pak ≡ DM-PRE ACCEPT (sent in DSB);
pca ≡ DM-CONNECT;
prq ≡ DM-PREEMPT;
sy ≡ DM-SETUP;
syo ≡ DM-OCCUPIED;
syp ≡ DM-SETUP PRES;
syr ≡ DM-RESERVED;
txC ≡ DM-TX CEASED.

Other abbreviations used are:

tc, representing traffic transmission;
lch, representing slots available for linearization; and
p?, representing slots available for pre-emption requests.

4.3.1 Constraints on the frame structure

In DMO the entire protocol procedure is based on a fixed frame structure and a knowledge of the current position (in time) within this structure. As shown in ETS 300 396-2 [2], subclause 4.5.1, the essential building blocks of the DMO structure are the frame which comprises four time slots, and the multiframe which comprises 18 Frames.

In order to facilitate the DMO protocol, a number of constraints are placed on this structure, in terms of what can be transmitted in any particular slot. ETS 300 396-2, subclause 9.4.5 provides some detail on the mapping of particular elements of the multiplex structure to the DM frame structure.

In order to explain the protocol the following points are of importance (but not relevant to a free channel):

- frame 18 is always used for synchronisation purposes, and usually carries a DSB in both slots 1 and 3;

- frames 6 and 12 carry occupation information in a DSB in slot 3, and may carry traffic in a DNB in slot 1;

- frames 6 and 12 carry reservation information in a DSB in slots 1 and 3;

- pre-emption, is permitted, during occupation, in slot 3 of frames 2, 5, 8, 11, 14 and 17;

- linearization, which is carried out in a DM Linearization Burst (DLB), may be permitted in slot 3 of frame 3 during a call;

- during occupation, frames 1 to 17 usually carry traffic in slot 1 (in a DNB).

4.3.2 Setting up a call

In DM MS-MS operation there are two options for call set-up:

- a direct set-up whereby transmission commences without explicit knowledge of the presence of any receiving MS(s); and

- set-up with presence checking whereby a specific acknowledgement is sought before transmission commences.

For group (point-to-multipoint) and individual (point-to-point) calls a direct set-up is the most basic mode of setting up a call in a DM channel. Figure 1 illustrates this procedure.

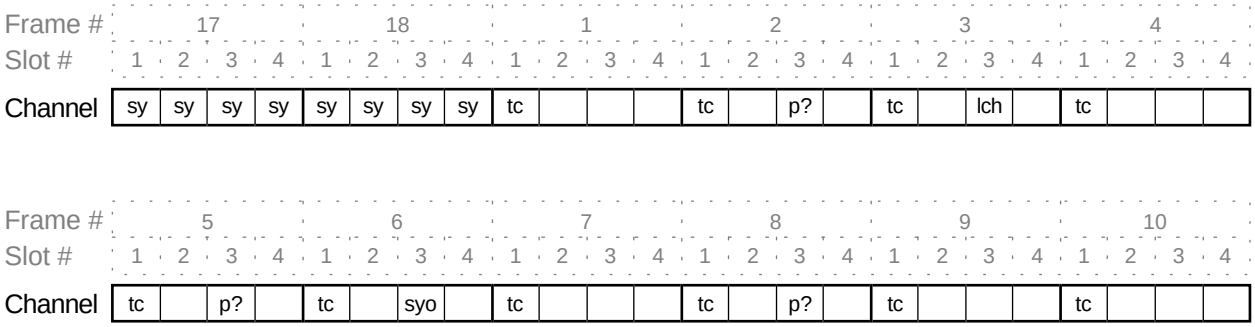


Figure 1: Call sequence for direct set-up

After following the procedures given in subclause 8.4.2 to ascertain the state of the channel, provided the channel is found to be in the state "free" a DM-MS establishes the channel synchronisation and simultaneously its role as "master" by transmitting a sequence of synchronisation bursts ("sy" in figure 1, with 8 being sent in this example) using the DSB structure as given in ETS 300 396-2 [2], subclause 9.4.3. These synchronisation bursts contain frame count information which in the example defines their position in the timing structure in frames 17 and 18 of the 18 frame cyclic multiframe structure. The master DM-MS may then immediately transmit traffic ("tc" in figure 1) using the DNB structure as given in ETS 300 396-2 [2], subclause 9.4.3 in the next available frame which in this example is frame number 1.

NOTE: In the case where the DM "A" channel is already occupied, sync bursts can only be transmitted in alternate slots on the "B" channel.

Figure 1 also illustrates the position of slots which are allocated to allow pre-emption requests to be made ("p?" in figure 1), the slot available for linearization ("lch" in figure 1), and the synchronisation bursts denoting occupation of the channel ("syo" in figure 1) which occur in slot 3 of frames 6, 12 and 18 following the initial synchronisation.

For individual (point-to-point) calls, but not for group calls, it is also possible to set-up a call using a presence check in order to ascertain the availability of the destination DM-MS. The following sequence diagram illustrates this procedure.

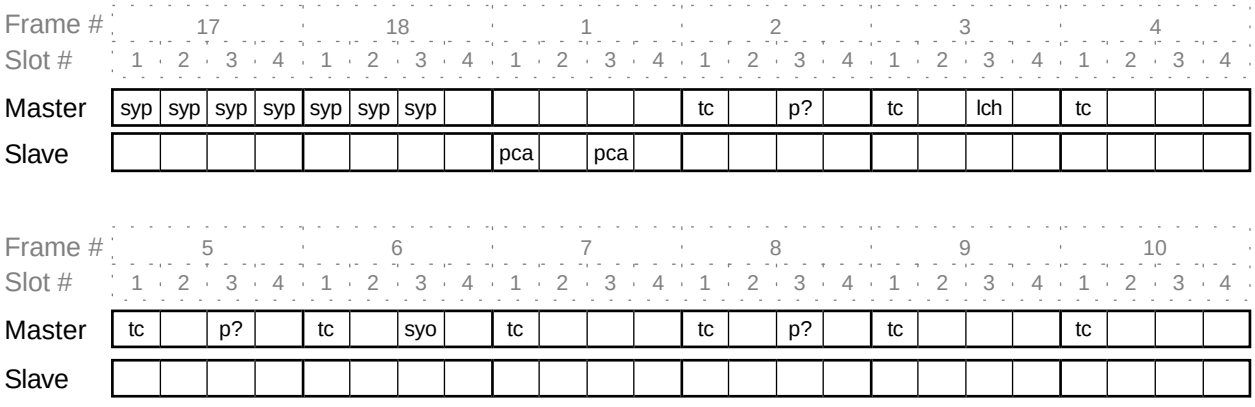
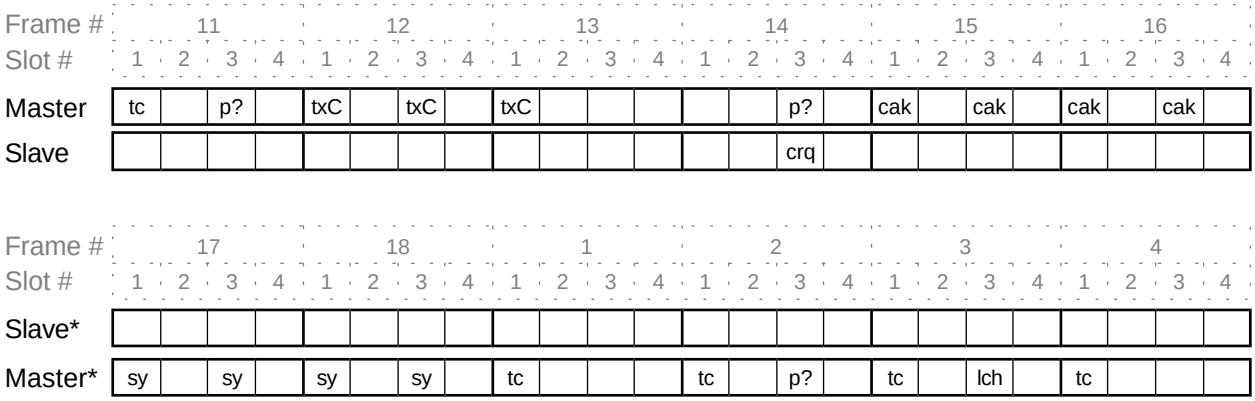


Figure 2: Call sequence for set-up with presence check

The procedure starts in a similar manner to the direct set-up, but the synchronisation burst ("syp" in figure 2, with 7 being sent in this example) now includes a parameter which is set to request a response indicating presence of the DM-MS which has been addressed as the recipient in the set-up attempt. This DM-MS which is defined as a "slave" for the transaction responds with a presence check acknowledge message ("pca" in figure 2) indicating its wish to receive the call and for the master to go ahead and transmit traffic. The slave responds with a minimum of two presence check acknowledge messages, and in some cases this may delay the first traffic burst by an additional frame.

4.3.3 Changeover in a call

In a DM call, each call transaction constitutes a separate transmission, with a designated master and slave(s) for each call transaction. The procedure for terminating one call transaction and starting another during a call is termed changeover and is illustrated by the following example sequence diagram.



NOTE: * indicates roles changed around after "cak" messages

Figure 3: Call sequence for changeover with no collisions

In order to changeover the talker (or sender) in a call, the master DM-MS shall first indicate that its call transaction has come to an end, using a transmit ceased message ("txC" in figure 3). This message is sent at least twice in slot 1 in consecutive frames and using the same burst format (DNB) as for normal traffic. Recipients of the call will therefore be aware of the termination of that call transaction and can then apply to the master to continue the call with a new call transaction using a changeover request message ("crq" in figure 3) which is sent in a slot 3. In the example, the timing of this message coincides with a slot allocated for pre-emption requests, which is allowed for by the protocol. Collisions between changeover request messages and pre-emption requests may occur if the slot positioning allows, as in this example, but the protocol is designed to control such contention with a random retry mechanism.

On receipt of a valid changeover request, the master may then surrender the channel to the successful applicant using a series of changeover acknowledgement messages ("cak" in figure 3). On transmission of the changeover acknowledgement messages, the master then becomes a slave and has no further responsibility for the channel. On receipt of the changeover acknowledgement, the requester transmits a sequence of synchronisation bursts ("sy" in figure 3) the action of which effects the call changeover with the requester providing his own synchronisation to the channel and thus becoming the new master for the next call transaction.

The frame numbering in figure 3 has been chosen arbitrarily as an example, but in this illustration, the first traffic burst of the new master has been delayed by a frame because of the need to provide synchronisation bursts in frame 18.

Figure 3 applies to both group and individual calls, but in group calls, there may be additional potential for contention between DM-MSs wishing to talk next and applying simultaneous changeover requests to the channel. In such instances a contention control random retry procedure is adopted as illustrated in figure 4.

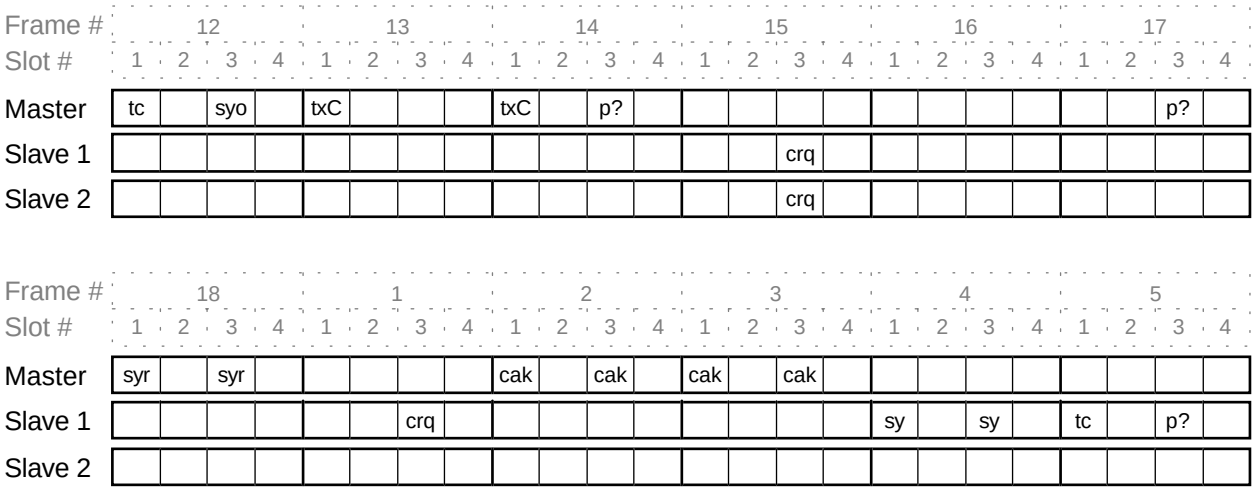


Figure 4: Call sequence for changeover with one collision

In this example two slave DM-MSs submit a changeover request to the channel at the same time. These requests may interfere at the master and produce an unintelligible result. The master thus receives no clear request and maintains the channel in reservation mode, applying reservation sync ("syr" in figure 4) as normal, until such time as another changeover request is successfully submitted or the reservation timer times out and the channel is released totally. In the example, slave 1 is shown to submit a second changeover request, which in this case is shown to be successful. slave 1 then becomes the master and goes to traffic in the normal way. The contention control/retry mechanism is detailed in subclause 8.5.7.

4.3.4 Pre-emption of a DM call

During a DM call, a DM-MS, who may or may not be from another group may wish to access the DM channel for a priority reason such as an emergency. In this case a mechanism for pre-empting the already occupied channel exists. It is illustrated in figure 5.

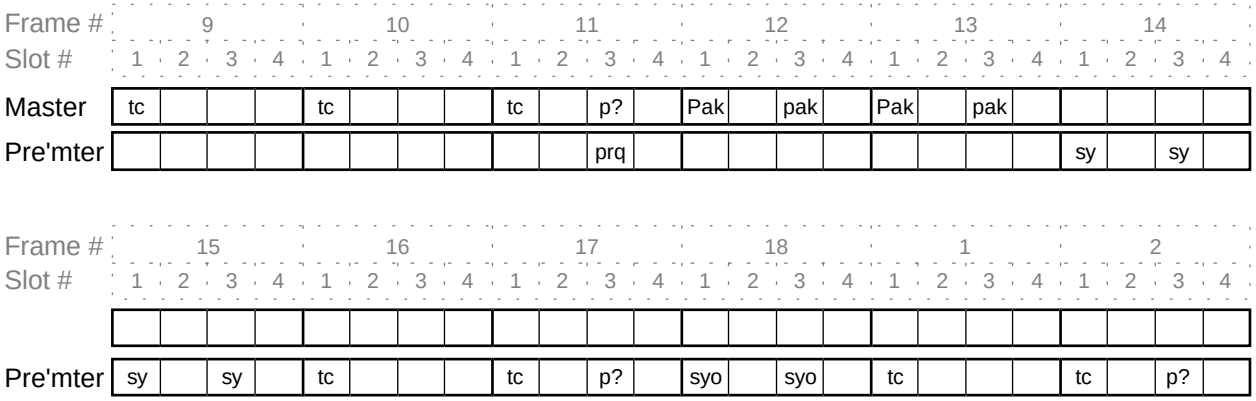


Figure 5: Call sequence for pre-emption of a DM call

The first master sequence shows normal progress of a call, with traffic bursts in slot 1. A DM-MS wishing to use the channel would in any case have had to first determine the state of the channel and in this illustration would have discovered the on-going call. It shall then have synchronised to the master MS and in the process determined the timing state of the channel, including the frame and slot numbers.

To effect the pre-emption, the DM-MS submits a pre-emption request message ("prq" in figure 5) at an appropriate position in the frame structure. Pre-emption is allowed only in slot 3 of frames 2, 5, 8, 11, 14 and 17. When the master successfully decodes this pre-emption request, assuming it is a valid request, it announces that the channel has been pre-empted to both the pre-empting DM-MS and the other DM-MSs which were involved in the ongoing call. This announcement is by means of the pre-emption

acknowledgement message ("Pak" and "pak" in figure 5), and on issuing this message the master ceases its role and relinquishes the channel.

The successful pre-emptor now shall transmit synchronisation bursts for what is in effect a new call, with a new group or individual addressee, and becomes master for the initial transaction of this new call.

4.3.5 Terminating a call

In DM the termination of a call is effected in the same way as cessation of a call transaction. After conclusion of its traffic, the master DM-MS issues transmit ceased messages and then provides reservation synchronisation bursts in frames 6, 12 and 18 until its channel reservation timer has expired. The master then ceases its transmission and the channel becomes free.

4.4 DM protocol layering

As outlined in ETS 300 396-1 [1], the protocol architecture of DM layering follows the generic OSI seven layer structure.

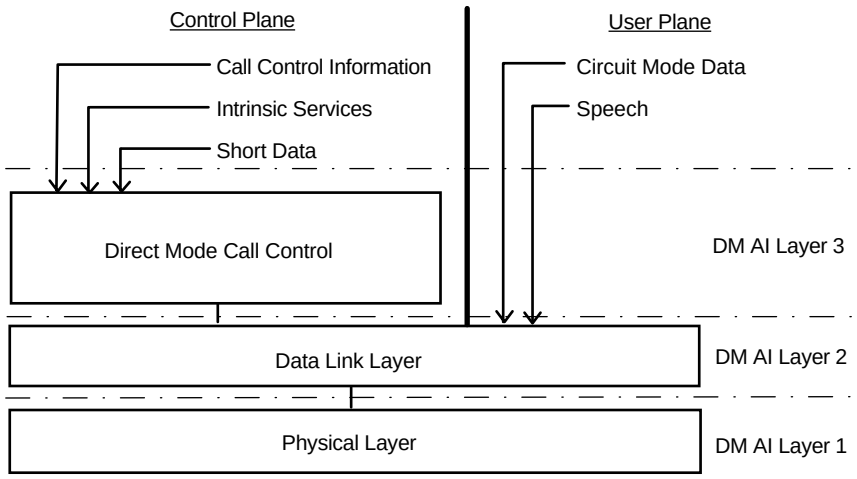


Figure 6: Protocol stack for MS functionality

The DLL (layer 2) handles the problem of sharing the medium by a number of users. At the DLL, the protocol stack is divided vertically into two parts:

- the User plane (U-plane) for transporting information without addressing capability; and

- the Control plane (C-plane) for signalling with addressing capability.

Layer 3, (DMCC) lies in the C-plane and is responsible for control of the call, provides the intrinsic services supported in DM, and supports the carriage of short data messages. U-plane access at layer 2 (DLL) supports the speech teleservice and the Circuit mode data bearer services which are available in TETRA DMO.

5 Layer 3 service description

5.1 Introduction

This clause describes the services offered by the DMCC entity.

5.2 Services offered

The DMCC services shall be provided with a DMCC entity at the Service Access Point DMCC-SAP. The DMCC-SAP shall then provide the following calling user application and called user application services:

- individual/group circuit mode call transmission and reception;

- direct call set-up;
- clear and encrypted circuit mode operation;
- pre-emption capability;
- user defined short message transmission and reception;
- pre-defined short message transmission and reception.

The flow of DM Call Control (DMCC) primitives shall be as given in figure 7.

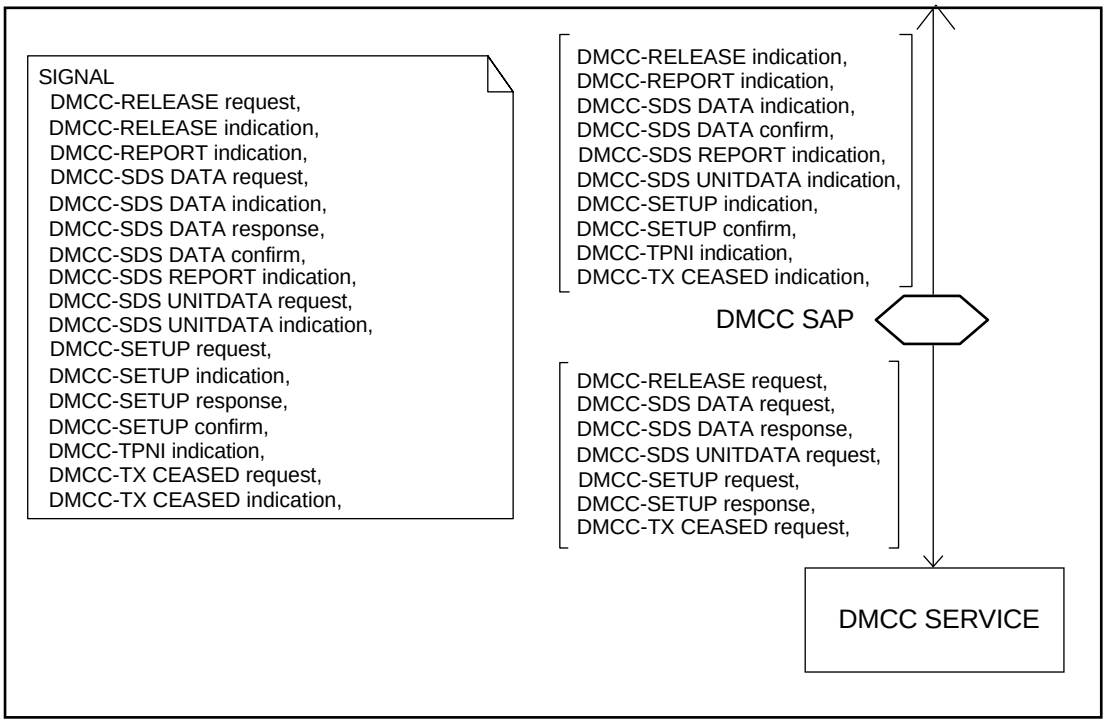


Figure 7: DMCC services provided at DMCC-SAP

5.3 Primitive description

The information contained in the primitive description tables which follow corresponds to the following key:

KEY: M: Mandatory; C: Conditional; O: Optional -: Not used

5.3.1 DMCC-RELEASE primitive

DMCC-RELEASE indication shall be used as an indicator to the user application that the circuit mode connection has ended.

DMCC-RELEASE request shall be used by the called user application to reject or leave a circuit mode call, or by the calling user application to terminate the call.

The parameters shall be as defined in table 1.

Table 1: Parameters for the DMCC-RELEASE primitive

Parameter	Request	Indication
Release cause	M	M

5.3.2 DMCC-REPORT primitive

DMCC-REPORT indication shall be used to indicate the failure of a DMCC-SETUP request in the case of a changeover request or pre-emption request in an ongoing call. It shall also be used for the DMCC to report a state change from CALL ACTIVE Tx to CALL ACTIVE Rx.

The parameters shall be as defined in table 2.

Table 2: Parameters for the DMCC-REPORT primitive

Parameter	Indication
Report	M

5.3.3 DMCC-SDS DATA primitive

DMCC-SDS DATA request shall be used by the calling user application to send a pre-defined or user defined short data message to another user given in the address parameter, using the acknowledged service.

DMCC-SDS DATA indication shall be used as an indication to the called user application that a pre-defined or user defined short data message from another user has been received over the DM air interface.

DMCC-SDS DATA response shall be used by the called user application if it wishes to respond to the previous DMCC-SDS DATA indication. The response data will be sent without an explicit acknowledgement from the peer entity.

DMCC-SDS DATA confirm shall be used as confirmation to the calling user application of the successful transmission of a pre-defined or user defined short data message. The confirm may carry a response message from the peer entity.

The parameters shall be as defined in table 3.

NOTE: For a user defined short data message, the content of the message is only known to the user. A pre-defined short data message is selected among a set of pre-defined messages and it is only the status number which is given as a parameter.

Table 3: Parameters for the DMCC-SDS DATA primitive

Parameter	Request	Indication	Response	Confirm
Short data message	M	M	M	C (note)
Called party TSI	M	M	-	-
Calling party TSI	-	M	-	-
Priority level	M	M	-	-
Extended error protection	M	-	M	-
NOTE: Included if the DM-SDS ACK PDU carried a short data message				

5.3.4 DMCC-SDS REPORT primitive

DMCC-SDS REPORT indication shall be used to indicate to the calling user application the failure of transmission of a short data message (either pre-defined or user-defined) or the completed transfer of an unacknowledged short data message.

The parameters shall be as defined in table 4.

Table 4: Parameters for the DMCC-SDS REPORT primitive

Parameter	Indication
SDS transfer result	M

5.3.5 DMCC-SDS UNITDATA primitive

DMCC-SDS UNITDATA request shall be used by the calling user application to send a pre-defined or user defined short data message to another user or users given in the address parameter, using the unacknowledged service.

DMCC-SDS UNITDATA indication shall be used as an indication to the called user application that a pre-defined or user defined message from another user has been received over the air interface. The message may either be an individual message or a group message.

The parameters shall be as defined in table 5.

NOTE: For a user defined short data message, the content of the message is only known to the user. A pre-defined short data message is selected among a set of pre-defined messages and it is only the status number which is given as a parameter.

Table 5: Parameters for the DMCC-SDS UNITDATA primitive

Parameter	Request	Indication
Short data message	M	M
Called party TSI	M	M
Calling party TSI	-	M
Priority level	M	M
Extended error protection	M	-

5.3.6 DMCC-SETUP primitive

DMCC-SETUP request shall be used by a calling user application to initiate or continue a voice or data circuit-mode call.

DMCC-SETUP indication shall be used to indicate to a called user application an incoming voice or data circuit-mode call.

DMCC-SETUP response shall be used by a called user application to accept a call set up request.

DMCC-SETUP confirm shall be used as a confirmation to the calling user whether or not a voice or data circuit-mode call has been successfully set up.

The parameters shall be as defined in table 6.

Table 6: Parameters for the DMCC-SETUP primitive

Parameter	Request	Indication	Response	Confirm
Basic service information	M	M	O	M
Called party TSI	M	M	-	-
Calling party TSI	-	C (note 1)	-	-
Presence check	M	M	-	-
Priority level	M	M	-	-
Late entry information	-	M	-	-
Minimum interleaving depth	C (note 2)	-	-	-
TPNI requirement	M	-	-	-
NOTE 1: Included if provided in the set-up PDU NOTE 2: Included for protected circuit mode data				

5.3.7 DMCC-TPNI primitive

DMCC-TPNI indication shall be used to indicate the transmitting party's address to the called user application if it was not provided in the DMCC-SETUP indication.

The parameters shall be as defined in table 7.

Table 7: Parameters for the DMCC-TPNI primitive

Parameter	Indication
Calling party TSI	M

5.3.8 DMCC-TX CEASED primitive

DMCC-TX CEASED request shall be used as a request from the calling user application to cease transmission of circuit mode voice or data.

DMCC-TX CEASED indication shall be used as an indication to either the calling or called user application that the transmitting MS in a call has ceased transmission.

The parameters shall be as defined in table 8.

Table 8: Parameters for the DMCC-TX CEASED primitive

Parameter	Request	Indication
Cease cause	-	M
Recent user priority	M	-
Priority level (note)	O	O
NOTE: Included only if different from DMCC-SETUP		

NOTE: It is recommended that the same value of "Recent user priority" is used by the user applications within one group in order to harmonise quality for a group call (i.e. the "Recent user priority" value should be an attribute for a group). For an individual call the "Recent user priority" should be set to "invoked".

5.4 Parameter description

Parameters shall be part of the primitives described in subclause 5.3 and if applied the parameters shall contain the values specified in this subclause.

1) basic service information (a set of parameters) =

- circuit mode service;
- communication type;
- data service/speech service;
- encryption flag;

a) circuit mode service =

- data;
- speech;

b) communication type =

- point-to-point;
- point-to-multipoint;

c) data service =

- unprotected: 7,2 kbit/s no interleaving;
- low protection: 4,8 kbit/s short interleaving depth = 1;
- low protection: 4,8 kbit/s medium interleaving depth = 4;
- low protection: 4,8 kbit/s long interleaving depth = 8;
- high protection: 2,4 kbit/s short interleaving depth = 1;
- high protection: 2,4 kbit/s medium interleaving depth = 4;
- high protection: 2,4 kbit/s long interleaving depth = 8;

NOTE: The increase in interleaving depth gives a better error protection, but also generates a longer transmission delay.

d) speech service =

- TETRA encoded speech;
- 7,2 kbit/s unprotected data, (see note 1);

NOTE: This service should carry a non-TETRA encoded speech and channel coding.

e) encryption flag =

- clear end-to-end transmission;
- end-to-end encrypted transmission;

2) Called party TSI =

- Individual TETRA Subscriber Identity (ITSI); or
- Group TETRA Subscriber Identity (GTSI);

3) Calling party TSI =

- Individual TETRA Subscriber Identity (ITSI);

4) Minimum interleaving depth =

- No Interleaving (N=1);
- Interleaving with N=4 (i.e. medium interleaving);
- Interleaving with N=8 (i.e. long interleaving);

5) Priority level =

- normal priority call;
- high priority call;
- pre-emptive priority call;
- emergency pre-emptive priority call;

6) Presence check =

- presence check requested;
- presence check not requested;

7) Recent user priority =

- invoked;
- not invoked;

8) Cease cause =

- cause not defined or unknown;
- normal end of transmission;
- pre-emptive use of resource;
- transmission time limit reached;
- channel now in reservation;

9) Release cause =

- cause not defined or unknown (request and indication);
- user initiated release (request and indication);
- pre-emptive use of resource (indication only);
- channel reservation timer expired (indication only);
- channel is busy (indication only);
- called party is not reachable (indication only);
- called party rejected call (request and indication);
- called party does not support end-end encryption (request and indication);

- called party does not support requested service (request and indication);
- called party offered unacceptable service (indication only);
- channel relinquished (indication only);
- pre-emption failure (indication only);
- pre-emption rejected (indication only);

10) Late entry information =

- Yes;
- No;

11) TPNI requirement =

- TPNI required;
- TPNI shall be suppressed;
- TPNI may be provided;

12) Report =

- changeover or pre-emption failure;
- changeover or pre-emption rejected;
- state change, CALL ACTIVE Tx to CALL ACTIVE Rx;

13) Short Data Message =

- user defined data 1 (16 bits); or
- user defined data 2 (32 bits); or
- user defined data 3 (64 bits); or
- user defined data 4 (0-2 047 bits); or
- status number

14) Status number =

0	emergency call;
1 to 32 767	reserved;
32 768 to 65 535	available for TETRA network specific definition

15) Extended error protection =

- requested;
- not requested;
- SDS transfer result =Unacknowledged short data transfer completed;
- failed short data transfer - outcome unknown;
- failed short data transfer - message cannot have been received;
- called party rejected short data (acknowledged service only);
- channel is busy;
- changeover or pre-emption failure;
- changeover or pre-emption rejected.

5.5 States for DMCC SAP

Circuit mode calls and short data are parallel services and thus separate SAP state transition diagrams are defined for them.

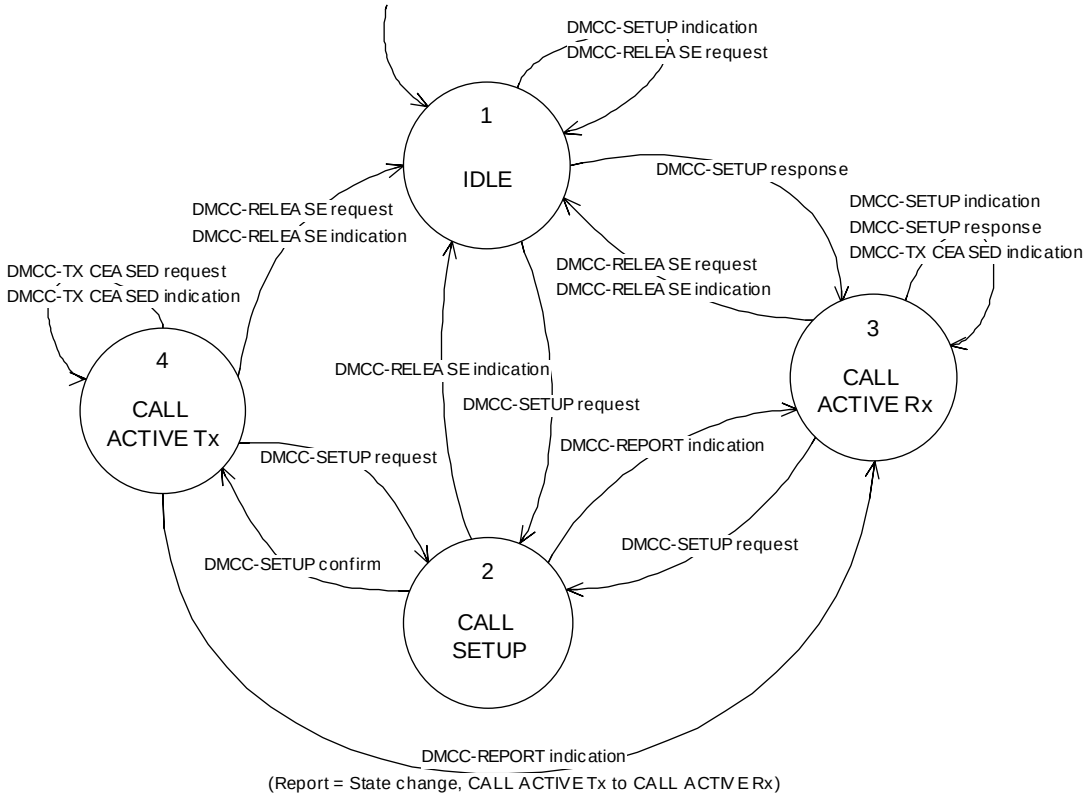


Figure 8: State transition diagram for circuit mode calls at the DMCC SAP

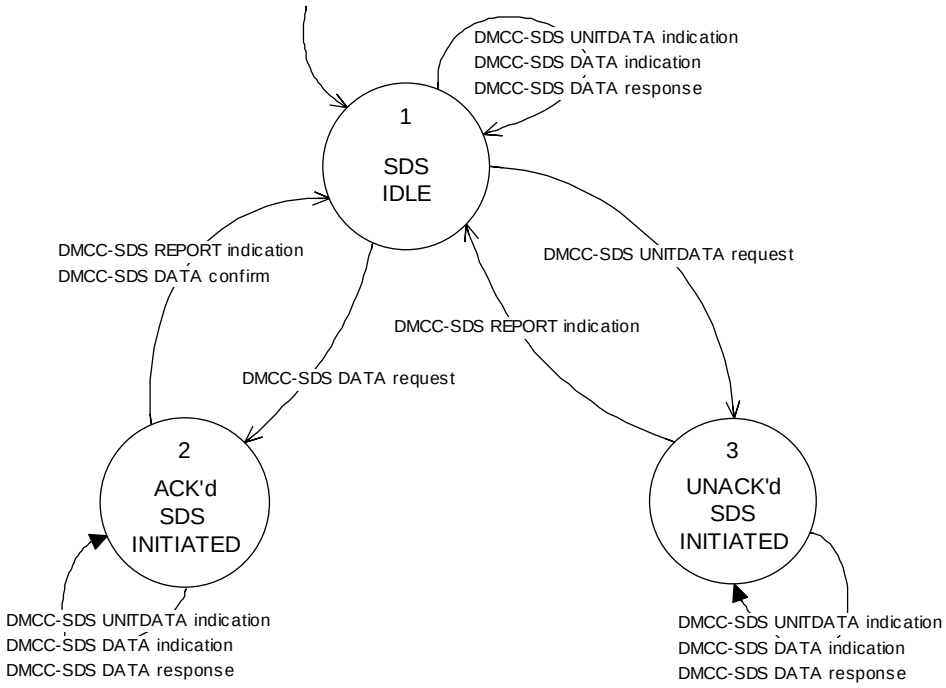


Figure 9: State transition diagram for short data at the DMCC SAP

6 Layer 3 protocol

6.1 Introduction

This clause describes the layer 3 protocol. In the direct MS-MS protocol, the layer 3 protocol is performed by the DMCC entity. The services provided at the DMCC-SAP to the user application are described in clause 5.

The DMCC performs the layer 3 functions for both circuit mode calls and short data messages (user-defined short messages and pre-coded status). The procedures are defined in subclauses 6.2 and 6.3 respectively.

6.1.1 DMCC protocol states

In this subclause there is given only the main description of the states. The actual state transitions are described in the DMCC procedures.

6.1.1.1 IDLE

This is the normal state when no calls exist and indicates that the DMCC entity is available to handle a circuit mode call or short data. This is the state that DMCC shall enter after initial start up.

6.1.1.2 CALL SETUP NORMAL

This state exists when a DM-MS originated set-up has been initiated without presence check but the call has not yet been established.

6.1.1.3 CALL SETUP PRES_CHECK

This state exists when a DM-MS originated set-up has been initiated with presence check but the call has not yet been established.

6.1.1.4 PRE-EMPTION

This state exists when a DM-MS has originated a pre-emption procedure.

6.1.1.5 CALL ACTIVE TX Occupation

This state exists when a call has been established and the DM-MS is transmitting circuit mode traffic.

6.1.1.6 CALL ACTIVE TX Reservation

This state exists when a call has been established and the DM-MS has ceased traffic transmission but the channel reservation time has not expired.

6.1.1.7 CALL ACTIVE RX Occupation

This state exists when a call has been established and the DM-MS is receiving traffic.

6.1.1.8 CALL ACTIVE RX Reservation

This state exists when a call has been established and the other previously transmitting DM-MS has ceased its traffic transmission but the channel reservation time has not expired.

6.1.1.9 WAIT RSP Occupation

This state exists when a call has been established and the DM-MS has initiated pre-emption (call continuation) while the DM-MS is receiving traffic.

6.1.1.10 WAIT RSP Reservation

This state exists when a call has been established and the DM-MS has initiated a changeover during the channel reservation period.

6.1.1.11 ACK SHORT DATA INITIATED

This state exists when an acknowledged short data transaction is in progress.

6.1.1.12 UNACK SHORT DATA INITIATED

This state exists when an unacknowledged short data transaction is in progress.

6.2 Circuit mode calls

This subclause defines the DM procedures for speech and data circuit mode calls.

A circuit mode call may be addressed to an individual (point-to-point call) or to a group (point-to-multipoint call). For individual calls, the signalling procedures support two types of call set-up, i.e. call set-up with or without presence check. For group calls, the signalling procedures support only one type of call set-up, i.e. call set-up without presence check.

In call set-up without presence check, the call set-up is signalled by the DM-SETUP PDU. Then, if the called user application can support the call, the called DM-MS is placed immediately into the call. The call priority may affect whether the user application accepts the call or not.

In call set-up with presence check, the call set-up is signalled by the DM-SETUP PRES PDU. The called DM-MS immediately sends a response indicating acceptance or rejection of the call (DM-CONNECT or DM-DISCONNECT PDU).

NOTE: For both types of set-up, immediate action is taken by the called user application to decide whether to accept or reject the call. The behaviour of the user application between the reception of the incoming set-up signalling and the acceptance/rejection of the call is outside the scope of this ETS. For call set-up without presence check, the called DM-MS does not signal that acceptance or rejection to the calling DM-MS.

DM does not support an equivalent procedure to the V+D on/off hook signalling.

When a calling DM-MS sends call set-up signalling, it becomes the master of the channel during its traffic transmission (occupation period) and the subsequent reservation period, until another DM-MS wishes to transmit or the reservation time expires. (The reservation period is the time during which the channel is reserved for further transmissions in the same call.) The called DM-MS(s) act as slaves throughout both the occupation and reservation periods.

During both the occupation and reservation periods, any other DM-MS that wishes to transmit traffic must first request and be granted permission by the current master. Having received permission, the DM-MS then performs a set-up procedure similar to that for initial call set-up and becomes master of the channel itself.

The pre-emption procedure applies either if a DM-MS not in the ongoing call wishes to take the channel during occupation/reservation or if a DM-MS receiving in the ongoing call wishes to interrupt the master DM-MS's traffic transmission. The changeover procedure applies if a DM-MS in the ongoing call sends a request during the reservation period, asking for permission to transmit next in the call.

6.2.1 Procedures for call set-up without presence check

Group circuit mode calls shall be set up using this procedure. Individual circuit mode calls may be set up using this procedure. The procedure is illustrated in figure 10.

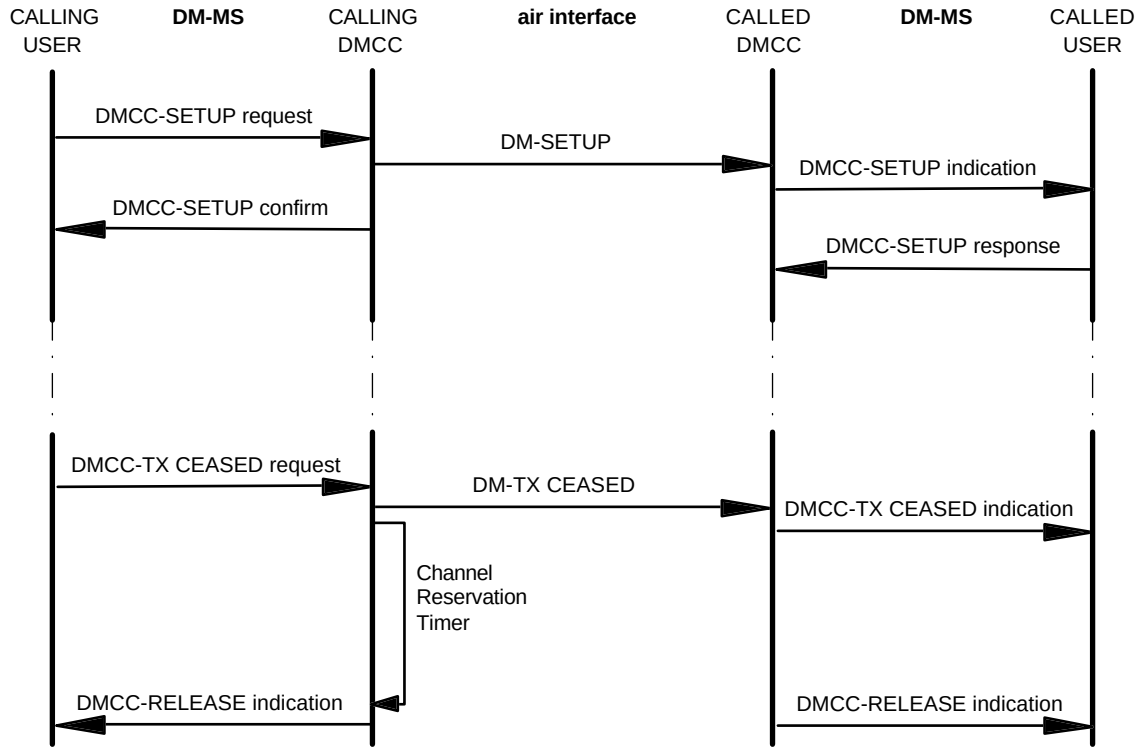


Figure 10: Direct call set-up

6.2.1.1 Outgoing call

A user application initiates call establishment or continuation of an ongoing call by transferring a DMCC-SETUP request primitive across the DMCC-SAP to the DMCC entity. The following procedure applies if the DMCC-SETUP request indicates that a presence check is not required. The DMCC-SETUP request includes parameters indicating the required service, which is not negotiable in this case. It also indicates the priority of the call.

If the request relates to call continuation then the DMCC shall use the procedures in subclause 6.2.4 or 6.2.5 to decide how to proceed. Otherwise, if the DM channel is not currently free (or in the case of frequency efficient mode neither "A" nor "B" channel is free), then the DMCC shall use the procedures in subclause 6.2.6 to decide whether pre-emption is valid. Otherwise, the DMCC shall immediately perform the following call set-up procedure.

The DMCC shall convert the DMCC-SETUP request into a corresponding DM-SETUP PDU and send it, and shall enter state CALL SETUP NORMAL. After sending the DM-SETUP PDU, the DMCC shall await a DMA-REPORT indication from layer 2, reporting on the progress of the transmission.

NOTE: The DMCC sends a single DM-SETUP PDU, which is given to layer 2 in a DMA-UNITDATA request primitive. Layer 2 then transmits the PDU the appropriate number of times using the appropriate transmission method; refer to clause 8. The same principle applies whenever the DMCC sends a PDU (see subclause 6.4).

If the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted then the DMCC shall enter state CALL ACTIVE Tx Occupation (following the procedures for a master DM-MS during occupation), inform the user application with a DMCC-SETUP confirm, issue a DMC-CONFIGURE request for lower layer traffic configuration and start timer T.311.

Otherwise, if the DMCC receives a DMA-REPORT indication reporting failure (i.e. the channel has become busy), it shall either:

a) inform the user application with a DMCC-RELEASE indication and return to state IDLE; or

b) for a sufficiently high priority request, invoke the pre-emption procedure; see subclause 6.2.6 or subclause 6.2.4.

NOTE: In the protocol model, it is the responsibility of the DMCC to determine, by address comparison, whether the DMCC-SETUP request primitive relates to a new call or to continuation of an ongoing call. A DMCC-SETUP request primitive relates to continuation of an ongoing call if the DM-MS is participating in the call (as master or slave) and:

- for an ongoing group call, the request primitive indicates that group address as the "called party TSI"; or
- for an ongoing individual call, the request primitive indicates the other participating party as the "called party TSI".

6.2.1.2 Incoming call

Notification of the arrival of an incoming call to the DMCC entity shall be made by the reception of a DM-SETUP PDU (delivered by layer 2 in a DMA-UNITDATA indication primitive). The information shall be delivered to the user application in a DMCC-SETUP indication via the DMCC-SAP.

If the user application can support the call and wishes to accept it, it shall immediately return a DMCC-SETUP response. On reception of the DMCC-SETUP response, the DMCC shall enter state CALL ACTIVE Rx Occupation (following the procedures for a slave DM-MS during occupation) and shall issue a DMC-CONFIGURE request for lower layer traffic configuration.

If the user application is unable to accept the incoming call (for example, if circuit mode data is requested but the terminal cannot support data) then the call shall be rejected locally by issuing a DMCC-RELEASE request to the DMCC via the DMCC-SAP. The DMCC shall return to state IDLE. No negotiation with the calling DM-MS shall be possible.

NOTE: If the DM-SETUP PDU relates to a continuation of a call in which the DM-MS is already participating, then the DMCC delivers the information to the user application in a DMCC-SETUP indication. It is an MS designer choice whether the user application then returns a DMCC-SETUP response or DMCC-RELEASE request (as above), or whether the DMCC itself may decide to accept the call continuation.

6.2.1.3 Temporary group address

If authorised by its configuration, a DM-MS may make a group call to a group to which it does not belong. The DM-MS shall implicitly assume temporary membership of the called group address for the duration of the call i.e. during all the subsequent occupation and reservation periods until the channel becomes free. When the DMCC sends the DM-SETUP PDU, it shall issue a DMC-CONFIGURE request primitive to the lower layers including the group address as one of its valid addresses. At the end of the call (i.e. when a DMCC-RELEASE primitive is transferred to or from the user application), the DMCC shall issue another DMC-CONFIGURE request primitive informing the lower layers that the temporary group address is no longer valid.

NOTE: The above procedure is only available for a DM-MS that has been specifically authorised, during its configuration, to use this facility. The temporary group membership enables the DM-MS to receive traffic transmissions sent in reply.

6.2.2 Procedures for call set-up with presence check

Individual circuit mode calls may be set up using this procedure. Group circuit mode calls shall not be set up using this procedure. The procedure is illustrated in figure 11.

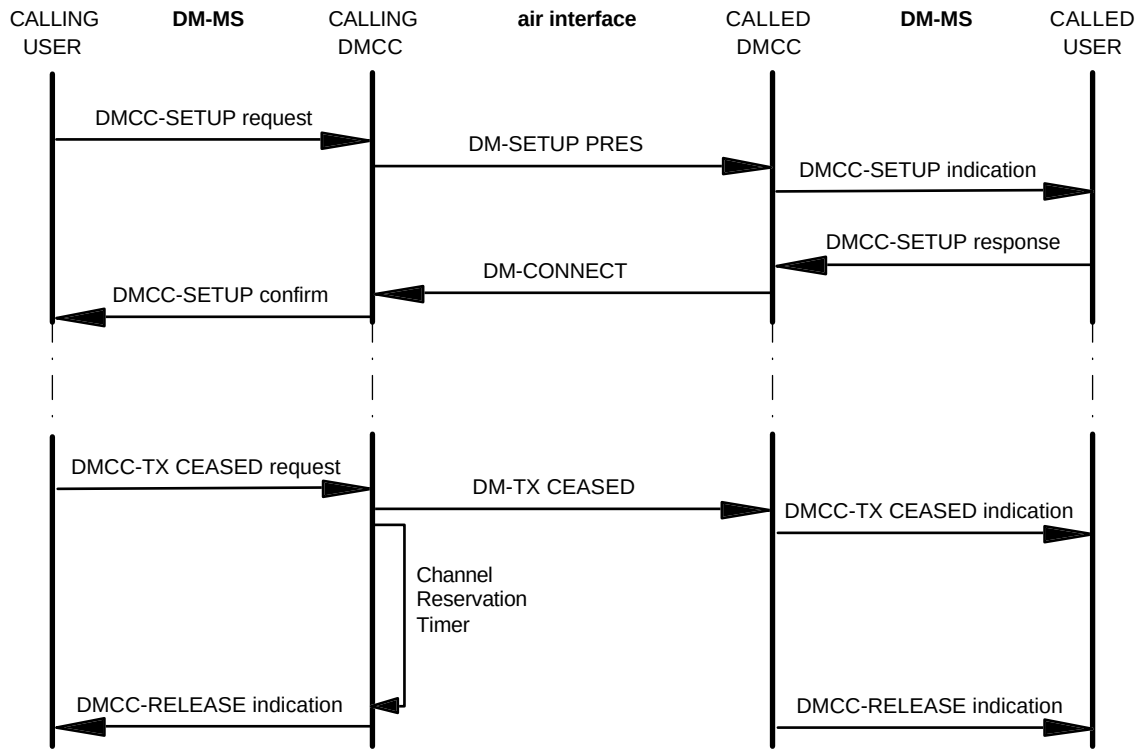


Figure 11: Call set-up with presence check

6.2.2.1 Outgoing call

A user application initiates call establishment or continuation of an ongoing call by transferring a DMCC-SETUP request primitive across the DMCC-SAP to the DMCC entity. The following procedure applies if the DMCC-SETUP request indicates that a presence check is required. In this case, the DMCC-SETUP request includes parameters indicating both the target grade of service and the lowest acceptable grade of service. This allows the called user application to accept a lower interleaving depth than that requested.

If the request relates to call continuation then the DMCC shall use the procedures in subclause 6.2.4 or subclause 6.2.5 to decide how to proceed. Otherwise, if the DM channel is not currently free (or in the case of frequency efficient mode neither "A" nor "B" channel is free), then the DMCC shall use the procedures in subclause 6.2.6 to decide whether pre-emption is valid. Otherwise, the DMCC shall immediately perform the following call set-up procedure.

The DMCC shall convert the DMCC-SETUP request into a corresponding DM-SETUP PRES PDU and send it, and shall enter state CALL SETUP PRES_CHECK. After sending the DM-SETUP PRES PDU, the DMCC shall await a DMA-REPORT indication from layer 2, reporting on the progress of the transmission:

- if the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted the appropriate number of times, the DMCC shall await a response from the called DM-MS;

- if it receives a DM-CONNECT PDU either accepting the requested service or offering an acceptable reduced service, the DMCC shall enter state CALL ACTIVE Tx Occupation (following the procedures for a master DM-MS during occupation), inform the user application with a DMCC-SETUP confirm, issue a DMC-CONFIGURE request for lower layer traffic configuration and start timer T.311 (see subclause 8.6.3);

- if it receives a DM-CONNECT PDU offering a reduced service that is not acceptable, the DMCC shall issue a DMC-CONFIGURE request but shall immediately send the DM-RELEASE PDU, issue a DMCC-RELEASE indication to the user application and return to state IDLE;

- if it receives a DM-DISCONNECT PDU, the DMCC shall send the DM-RELEASE PDU, issue a DMCC-RELEASE indication to the user application and return to state IDLE;

- if it does not receive a response within a time T.303 following the DMA-REPORT indication, the DMCC shall issue a DMC-CONFIGURE request and shall immediately send the DM-RELEASE PDU. It shall then either send the DM-SETUP PRES PDU again (without indicating "immediate retransmission" in the DMA-UNITDATA request), or otherwise issue a DMCC-RELEASE indication to the user application and return to state IDLE, see figure 12. The DMCC shall attempt the call set-up for up to a maximum of N.303 times or until successful.

Otherwise, if the DMCC receives a DMA-REPORT indication reporting failure (i.e. the channel has become busy), it shall either:

a) inform the user application with a DMCC-RELEASE indication and return to state IDLE; or

b) for a sufficiently high priority request, invoke the pre-emption procedure, (see subclause 6.2.6 or subclause 6.2.4).

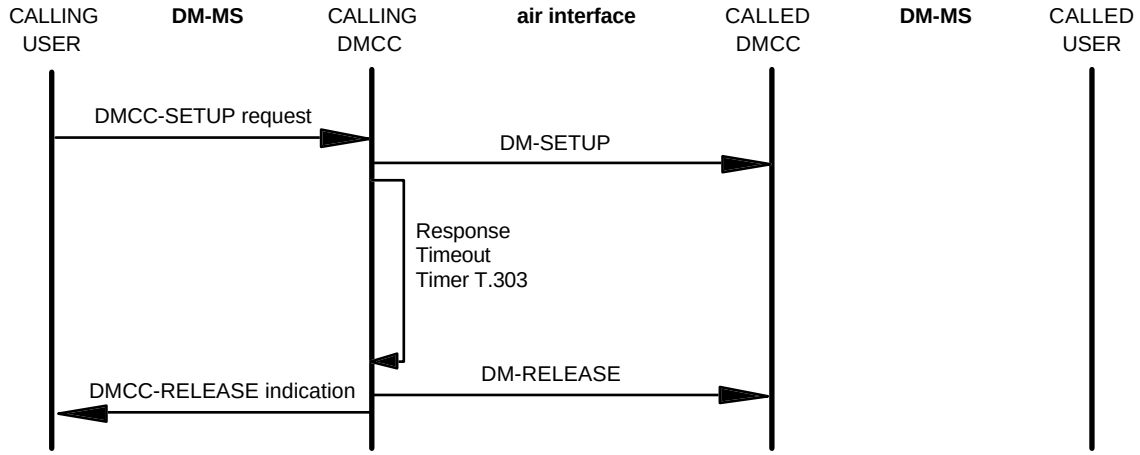


Figure 12: Call set-up failure

6.2.2.2 Incoming call

Notification of the arrival of an incoming call to the DMCC entity shall be made by the reception of a DM-SETUP PRES PDU. The information shall be delivered to the user application in a DMCC-SETUP indication via the DMCC-SAP.

If the user application wishes to accept the call, either with the requested service or with a reduced interleaving depth for protected data, it shall immediately return a DMCC-SETUP response. The DMCC shall then send a DM-CONNECT PDU to the calling DM-MS, enter state CALL ACTIVE Rx Occupation (following the procedures for a slave DM-MS during occupation) and issue a DMC-CONFIGURE request for lower layer traffic configuration. The DM-CONNECT PDU shall contain the offered service information.

NOTE: In DMO, the only service negotiation currently supported is reduction of interleaving depth. So, if interleaving depth N = 8 was requested then N = 4 or N = 1 may be offered; if N = 4 was requested then N = 1 may be offered.

If the user application is unable to accept the incoming call, it shall immediately return a DMCC-RELEASE request. The DMCC shall then send the DM-DISCONNECT PDU indicating the disconnection cause and shall return to state IDLE (see figure 13).

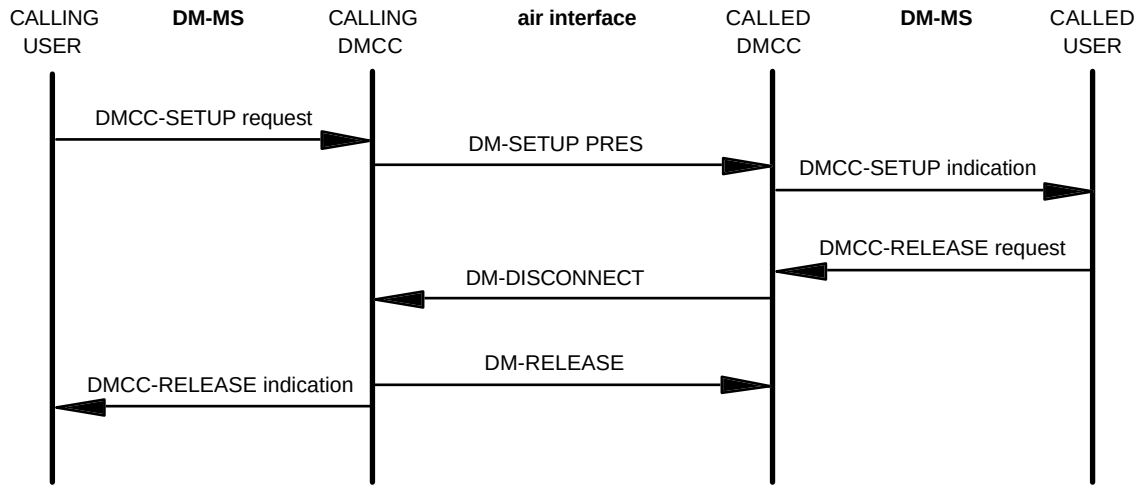


Figure 13: Call rejection

6.2.3 Procedures for late entry

At the start of circuit mode traffic transmission, the master DMCC (i.e. the calling DMCC) shall issue a DMA-UNITDATA request to layer 2 containing a DM-OCCUPIED PDU. While it is transmitting circuit mode traffic, layer 2 sends the DM-OCCUPIED PDU at intervals, (see clause 8). This PDU is similar to the DM-SETUP PDU and enables late entry by DM-MSs that did not receive the initial set-up signalling.

If a DMCC that is not already participating in the related call receives a DM-OCCUPIED PDU that has not been received already, it shall inform the user application of the incoming call in a DMCC-SETUP indication (indicating that this is late entry information). The procedure shall then be the same as for an incoming call without presence check, as defined in subclause 6.2.1.2.

6.2.4 Procedures during occupation

6.2.4.1 Master DM-MS

A master DM-MS sending circuit mode traffic shall obey the following procedures:

a) during the traffic transmission, the DMCC may receive a DM-PREEMPT PDU requesting pre-emptive use of the channel. It shall check that the request is valid i.e. that the priority is pre-emptive priority or emergency pre-emptive priority and is higher than the ongoing call. If the pre-emption request is valid then the DMCC shall immediately:

   - send a DM-PRE ACCEPT PDU addressed to the pre-emptor; and
   - stop timer T.311; and
     - if the DM-PREEMPT is for continuation of the ongoing call: send a DM-TX CEASED PDU addressed to the called DM-MS(s) in the ongoing call indicating that the transmission has been pre-empted, issue a DMCC-TX CEASED indication and DMCC-REPORT indication to the user application and enter state CALL ACTIVE Rx Reservation as a slave DM-MS during reservation; or
     - if the DM-PREEMPT relates to a new call: send a DM-RELEASE PDU addressed to the called DM-MS(s) in the ongoing call indicating that the call has been pre-empted, inform the user application with a DMCC-RELEASE indication and return to state IDLE;

   NOTE: The DM-TX CEASED / DM-RELEASE and DM-PRE ACCEPT PDUs should be given to layer 2 at the same time. Layer 2 will place the two PDUs in the two halves of the same slots for transmission over the air, sending them at the first opportunity.

if the pre-emption request is not valid then the DMCC shall send a DM-REJECT PDU addressed to the pre-emptor (and shall remain in state CALL ACTIVE Tx Occupation);

b) at the end of a transmission, the user application normally transfers a DMCC-TX CEASED request across the DMCC-SAP to the DMCC and indicating whether "Recent user priority" is invoked or not. The DMCC shall send this information in a DM-TX CEASED PDU addressed to the called DM-MS(s) and shall stop timer T.311. It shall enter state CALL ACTIVE Tx Reservation as master during the following reservation period. For a normal end of transmission, the master DM-MS should set the reservation time to a value greater than zero, allowing for changeover requests. The DMCC shall set the internal parameter "recent user flag" to value 1;

c) if the user application wishes to terminate the call then it shall transfer a DMCC-RELEASE request to the DMCC. The DMCC shall send a DM-RELEASE PDU to the called DM-MS(s), stop timer T.311 and return to state IDLE;

d) on expiry of timer T.311 (the call transmission timer), the DMCC shall issue a DMCC-TX CEASED indication to the user application and shall send a DM-TX CEASED PDU to the called DM-MS(s). It shall enter state CALL ACTIVE Tx Reservation as master during the following reservation period.

6.2.4.2 Slave DM-MS

A slave DM-MS receiving circuit mode traffic shall obey the following procedures:

a) if the DMCC receives a DM-TX CEASED PDU then it shall inform the user application with a DMCC-TX CEASED indication. It shall enter state CALL ACTIVE Rx Reservation, following the procedures for a slave DM-MS during reservation; see subclause 6.2.5.2;

b) if the DMCC receives a DM-RELEASE PDU then it shall inform the user application with a DMCC-RELEASE indication and shall return to state IDLE;

c) if the DMCC receives a DM-SDS UDATA PDU then it shall process that PDU as defined in subclause 6.3.2.1 (and shall remain in the same circuit mode state);

d) if the user application wishes to leave the call then it shall transfer a DMCC-RELEASE request to the DMCC. The DMCC shall issue a DMC-CONFIGURE request to layer 2 indicating "call release" and shall return to state IDLE;

NOTE: In this case the slave DM-MS leaves the call without signalling. It is recommended that this procedure is not used for an individual call other than for emergency reasons.

e) if layer 2 reports that the channel is now in reservation for the call (DMC-REPORT indication), then the DMCC shall inform the user application with a DMCC-TX CEASED indication. It shall enter state CALL ACTIVE Rx Reservation, following the procedures for a slave DM-MS during reservation; see subclause 6.2.5.2;

f) if layer 2 reports that the call has been lost (DMC-REPORT indication) then the DMCC shall inform the user application with a DMCC-RELEASE indication and shall return to state IDLE;

g) if the user application issues a DMCC-SETUP request for continuation of the ongoing call then the DMCC shall check whether pre-emption is valid i.e. whether the request priority is pre-emptive or emergency pre-emptive and is higher than the priority of the current transmission;

- if pre-emption is valid then the DMCC may send a DM-PREEMPT PDU addressed to the master DM-MS and shall enter state WAIT RSP Occupation. It shall then wait for a response from the master:

  - if it receives a DM-PRE ACCEPT PDU, it shall then obey the appropriate procedures for outgoing call set-up, as defined in subclause 6.2.1.1 or 6.2.2.1;

- if it receives a DM-REJECT PDU then it shall inform the user application with a DMCC-REPORT indication and shall return to state CALL ACTIVE Rx Occupation;

- if it receives a DMA-REPORT indication reporting a change of master DM-MS, and if the pre-emption is still valid, then the DMCC may re-send the DM-PREEMPT addressed to the new master. Or, if it receives a DMA-REPORT indicating that the channel is now free then the DMCC may obey the appropriate procedures for outgoing call set-up, as defined in subclauses 6.2.1.1 or 6.2.2.1. For other DMA-REPORTs indicating random access failure, the DMCC shall inform the user application of the failure with a DMCC-REPORT indication and shall return to state CALL ACTIVE Rx Occupation;

- if pre-emption is not valid then the DMCC may either discard the request (informing the user application with a DMCC-REPORT indication) or may hold the request until the end of the current transmission and then send a changeover request, as defined in subclause 6.2.5.2, and indicating that the changeover request has been held during occupation when it issues the DMA-UNITDATA request (see subclause 6.4 g). If the "recent user flag" is set to value 1 then the DMCC shall also indicate in the primitive that this is a recent user changeover request.

After procedures a), b), d), e), f) and g), the DMCC shall set its internal parameter "recent user flag" to value 0.

6.2.4.3 Transmitting Party Number Identification (TPNI)

For an intra-MNI call, and if the master DM-MS used its true Individual Short Subscriber Identity (ISSI) as the layer 2 source address when sending the DM-SETUP or DM-SETUP PRES PDU, the called DMCC(s) shall provide TPNI to the user application as the "calling party TSI" parameter in the DMCC-SETUP indication primitive.

For an inter-MNI call or for an intra-MNI call if the master DM-MS did not use its true ISSI as the layer 2 source address, and if the DMCC-SETUP request primitive required TPNI to be provided, then during occupation the master DMCC shall send the DM-INFO PDU containing its TSI.

If a slave DM-MS receiving circuit mode traffic receives a DM-INFO PDU containing TPNI information, and if the information has not been received already, then the DMCC shall deliver the information to the user application in a DMCC-TPNI indication primitive.

6.2.5 Procedures during reservation

6.2.5.1 Master DM-MS

During the reservation period, the master DM-MS shall obey the following procedures:

a) if the DMCC receives a DM-PREEMPT PDU requesting pre-emptive use of the channel, it shall check that the request is valid i.e. that the priority is pre-emptive priority or emergency pre-emptive priority and is higher than the ongoing call;

   if the pre-emption request is valid then the DMCC shall send a DM-PRE ACCEPT PDU addressed to the pre-emptor. Also, if the DM-PREEMPT is for continuation of the ongoing call, the DMCC shall issue a DMCC-REPORT indication to the user application and enter state CALL ACTIVE Rx Reservation as a slave DM-MS during reservation; or, if the DM-PREEMPT relates to a new call, the DMCC shall inform the user application with a DMCC-RELEASE indication and shall return to state IDLE;

   if the pre-emption request is not valid then the DMCC shall send a DM-REJECT PDU addressed to the pre-emptor (and shall remain in the same state);

b) if the DMCC receives a DM-TX REQUEST PDU requesting continuation of the ongoing call, it may perform validity checks on the request. If the changeover request is accepted then the DMCC shall send a DM-TX ACCEPT PDU addressed to the requesting DM-MS, issue a DMCC-REPORT indication to the user application and enter state CALL ACTIVE Rx Reservation as a slave DM-MS during reservation. If the changeover request is not accepted the DMCC shall send a DM-REJECT PDU (and shall remain in the same state);

c) if the DMCC receives a DM-SETUP or DM-SETUP PRES PDU, it shall issue a DMCC-RELEASE indication to the user application and obey the procedures for an incoming call, defined in subclauses 6.2.1.2 or 6.2.2.2;

d) if the DMCC receives a DM-SDS UDATA or DM-SDS DATA PDU, it shall issue a DMCC-RELEASE indication to the user application, obey the procedures for incoming short data, defined in subclause 6.3.2 and return to state IDLE;

e) if the user application issues a DMCC-SETUP request primitive requesting continuation of traffic transmission then the DMCC shall obey the procedures for an outgoing call, defined in subclauses 6.2.1.1 or 6.2.2.1;

f) if the user application issues a DMCC-RELEASE request primitive then the DMCC shall send a DM-RELEASE PDU and shall return to state IDLE;

g) if the reservation period expires without any of the above occurring then the DMCC shall issue a DMCC-RELEASE indication to the user application and return to state IDLE.

NOTE 1: During (and at the end of) the reservation period, the layer 2 in the master DM-MS sends the DM-RESERVED PDU as a channel maintenance message; refer to clause 8. Layer 3 is not responsible for the transmission of this message.

Layer 2 reports to layer 3 when the reservation period has expired using a DMC-REPORT indication primitive.

NOTE 2: In c) and d) above (i.e. if the master DMCC receives a call set-up or short data message without having received and accepted a pre-emption or changeover request), then it obeys the received message. However, it may then attempt pre-emption if valid.

6.2.5.2 Slave DM-MS

During the reservation period, a slave DM-MS in the ongoing call shall obey the following procedures:

a) if the user application issues a DMCC-SETUP request primitive requesting to transmit in the ongoing call then the DMCC shall send a DM-TX REQUEST PDU addressed to the master DM-MS and shall enter state WAIT RSP Reservation. It shall then wait for a response from the master:

- if it receives a DM-TX ACCEPT PDU, it shall then obey the procedures for outgoing call set-up defined in subclause 6.2.1.1 or 6.2.2.1. It shall use the procedure for set-up without presence check (subclause 6.2.1.1) unless this is an individual call and there is a change of service type. figure 14 illustrates a successful changeover procedure;

- if it receives a DM-REJECT PDU then it shall inform the user application with a DMCC-REPORT indication and shall return to state CALL ACTIVE Rx Reservation;

- if it receives a DMA-REPORT indication reporting that the channel is now free then the DMCC may obey the appropriate procedures for outgoing call set-up, as defined in subclause 6.2.1.1 or 6.2.2.1. For other DMA-REPORTs indicating random access failure, the DMCC shall inform the user application of the failure with a DMCC-REPORT indication and shall return to state CALL ACTIVE Rx Reservation;

- if, while waiting for a response, condition b), c) or d) applies then the DMCC shall abandon its request procedure (reporting the failure of the user application) and shall obey that other procedure. It shall also obey procedures e) and f) unless it chooses to attempt outgoing call set-up on the free channel;

b) if the DMCC receives a DM-SETUP or DM-SETUP PRES PDU then it shall obey the procedures for an incoming call, defined in subclauses 6.2.1.2 or 6.2.2.2;

c) if the DMCC receives a DM-SDS UDATA or DM-SDS DATA PDU then it shall obey the procedure for incoming short data, defined in subclause 6.3.2. After obeying the short data procedure, and if the SDS message was sent as a transaction within the circuit mode call, the DMCC shall continue in state CALL ACTIVE Rx Reservation as a slave DM-MS during reservation; otherwise the DMCC shall return to state IDLE, issuing a DMCC-RELEASE indication to the user application;

d) if the user application issues a DMCC-RELEASE request primitive then the DMCC shall issue a DMC-CONFIGURE request to layer 2 indicating "call release" and shall return to state IDLE;

e) if the DMCC receives a DM-RELEASE PDU then it shall issue a DMCC-RELEASE indication to the user application and shall return to state IDLE;

f) if the reservation period expires without any of the above occurring then the DMCC shall issue a DMCC-RELEASE indication to the user application and shall return to state IDLE. The expiry of the reservation period is reported by layer 2 in a DMC-REPORT indication primitive.

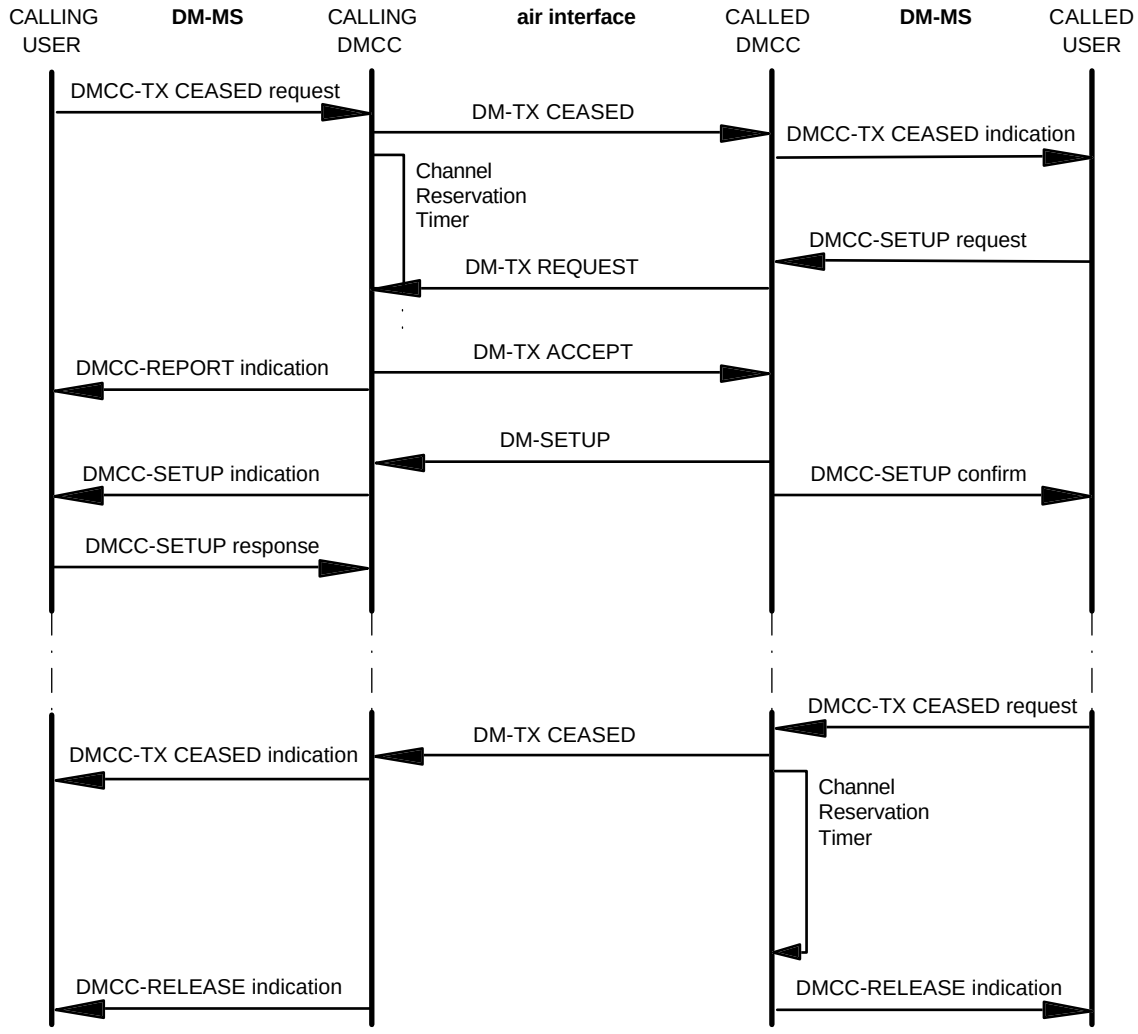


Figure 14: Call changeover

6.2.6 Procedures to set up a new call by pre-emption

If the user application initiates a new call establishment and the DM channel is not currently free (or in the case of frequency efficient mode neither "A" nor "B" channel is free) then the DMCC shall check whether the use of pre-emption is valid:

- if the priority level in the DMCC-SETUP request is not set to one of the pre-emptive priority levels, or if the ongoing calls are of the same or higher priority or of unknown priority, then the DMCC shall issue a DMCC-RELEASE indication to the user application and shall discard the call request;

- otherwise, the DMCC may send a DM-PREEMPT PDU addressed to the master DM-MS of the circuit mode call or short data transmission that is to be interrupted, and shall enter state PRE-EMPTION. It shall then wait for a response from the master:

    - if it receives a DM-PRE ACCEPT PDU, it shall then obey the appropriate procedures for outgoing call set-up, as defined in subclause 6.2.1.1 or 6.2.2.1. figure 15 illustrates a successful pre-emption procedure;

    - if it receives a DM-REJECT PDU then it shall inform the user application with a DMCC-RELEASE indication and shall return to state IDLE;

    - if it receives a DMA-REPORT indication reporting a change of master DM-MS, and if the pre-emption is still valid, then the DMCC may re-send the DM-PREEMPT addressed to the new master. Or, if it receives a DMA-REPORT indicating that the channel is now free then the DMCC may obey the appropriate procedures for outgoing call set-up, as defined in subclause 6.2.1.1 or 6.2.2.1. For other DMA-REPORTs indicating random access failure, the DMCC shall inform the user application of the failure with a DMCC-RELEASE indication and shall return to state IDLE.

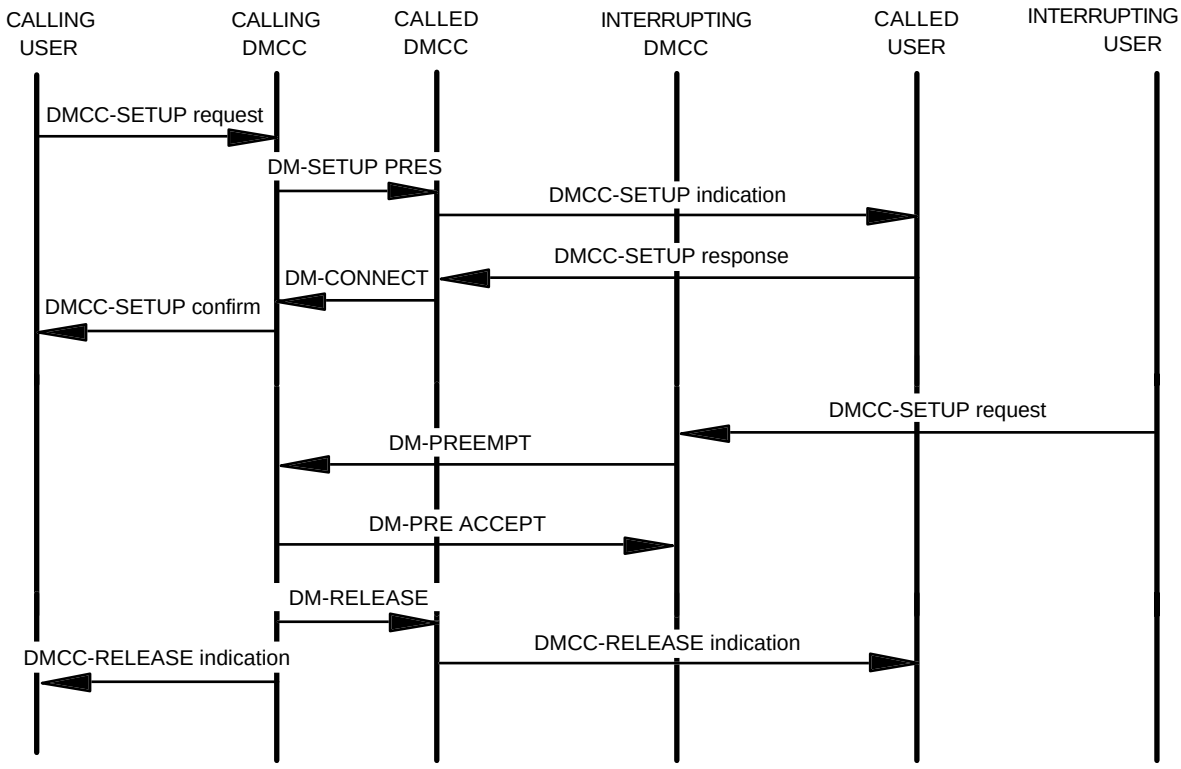


Figure 15: Call pre-emption (successful)

6.3 Short data service procedures

This subclause defines the DM procedures for the Short Data Service (SDS). The SDS provides transmission and reception of both user-defined short messages (up to 2 047 bits) and predefined 16-bit messages (i.e. status messages).

Three types of service are available:

1) an unacknowledged service, which shall be used for sending short data to a group and may be used for sending short data to an individual DM-MS;

2) an acknowledged service, which may be used for sending short data to an individual DM-MS;

3) an acknowledged service where the called DM-MS chooses to include limited data within the acknowledgement. The data in the acknowledgement is not itself acknowledged (though the calling DM-MS may retransmit its own message if it does not receive the acknowledgement).

The primitives used shall be DMCC-SDS UNITDATA for the unacknowledged service and DMCC-SDS DATA for the acknowledged service.

For the unacknowledged SDS, when the calling DMCC sends the DM-SDS UDATA PDU, it may instruct layer 2 to transmit the complete message several times (up to a maximum of N.314 times). Whereas, for the acknowledged services, the calling DMCC is responsible for requesting a retransmission if a response is not received from the called party.

Short data messages may be sent in one of four modes:

a) as a stand-alone transaction on a free channel;

b) as a stand-alone transaction, after pre-empting an ongoing call;

c) by a master DM-MS transmitting traffic in a circuit mode call, with the short data message sent by stealing from the traffic capacity (unacknowledged short data service only);

d) as a transaction within an ongoing circuit mode call (using the pre-emption or changeover procedure to become master of the channel).

Both user-defined and predefined messages shall be carried in the same PDUs:

- DM-SDS UDATA for sending unacknowledged short data;

- DM-SDS DATA for sending acknowledged data;

- DM-SDS ACK for acknowledging short data (optionally also including limited data).

The DM-SDS ACK may include a predefined message, or up to 240 bits of user-defined data if using a Frame Check Sequence (FCS), or up to 272 bits of user-defined data if not using an FCS.

When a DM-MS sends a DM-SDS UDATA or DM-SDS DATA PDU, it becomes master of the channel. If another DM-MS wishes to take the channel to send either circuit mode traffic or short data, it must first either wait for the possibility of a changeover or send a pre-emption request and be granted permission by the current master.

A DM-MS sending a DM-SDS ACK PDU continues to be a slave (even if the PDU contains data).

6.3.1 Sending short data

6.3.1.1 Sending short data on a free channel

A user application initiates short data message transfer by transferring either a DMCC-SDS UNITDATA or DMCC-SDS DATA request primitive across the DMCC-SAP to the DMCC entity.

If the DM channel is not currently free then the DMCC shall use the procedures in subclauses 6.3.1.2, 6.3.1.3 and 6.3.1.4 to decide whether pre-emption, stealing or changeover are valid. If the channel is free then the DMCC shall perform the following procedure.

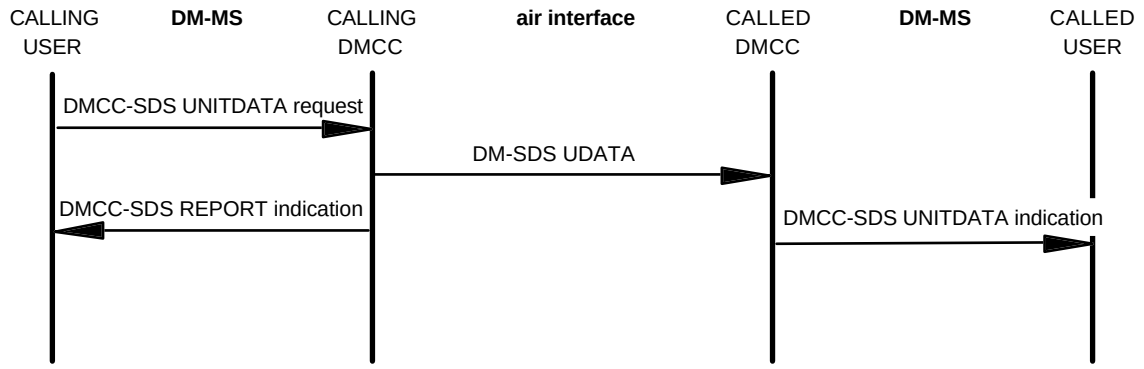


Figure 16: Unacknowledged SDS message

The DMCC shall convert the request primitive into a corresponding DM-SDS UDATA or DM-SDS DATA PDU (including a FCS if requested) and shall send it. It shall then enter state UNACKNOWLEDGED SHORT DATA INITIATED or state ACKNOWLEDGED SHORT DATA INITIATED respectively. After sending the PDU, the DMCC shall await DMA-REPORT indication(s) from layer 2, reporting on the progress of the transmission. While waiting, the DMCC shall not accept further short data request primitives from the user application:

- if the DMCC receives a DMA-REPORT indication reporting failure because the channel has become busy, it shall either:

  a) inform the user application using a DMCC-SDS REPORT indication with parameter "channel is busy" and return to state IDLE, or

  b) for a sufficiently high priority request, invoke the pre-emption procedure;

- if the DMCC receives a DM-PREEMPT PDU requesting pre-emptive use of the channel, it shall check that the request is valid i.e. that the priority is pre-emptive priority or emergency pre-emptive priority and is higher than the ongoing short data;

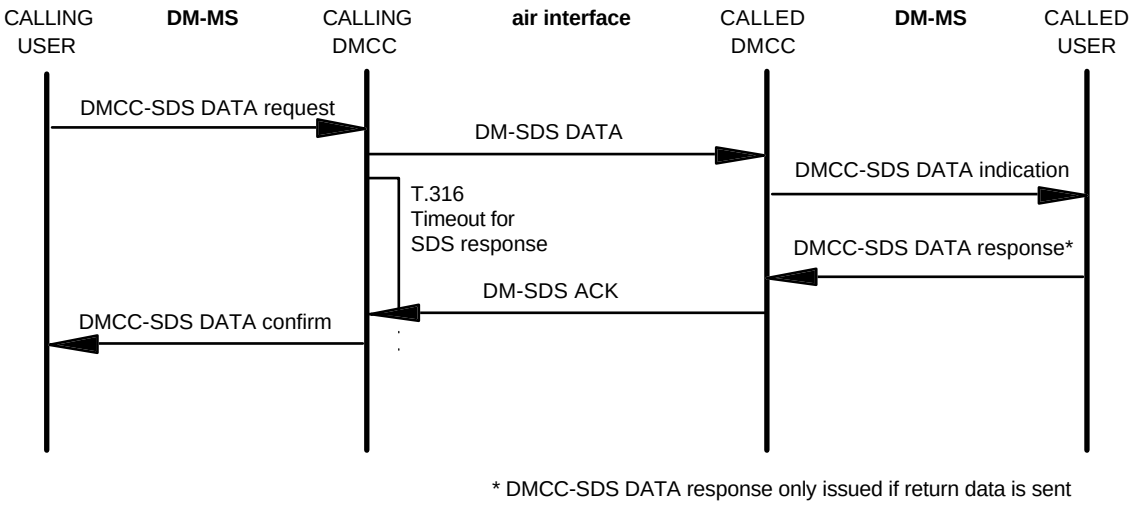
  if the pre-emption request is valid then the DMCC shall immediately send a DM-PRE ACCEPT PDU addressed to the pre-emptor. If, within a time T.314, it does not receive a DMA-REPORT indication reporting that its DM-SDS UDATA PDU has been transmitted the required number of times, or a DM-SDS ACK PDU indicating that its DM-SDS DATA PDU has been fully received by the peer entity, or a DM-REJECT PDU rejecting its DM-SDS DATA PDU, then the DMCC shall issue a DMCC-SDS REPORT indication to the user application with parameter "failed transfer" and shall return to state IDLE;

  if the pre-emption request is not valid then the DMCC shall ignore the request and shall remain in state UNACKNOWLEDGED SHORT DATA INITIATED or state ACKNOWLEDGED SHORT DATA INITIATED;

- for a DM-SDS UDATA PDU: if the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted the required number of times, the DMCC shall inform the user application using a DMCC-SDS REPORT indication with parameter "transfer completed" and shall return to state IDLE;

- for a DM-SDS DATA PDU: if the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted, the DMCC shall await a response from the called DM-MS:

  - if it receives a DM-SDS ACK indicating that the message was fully received then the DMCC shall confirm the success of the transmission to the user application by a DMCC-SDS DATA confirm primitive, delivering the contained user-defined or predefined data (if any), and shall return to state IDLE (illustrated in figure 17);



* DMCC-SDS DATA response only issued if return data is sent

Figure 17: Acknowledged SDS message (successful)

- if it receives a DM-SDS ACK indicating that the message was received but the FCS failed, or that the message was not fully received, then the DMCC shall either send the DM-SDS DATA PDU again (indicating "immediate retransmission" in the DMA-UNITDATA request), or issue a DMCC-SDS REPORT indication to the user application with parameter "failed transfer" and return to state IDLE. The DMCC shall attempt the short data transmission until successful or up to a maximum of N.315 times if a negative acknowledgement has been received (thereby indicating that the called DM-MS is present and within range);

- if it receives an incomplete DM-SDS ACK, or a DM-SDS ACK with incorrect FCS, then the DMCC shall either confirm the success of its own transmission to the user application or send an immediate retransmission of its DM-SDS DATA PDU (up to a maximum of N.315 times);

- if it receives a DM-REJECT PDU then the DMCC shall issue a DMCC-SDS REPORT indication to the user application with parameter "called party rejected short data" and shall return to state IDLE (illustrated in figure 18);

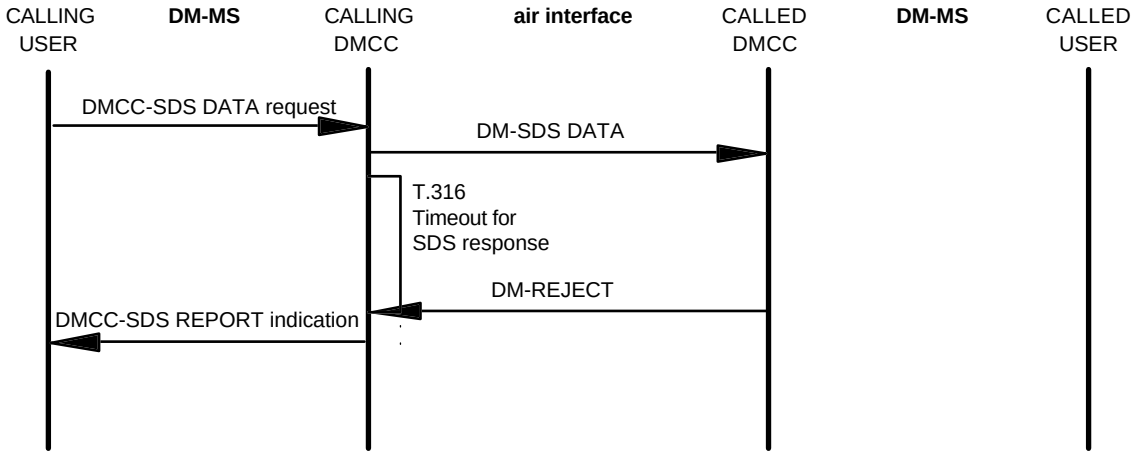


Figure 18: Acknowledged SDS Message (rejected)

- if it does not receive a response within a time T.316 following the DMA-REPORT indication, the DMCC shall either send the DM-SDS DATA PDU again (without indicating "immediate retransmission" in the DMA-UNITDATA request), or issue a DMCC-SDS REPORT indication to the user application with parameter "failed transfer" and return to state IDLE. The DMCC shall attempt the short data transmission up to a maximum of N.316 times if no acknowledgement has been received. This procedure is illustrated in figure 19.

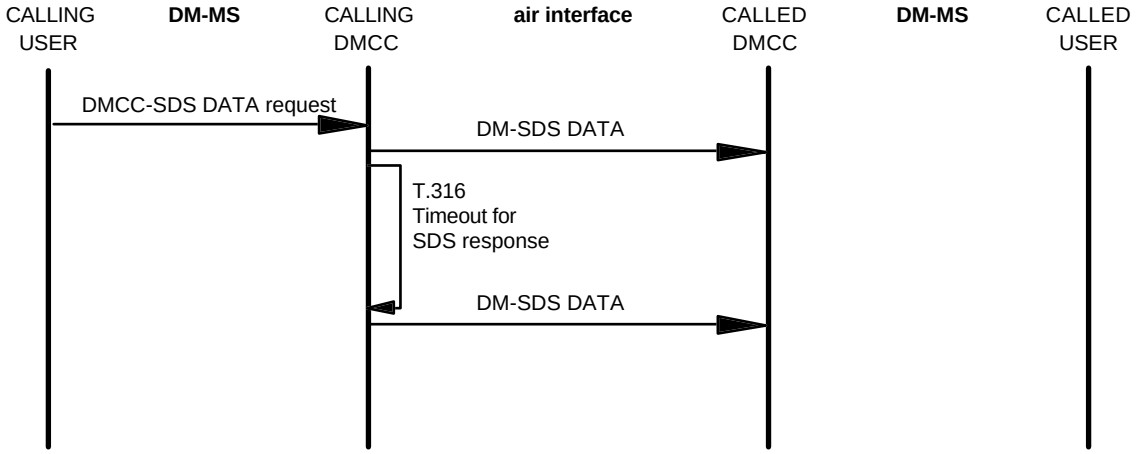


Figure 19: Acknowledged SDS message (time-out and retry)

NOTE: When the DMCC issues a DMCC-SDS REPORT indication to the user application with parameter "failed transfer", the DMCC may indicate whether the message has been completely sent at least once and the called DM-MS(s) may have received the data (i.e. outcome unknown) or whether it is known that the called DM-MS(s) cannot have received the data (e.g. if the message was not completely sent or was always negatively acknowledged).

6.3.1.2 Sending short data by pre-emption

If the user application initiates a short data message transfer not related to an ongoing circuit mode call and the DM channel is not currently free (or in the case of frequency efficient mode neither "A" nor "B" channel is free) then the DMCC shall check whether the use of pre-emption is valid:

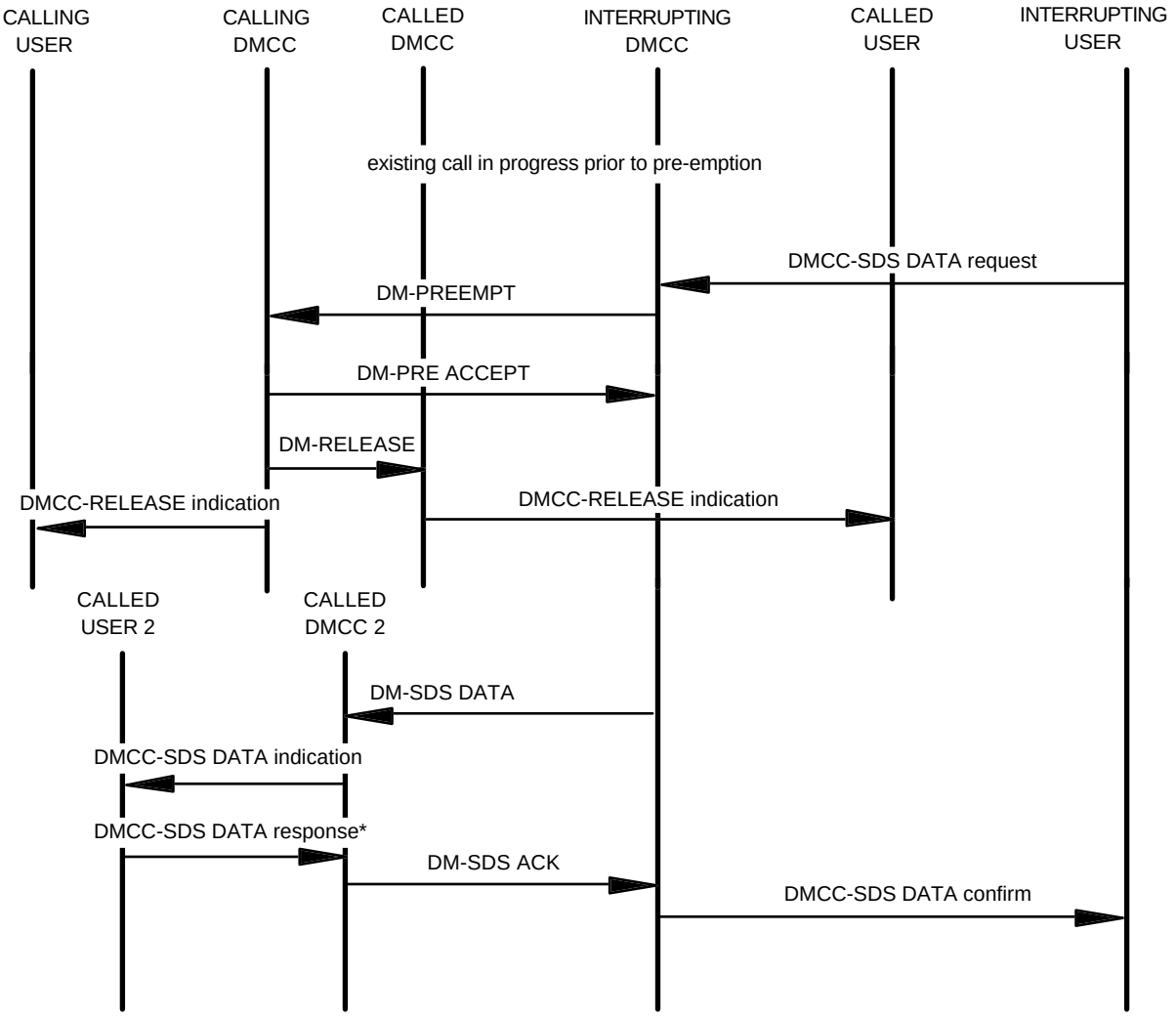
- if the priority level in the DMCC-SDS UNITDATA or DMCC-SDS DATA request is not set to one of the pre-emptive priority levels, or if the ongoing calls are of the same or higher priority or of unknown priority, then the DMCC shall issue a DMCC-SDS REPORT indication to the user application with parameter "channel is busy" and shall discard the request;

- otherwise, the DMCC may send a DM-PREEMPT PDU addressed to the master DM-MS of the circuit mode call or short data transmission that is to be interrupted, and shall enter state PRE-EMPTION. It shall then wait for a response from the master:

  - if it receives a DM-PRE ACCEPT PDU, it shall then obey the procedures for sending short data on a free channel, as defined in subclause 6.3.1.1;

  - if it receives a DM-REJECT PDU then it shall inform the user application using a DMCC-SDS REPORT indication with parameter "pre-emption rejected" and shall return to state IDLE;

  - if it receives a DMA-REPORT indication reporting a change of master DM-MS, and if the pre-emption is still valid, then the DMCC may re-send the DM-PREEMPT addressed to the new master. Or, if it receives a DMA-REPORT indicating that the channel is now free then the DMCC may obey the procedures for sending short data on a free channel. For other DMA-REPORTs indicating random access failure, the DMCC shall inform the user application of the failure with a DMCC-SDS REPORT indication with parameter "pre-emption failure" and shall return to state IDLE.



* DMCC-SDS DATA response only issued if return data is sent

Figure 20: Sending short data by pre-emption of a circuit mode call (successful)

6.3.1.3 Sending short data during circuit mode transmission

If the user application initiates unacknowledged short data message transfer while the DM-MS is transmitting circuit mode traffic, and if the message can be transmitted within one stolen timeslot, then the DMCC may send the DM-SDS UDATA PDU (setting the "stealing priority" parameter in the DMA-UNITDATA request appropriately and indicating the required number of repetitions). The progress of the transmission of the DM-SDS UDATA PDU shall be given locally to the DMCC in DMA-REPORT indication primitives: an interim report issued after the first transmission and a final report after the PDU has been transmitted the required number of times.

If the DMCC receives a final DMA-REPORT indication, the DMCC shall inform the user application using a DMCC-SDS REPORT indication with parameter "transfer completed".

If the DM-MS stops transmitting circuit mode traffic before layer 2 has issued the final DMA-REPORT indication, the DMCC may either inform the user application using a DMCC-SDS REPORT indication (with parameter "failed transfer") or may retain the request for sending during or after the reservation period.

NOTE: For short data sent by stealing, and if neither layer 3 source addressing nor FCS are needed, the maximum size of user defined message is 129 bits. If source addressing and/or FCS are required then the maximum payload is reduced accordingly.

If the user application initiates acknowledged short data message transfer while the DM-MS is transmitting circuit mode traffic, then the DMCC may either discard the request (informing the user application with a DMCC-SDS REPORT indication) or may hold the request until the end of the current transmission.

6.3.1.4 Sending short data as a transaction within a circuit mode call

If the user application initiates short data message transfer relating to an ongoing circuit mode call, and if the DM-MS is currently master of the circuit mode call, then the DMCC may send the short data during the circuit mode reservation period. Refer to subclause 6.3.1.4.3.

If the user application initiates short data message transfer relating to an ongoing circuit mode call, and if the DM-MS is currently a slave in the circuit mode call, then the DMCC may use the pre-emption procedure during occupation, or changeover procedure during reservation, to request to send the short data. Refer to subclause 6.3.1.4.1 or 6.3.1.4.2.

A short data request primitive (DMCC-SDS UNITDATA or DMCC-SDS DATA request) may be regarded as relating to an ongoing circuit mode call if the DM-MS is participating in the call (as master or slave) and:

- for a circuit mode group call: the short data request primitive indicates that group address as the "called party TSI"; or

- for a circuit mode individual call: the short data request primitive indicates the other participating party as the "called party TSI".

6.3.1.4.1 Pre-emption to send short data as a transaction within a circuit mode call

If the user application initiates short data message transfer relating to an ongoing circuit mode call during an occupation period then a slave DMCC shall check whether pre-emption is valid as defined in subclause 6.3.1.2.

If pre-emption is valid then the DMCC may follow the pre-emption procedure defined in subclause 6.3.1.2 except that, if it receives a DM-PRE ACCEPT PDU, it shall then send the short data using the procedure defined in subclause 6.3.1.4.3.

If pre-emption is not valid then the DMCC may either discard the request (informing the user application with a DMCC-SDS REPORT indication) or may hold the request until the end of the current transmission and then send a changeover request, as defined in subclause 6.3.1.4.2.

6.3.1.4.2 Changeover request to send short data as a transaction within a circuit mode call

If the user application issues a DMCC-SDS UNITDATA or DMCC-SDS DATA request primitive during a circuit mode reservation period, requesting to transmit short data related to the ongoing call, then a slave DMCC shall send a DM-TX REQUEST PDU addressed to the master DM-MS. It shall then wait for a response from the master:

- if it receives a DM-TX ACCEPT PDU, it shall then send the short data using the procedure defined in subclause 6.3.1.4.3;

- if it receives a DM-REJECT PDU then it shall inform the user application with a DMCC-SDS REPORT indication with parameter "changeover rejected";

- if it receives a DMA-REPORT indication reporting that the channel is now free then the DMCC may obey the procedures for sending short data on a free channel. For other DMA-REPORTs indicating random access failure, the DMCC shall inform the user application of the failure with a DMCC-SDS REPORT indication with parameter "changeover failure";

- if, while waiting for a response, condition b), c) or d) of subclause 6.2.5.2 applies then the DMCC shall abandon its request procedure (reporting the failure to the user application) and shall obey that

other procedure. It shall also obey procedures e) and f) except that it may attempt to send its short data on the free channel.

6.3.1.4.3 Sending the short data as master of the circuit mode call

When the DM-MS becomes master in order to send short data during a circuit mode call, or if it is already master, the DMCC shall send the short data using the procedure for a free channel (as defined in subclause 6.3.1.1) except that:

a) the DM-SDS UDATA or DM-SDS DATA PDU shall indicate that this is a transaction within a circuit mode call;

b) for all retransmission of a DM-SDS DATA PDU, the DMCC shall indicate "immediate retransmission" in the DMA-UNITDATA request primitive;

c) if the DMCC accepts a DM-PREEMPT PDU from another DM-MS, it shall either enter state CALL ACTIVE Rx as a slave DM-MS during reservation or return to state IDLE (depending on whether or not the DM-PREEMPT refers to continuation of the ongoing circuit mode call); it shall issue either a DMCC-REPORT indication or DMCC-RELEASE indication respectively to the user application;

d) after completion of the short data transfer (or a failure other than pre-emption) then, instead of returning to state IDLE, the DMCC shall enter state CALL ACTIVE Tx as a master DM-MS during reservation and shall follow the procedures defined in subclause 6.2.5.1.

6.3.2 Receiving short data

6.3.2.1 Receiving DM-SDS UDATA PDU

On reception of a DM-SDS UDATA PDU:

- if the PDU contains an FCS and the FCS is correct, or if the PDU does not contain an FCS, the DMCC shall deliver the information to the user application using a DMCC-SDS UNITDATA indication primitive;

- if the PDU contains an FCS and the FCS is not correct, the DMCC shall discard the data message;

- if the DM-MS does not have a short data capability, the DMCC shall ignore the PDU.

6.3.2.2 Receiving DM-SDS DATA PDU

On reception of a DM-SDS DATA PDU marked as fully received by layer 2:

- if the PDU contains an FCS and the FCS is correct, or if the PDU does not contain an FCS, the DMCC shall deliver the information to the user application using a DMCC-SDS DATA indication primitive. It shall then wait for a DMCC-SDS DATA response primitive from the user application (containing user-defined data or a pre-coded status message to be sent as a reply) or for a DMC-REPORT indication from layer 2:

    - on reception of a DMCC-SDS DATA response primitive, the DMCC shall send a DM-SDS ACK PDU indicating that the sender's data message was fully received and containing the appropriate data;

    - if no response primitive has been received from the user application, and the DMCC receives a DMC-REPORT indication from layer 2 indicating that the acknowledgement must now be sent, then the DMCC shall send a DM-SDS ACK PDU indicating that the sender's data message was fully received and containing no response data;

- if the PDU contains an FCS and the FCS is not correct, the DMCC shall discard the data and shall send a DM-SDS ACK PDU indicating that the message was received but the FCS failed.

On reception of a DM-SDS DATA PDU marked as not fully received by layer 2, the DMCC shall discard any data and shall send a DM-SDS ACK PDU indicating that the message was not fully received.

On reception of a DM-SDS DATA PDU, and if the called DM-MS does not have a short data capability, the DMCC shall send a DM-REJECT PDU.

NOTE 1: The user application is not precluded from returning a pre-coded status message in response to a user-defined data message or a user-defined data message in response to a pre-coded status message.

NOTE 2: If the DMCC receives a DMCC-SDS DATA response primitive at a time when it is not waiting to send a short data acknowledgement then it may treat the primitive as if it were a request primitive (see subclause 6.3.1.1). Otherwise it may issue a DMCC-SDS REPORT indication with parameter "failed transfer".

6.3.3 Additional addressing

For an intra-MNI short data message, and if the master DM-MS is using its true ISSI as its layer 2 source address, then no additional addressing is needed and the called DMCC(s) shall use the addressing information provided in the DMA-UNITDATA indication to generate the "calling party TSI" parameter in the DMCC-SDS UNITDATA or DMCC-SDS DATA indication primitive.

For an inter-MNI short data message, or for an intra-MNI short data message if the master DM-MS is not using its true ISSI as the layer 2 source address, the master DM-MS shall provide the additional addressing information within the layer 3 PDU. The called DMCC(s) shall use that addressing information to generate the "calling party TSI" parameter in the DMCC-SDS UNITDATA or DMCC-SDS DATA indication primitive.

6.3.4 Extended error protection

An extended error detection (FCS) shall be offered as a selectable part of the short data service, to minimise the number of undetected erroneous messages. When selected, the sending DMCC shall calculate the FCS over the other elements of the layer 3 PDU (i.e. the DM-SDU elements) and shall append the FCS to the PDU.

If an FCS is included within the PDU, the receiving DMCC shall test the received PDU against the FCS to detect whether errors have been introduced into the PDU during transmission. If the receiving DMCC detects errors, it shall not pass the erroneous data to the user application, but instead shall discard the data and enforce a retransmission if appropriate.

The FCS is defined in annex B.

6.4 Usage of DMA-UNITDATA primitive

When subclauses 6.2 and 6.3 refer to the DMCC "sending a PDU", the DMCC shall give the PDU to layer 2 in a DMA-UNITDATA request primitive. Layer 2 then transmits the PDU the appropriate number of times using the appropriate transmission method. Similarly, when the DMCC receives a PDU, the message is delivered by layer 2 in a DMA-UNITDATA indication primitive.

When sending a PDU, the DMCC shall construct the DM-SDU (as defined in clause 9) for inclusion in the DMA-UNITDATA request and shall provide the "message type" (e.g. DM-SETUP, DM-RELEASE, DM-SDS UDATA) as a parameter in the primitive. It shall also provide destination addressing information when required. For example, for a DM-SETUP, DM-SETUP PRES, DM-OCCUPIED, DM-SDS UDATA, DM-SDS DATA, DM-TX CEASED, DM-RELEASE or DM-INFO PDU, the destination address is usually the TSI of the called DM-MS(s).

The DMCC shall also include the following parameters in the DMA-UNITDATA request primitive when appropriate:

a) for a DM-SETUP, DM-SETUP PRES, DM-OCCUPIED, DM-TX CEASED, DM-SDS UDATA, DM-SDS DATA, DM-TX REQUEST or DM-PREEMPT PDU, the DMCC shall include the call priority;

b) for a DM-SDS UDATA or DM-SDS DATA PDU, the DMCC shall indicate whether the short data is being sent as part of an ongoing circuit mode call (SDS transaction type);

c) for a DM-SDS UDATA, DM-SDS DATA, or DM-SDS ACK PDU, the DMCC shall indicate whether an FCS is included within the PDU (FCS flag);

d) for a DM-TX CEASED PDU, the DMCC may indicate the required reservation time following this traffic transmission;

e) for a DM-SETUP, DM-SETUP PRES, DM-SDS UDATA or DM-SDS DATA PDU, the DMCC shall indicate whether the message is being sent after pre-emption / changeover;

f) for a DM-SDS DATA PDU, the DMCC shall indicate whether the message is to be sent as an immediate retransmission;

g) for a DM-TX REQUEST PDU, the DMCC shall indicate whether the changeover request has been held during occupation and whether it is a recent user request;

h) for a DM-SDS UDATA or DM-INFO PDU sent during circuit mode occupation, the DMCC shall indicate the stealing priority;

j) for a DM-SDS UDATA or DM-INFO PDU, the DMCC shall indicate the number of transmissions required.

Items a) to d) shall be mapped by layer 2 into the MAC PDU header, whereas items e) to j) shall be used locally within layer 2.

7 Layer 2 service description

7.1 Introduction

This clause describes the services offered by the layer 2 of the TETRA DM Air Interface. The service description is described in terms of Service Access Points (SAPs), primitives and their parameters.

The internal boundaries between the layers and sub-layers described herein are not testable and do not imply any specific implementation, but are rather used for the description of the model. In the following subclauses the word "shall" is used with SAPs, service primitives and parameters for traceability reasons in the protocol model, but again those SAPs and primitives are not testable. The following description also does not imply any specific implementation.

7.2 Layer 2 architecture

Layer 2 - the DLL - comprises two sub-layers. These both perform Medium Access Control (MAC) functions and they are referred to in the protocol description as the upper MAC and lower MAC. The lower MAC performs channel coding and interleaving, and the upper MAC performs other layer 2 protocol functions. The basic functionality of the DLL sub-entities is summarised in ETS 300 396-1 [1], clause 5. The services offered by layer 2 to layer 3 (the DMCC entity) are described in this clause.

NOTE: DM does not offer an equivalent to the V+D advanced link. Some V+D basic link functions that were performed by the Logical Link Control (LLC) entity are performed by the DM layer 3 entities, and there is no LLC specified within the DM layer 2.

Figure 21 shows the model of layer 2 and its internal subdivision. It also shows its interaction with layer 3 (DMCC) and layer 1 (physical layer).

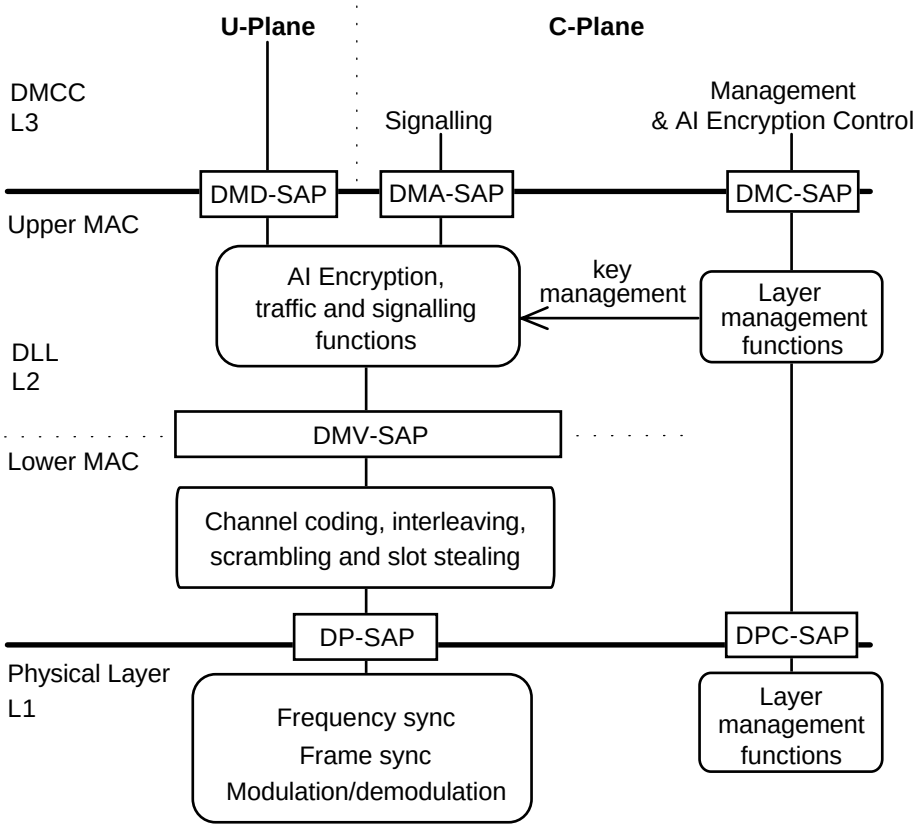


Figure 21: Layer 2 reference architecture

In the protocol model, layer 2 shall provide services to the DMCC through SAPs supporting different functions, i.e. DMA-SAP for all C-plane signalling messages and DMC-SAP for layer management, status and configuration.

Layer 2 shall provide service to the U-plane application through the DMD-SAP, which is used to support traffic transmission and reception in circuit mode. In circuit mode, some traffic capacity may be stolen for signalling purposes. This may be either for C-plane signalling (DMA-SAP) or U-plane signalling (DMD-SAP).

A virtual SAP, DMV-SAP, is also defined within layer 2, between the upper MAC and lower MAC, to allow a protocol description using primitives and logical channels. The selection of a specific logical channel triggers specific channel coding at the lower MAC. The primitives at the DMV-SAP are described in clause 8.

The SAP, DP-SAP, shall be used for communication between the MAC and the Physical Layer (PL). To exchange information at the DP-SAP, pre-formed subslots and blocks with burst type indication shall be used.

7.2.1 Lower layer management in layer 2

The protocol architecture as shown in figure 21 shows how the lower layer management entity is incorporated into all lower layers and is accessible via DxC-SAPs. These access points enable access to information such as measured values, status and general information.

7.3 Service descriptions

7.3.1 Services at the DMA-SAP

The DMA-SAP shall be used for the transfer of signalling information over the air interface. It provides the following services to layer 3:

- data manipulation (PDU composition/decomposition, including fragmentation of long messages);

- transfer of PDUs.

Service Data Units (SDUs), DM-SDUs, shall be transferred between layer 2 and layer 3 using the DMA-UNITDATA primitive.

The DMA-UNITDATA request from layer 3 to layer 2 shall be used when layer 3 wishes to send data to the peer entity.

The DMA-UNITDATA indication from layer 2 to layer 3 shall be used to deliver data addressed to that DM-MS. Layer 2 may use some information from messages addressed to other DM-MSs but shall not deliver the message to layer 3.

Progress of a request procedure shall be reported locally to layer 3 using the DMA-REPORT indication primitive.

The DM-SDU is that part of the message which is not visible at layer 2 and which shall not be used by DM-MSs not addressed by the message. The DMA-UNITDATA primitive contains, as parameters, the DM-SDU and message type, and also other layer 3 elements to be included in a transmitted message (or that were included in a received message). This is illustrated in figure 22. In this figure, the "other parameters" from layer 3 may either be mapped into the MAC PDU or be used within layer 2.

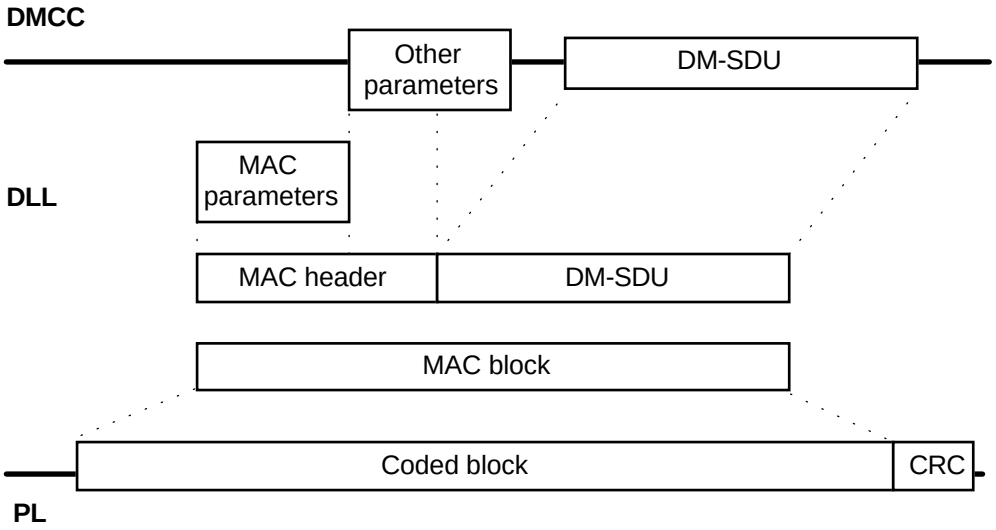


Figure 22: Layer 2 data structure

The signalling service offered by layer 2 to layer 3 shall be an unacknowledged service except when the random access protocol is used. layer 2 receives a DMA-UNITDATA request primitive from layer 3, transmits the message (in one or more MAC blocks) sending it the appropriate number of times, and then reports to layer 3 when the message has been sent. Acknowledgement and retransmission are under the control of layer 3.

If the random access protocol is used however (i.e. for pre-emption and changeover requests), layer 2 is responsible for sending retries until a response is received or the access attempt fails.

7.3.1.1 Service primitives at the DMA-SAP

The information contained in the primitive description tables which follow corresponds to the following key:

KEY: M: Mandatory; C: Conditional; O: Optional -: Not used

7.3.1.1.1 DMA-REPORT primitive

The DMA-REPORT indication shall be used by layer 2 to report on the progress or failure of a request procedure.

When layer 2 receives a DMA-UNITDATA request from layer 3, it shall generate a local identifier for the service request - referred to as the "Handle to the request" - and shall immediately give that handle to layer 3 using a DMA-REPORT indication. The handle is then used for routing subsequent reports concerning the result of the transfer.

The parameters shall be defined as follows:

Table 9: Parameters for the DMA-REPORT primitive

Parameter	Indication (note)
Handle to the request	M
Report	M
NOTE: Not sent over the air interface	

7.3.1.1.2 DMA-UNITDATA primitive

The DMA-UNITDATA request shall be used to request layer 2 to transmit a message.

The DMA-UNITDATA indication shall be used by layer 2 to deliver a received message.

The parameters shall be defined as follows:

Table 10: Parameters for the DMA-UNITDATA primitive

Parameter	Request	Indication
DM-SDU	M	M
DM-SDU length (note)	M	M
Destination address type	M	M
Destination address	M	M
Source address type	O	M
Source address	-	M
Message type	M	M
Air Interface encryption state	M	M
AI encryption information	C	C
Priority	C	C
SDS transaction type	C	C
FCS flag	C	C
Recent user priority	C	-
Reservation time	O	-
Stealing priority (note)	C	-
Number of repeats (note)	C	-
Immediate retransmission (note)	C	-
Changeover request held during occupation (note)	C	-
Recent user changeover request (note)	C	-
Call set-up after pre-emption or changeover (note)	C	-
Incomplete DM-SDS DATA / ACK received (note)	-	C
NOTE: Not sent over the air interface		

7.3.2 Services at the DMC-SAP

The DMC-SAP is used for the transfer of local layer management information. It provides no data transfer services over the air interface. It may be used, for example, for layer 3 to instruct layer 2 to reconfigure its parameters or for layer 2 to issue reports on progress.

7.3.2.1 Service states for the DMC-SAP

Annex C illustrates the boundary state model, showing the MS's perception of the state of the DM channel. In the protocol model, layer 2 is responsible for updating and maintaining the channel state. The channel state is then visible to layer 3 via the DMC-SAP, which is required for correct behaviour of layer 3.

7.3.2.2 Service primitives at the DMC-SAP

The information contained in the primitive description tables which follow corresponds to the following key:

KEY: M: Mandatory; C: Conditional; O: Optional -: Not used

7.3.2.2.1 DMC-CONFIGURE primitive

DMC-CONFIGURE request, confirm shall be used to set-up and configure the lower layers.

The parameters shall be defined as follows:

Table 11: Parameters for the DMC-CONFIGURE primitive

Parameter	Request	Confirm
Circuit Mode Information	C	C
Call Release	C	C
Valid addresses	C	C
MS Mode	C	C

7.3.2.2.2 DMC-REPORT primitive

The DMC-REPORT indication shall be used by layer 2 to report on the status of the DM channel. In the protocol description it is also used for the layer 2 in a slave DM-MS to indicate to layer 3 when a response is due.

The parameters shall be defined as follows:

Table 12: Parameters for the DMC-REPORT primitive

Parameter	Indication
Report	M

7.3.3 Services at the DMD-SAP

The DMD-SAP shall provide the interface between layer 2 and the circuit mode U-plane application (e.g. the speech CODEC). It shall be used for the transfer of speech frames or circuit mode data. It shall also be used if the U-plane application steals from the traffic capacity to send encryption synchronisation information and/or user-to-user signalling messages.

The primitives at the DMD-SAP are the DMD-UNITDATA request/indication and DMD-REPORT indication.

7.3.3.1 Service primitives at the DMD-SAP

The information contained in the Primitive description tables which follow corresponds to the following key:

KEY: M: Mandatory; C: Conditional; O: Optional; -: Not used

7.3.3.1.1 DMD-REPORT primitive

The DMD-REPORT indication shall be used by layer 2 to report on the progress of a request procedure. For example, it shall be used by the sending MAC to report to the U-plane application when MAC has stolen traffic capacity.

The half slot synchronisation shall be a parameter (or any local signal) that the MAC shall give internally to the U-plane application to enable a distinction between the first and the second half slot, i.e. a proper use of first half slot and second half parameters by the U-plane application. For the purpose of this description, a DMD-REPORT indication shall be sent before any DMD-UNITDATA request as an initial synchronisation for the U-plane application.

The parameters shall be as defined as follows:

Table 13: Parameters used in the DMD-REPORT primitive

Parameter	Indication (note)
Half slot synchronisation	C
Circuit Mode Information	C
Report	M
NOTE: Not sent over the air interface.	

7.3.3.1.2 DMD-UNITDATA primitive

DMD-UNITDATA request shall be used to request the MAC to transmit one half slot.

DMD-UNITDATA indication shall be used by the MAC to deliver one half slot.

The parameters shall be defined as follows:

Table 14: Parameters used in the DMD-UNITDATA primitive

Parameter	Request	Indication
Half slot content	M	M
Half slot position (see note)	C	C
Half slot importance (see note)	M	-
Stolen indication	M	M
Half slot condition (see note)	-	M
NOTE: Not sent over the air interface.		

NOTE: The half slot position may be implicit after the first synchronisation phase.

7.4 Parameter listing

7.4.1 Air interface encryption information

This parameter shall contain details relating to air interface encryption information which is to be contained in the DMAC-SYNC PDU.

7.4.2 Air interface encryption state

This parameter shall define whether the signalling message shall be encrypted by the MAC before its transmission over the air interface. At the receiving side, it shall define whether the message has been encrypted for transmission over the air interface.

7.4.3 Call release

This parameter shall indicate call release to the MAC when a user receiving traffic within a circuit mode call wishes to leave that call.

7.4.4 Call set-up after pre-emption or changeover

This parameter shall be used for layer 3 to specify whether the message is a call set-up (or short data message) sent after a successful pre-emption or changeover procedure.

7.4.5 Changeover request held during occupation

This parameter shall be used for layer 3 to specify, for a DM-TX REQUEST message, whether the message has been held by the DMCC during occupation.

7.4.6 Circuit mode information

This parameter shall be used for the layer 3 (DMCC) to give instructions to the MAC when switching to traffic mode. It may comprise the following indications:

- type of circuit (i.e. TCH/S, TCH/7,2, TCH/4,8, TCH/2,4);
- interleaving depth N;
- end-end encryption flag;
- user device.

7.4.7 Destination address

This parameter shall be the address of the destination of this message and is either a true TSI or a pseudo SSI.

7.4.8 Destination address type

This parameter shall be used to indicate the type of destination address used.

7.4.9 DM-SDU

The DM-SDU is the service user data message from the DMCC, including FCS when appropriate. It is considered here as a parameter of the service primitive.

7.4.10 DM-SDU length

The DM-SDU length shall be the number of bits of the DM-SDU.

7.4.11 FCS flag

This parameter shall be used for layer 3 to specify, for a DM-SDS UDATA or DM-SDS DATA or DM-SDS ACK message, whether an FCS is included within the PDU. For these messages, layer 2 shall include the FCS flag as a message dependent element.

This parameter shall also be used for layer 2 to indicate to layer 3 whether an FCS is included within a received DM-SDU.

7.4.12 Half slot condition

This parameter shall indicate whether a half traffic slot was received successfully.

7.4.13 Half slot content

This parameter shall define the U-plane information content that is to be carried (or was received) in a half slot in a circuit mode transmission.

7.4.14 Half slot importance

This parameter shall define the importance of the U-plane information that is to be carried in the circuit. It is defined as follows:

Table 15: Definition of half slot importance

Half slot importance	Meaning
0	No importance
1	Low
2	Medium
3	High

7.4.15 Half slot position

This shall define the position of the U-plane information within the timeslot (i.e. first or second half slot).

7.4.16 Half slot synchronisation

This shall be a local signal provided by the MAC to the U-plane application so that the first half slot and second half slot parameters correspond to the first and, respectively, second half slot of the timeslot. It is provided for the purpose of this description and does not imply any particular implementation. It requires that the application keeps synchronised to the half slot in the MAC transmission.

7.4.17 Handle to the request

This shall be a local identifier which acts as a reference to a specific service request. Its implementation is outside the scope of this ETS.

7.4.18 Immediate retransmission

This parameter shall be used for layer 3 to specify, for a retransmission of DM-SDS DATA, whether the message should be sent immediately as a master transmission (without further checking that the channel is free).

7.4.19 Incomplete DM-SDS DATA/ACK received

This parameter shall be used by layer 2 to indicate to layer 3 that an incomplete DM-SDS DATA or DM-SDS ACK message has been received.

7.4.20 Message type

This parameter shall be used for layer 3 to specify the message type of the PDU to be sent. Layer 2 shall include the message type as a message dependent element when it constructs the message.

This parameter shall also be used for layer 2 to indicate to layer 3 the message type when it delivers a received message.

7.4.21 Number of repeats

This parameter shall be used for layer 3 to specify the required number of transmissions of a DM-SDS UDATA or DM-INFO message.

7.4.22 Priority

This parameter shall be used for layer 3 to specify, when appropriate, the priority of the message or call. Layer 2 shall then include the priority as a message dependent element when it constructs the message.

This parameter shall also be used for layer 2 to indicate to layer 3 the priority of a received message.

7.4.23 Recent user changeover request

This parameter shall be used for layer 3 to specify, for a DM-TX REQUEST message, whether the message is a recent user changeover request.

7.4.24 Recent user priority

This parameter shall be used for layer 3 to specify, for a DM-TX CEASED message, whether the recent user priority facility is invoked for changeover requests.

7.4.25 Report

Report shall generally indicate the progress or failure of information transfer and the cause of it.

At the DMA-SAP, possible reports include: first complete transmission, transmissions completed, random access success, random access failure (and type of failure), channel is busy.

7.4.26 Reservation time

This parameter may be used for layer 3 to specify, for a DM-TX CEASED message, the required channel reservation period. If not included then layer 2 may use a pre-set value.

7.4.27 SDS transaction type

This parameter may be used for layer 3 to specify, for a DM-SDS UDATA or DM-SDS DATA message, whether the short data is being sent as a transaction within an ongoing circuit mode call. For these messages, layer 2 shall include the SDS transaction type as a message dependent element.

7.4.28 Source address

This parameter shall be the address of the source MS and is either a true TSI or a Pseudo SSI.

7.4.29 Source address type

This parameter shall be used to indicate the type of source address used.

7.4.30 Stealing priority

This parameter shall define whether the MAC may use stealing to send this SDU. Within layer 2 it may have meanings: steal immediately or steal when convenient.

7.4.31 Stolen indication

This shall indicate whether or not the information content of a halfslot is stolen for signalling purposes. At the transmitting side, this parameter may be used to force signalling mode in the MAC for either the first or both half slots within a timeslot to be transmitted. At the receiving side, this parameter shall be available to the U-plane application to enable correct handling of stolen information.

7.4.32 Valid addresses

Valid addresses are the addresses that the MAC shall recognise as the ones attached to the MS.

NOTE: This parameter may be used to add a temporary group address to the MS's list of valid addresses, and then used again to delete it from the list.

8 Layer 2 protocol

8.1 Introduction

ETS 300 396-1 [1], clause 5 provides a brief overview of the general architecture and a description of all layers within the DMO protocol including the functionality of the DLL. This clause describes in detail the layer 2 protocol and defines the operation of the DLL in the MS.

The DLL is divided into two sub-layers, i.e. the upper MAC and the lower MAC.

8.1.1 Functions of lower MAC

The lower MAC provides the following services to the upper MAC:

- transfer of MAC PDUs into suitable physical layer bursts in accordance with the appropriate timeslot;
- choice of preamble and training sequence corresponding to the slot flag value and vice versa;
- Signal Strength Measurement (RSSI);
- frame and multiframe synchronisation;
- channel coding as described in ETS 300 396-2 [2], clause 8;
- Forward Error Correction (FEC) and interleaving of MAC blocks;
- scrambling and de-scrambling of MAC blocks;
- Cyclic Redundancy Check (CRC) calculation.

See ETS 300 396-2 [2] for specific details of the lower MAC functionality.

8.1.2 Functions of upper MAC

The principal functions of the upper MAC are as follows:

- providing service to U-plane applications (e.g. speech CODEC or circuit mode data);
- transmission of messages received from layer 3;
- reception of messages from other DM-MSs;
- the random access procedure (contention control);
- fragmentation of long messages received from layer 3 (subdividing the layer 3 message between more than one MAC block);
- stealing from the traffic channel capacity, when required, to send signalling messages;
- management for layer 2 addressing;
- application and control of air interface encryption if appropriate;
- determination of the DM channel state;
- radio path establishment.

The functions of the upper MAC are described in the following subclauses. Unless specified otherwise, references to "the DM-MAC" in these subclauses imply reference to the upper MAC.

8.2 Interface between lower and upper MAC

From the protocol point of view, the upper MAC shall communicate with the lower MAC by means of primitives through logical channels. The DMV-SAP virtual access point has been defined to assist in describing this interface.

NOTE: The DMV-SAP boundary is defined only to clarify this protocol description and does not imply any MS implementation. The word "shall" is used to describe this SAP and the primitives for traceability reasons in the protocol model, but they are not testable.

8.2.1 Logical channels defined at the DMV-SAP

The following logical channels are defined within the MAC:

- Synchronisation Channel (SCH/S);
- Half-Slot Signalling Channel (SCH/H);
- Full-Slot Signalling Channel (SCH/F);
- Traffic Channel (TCH);
- Stealing Channel (STCH);
- Linearisation Channel (LCH).

These logical channels are mapped within the lower MAC to the physical burst structures in the DM Physical Layer . Within this mapping, the different logical channels are subjected to differing error control schemes as described in ETS 300 396-2 [2], clause 8.

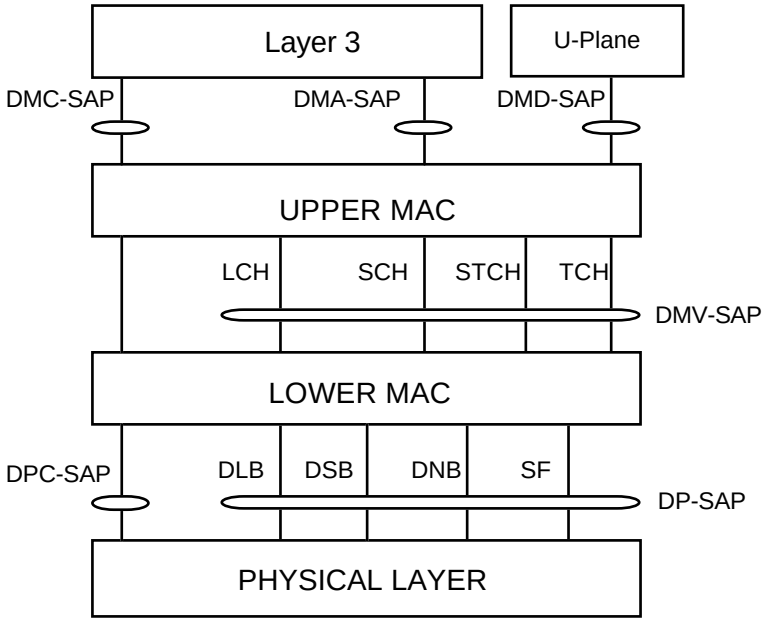


Figure 23: MAC sub-layers, SAPs, logical channels and burst types

Table 16 provides a summary of the mapping between logical channels within the MAC and the physical layer burst structure.

Table 16: Mapping between MAC logical channels and physical layer bursts

Logical channel in DMV-SAP	Definition	Physical burst	Definition
SCH/S	synchronisation channel	BKN1 of DSB	1st half of synchronisation burst
SCH/H	half slot signalling channel	BKN2 of DSB	2nd half of synchronisation burst
SCH/F	full slot signalling channel	DNB	normal burst
STCH	stealing channel	DNB+SF	normal burst and slot flag (note)
TCH	traffic channel	DNB	normal burst
LCH	linearization channel	DLB	linearization burst
NOTE:	Slot flag is an indicator of the type of normal training sequence used in DNB.		

8.2.2 Service primitives at the DMV-SAP

The lower MAC provides services to the upper MAC via the DMV-SAP. Tables 17 and 18 respectively show the correspondence between service primitives at the DMV-SAP and the associated parameters.

Table 17: Correspondence between the upper and lower MAC at the DMV-SAP

Upper MAC service primitive	Lower MAC service primitive (DMV-SAP)
DMA-UNITDATA request or DMD-UNITDATA request	DMV-UNITDATA request
DMA-REPORT indication or DMA-UNITDATA indication or DMC-REPORT indication or DMD-UNITDATA indication	DMV-UNITDATA indication

Table 18: Parameters used in the DMV-UNITDATA primitive

PARAMETER	request	indication
MAC block	M	M
MAC block length (note)	M	M
Logical channel (note)	M	M
CRC pass/fail indication (note)	-	M
DM Colour Code (DCC) (note)	M	-
Report (note)	-	C
NOTE: Not sent over the air interface.		

KEY: M: Mandatory; C: Conditional; -: Not used.

Many of the parameters exchanged at the DMV-SAP are not sent over the air interface but may be deduced from the physical layer transmission or reception. For example, the colour code is not sent as part of the information content, but modifies the information so that reception with a wrong colour code will generate an erroneous CRC and so the information will be discarded. On the contrary, reception with the correct colour code will only be affected by the transmission medium errors.

The MAC block is the SDU from the upper MAC. The size of the MAC block shall be equal to the appropriate SDU size for the logical channel being used.

For C-plane signalling, the upper MAC shall assure this size by appropriate fragmentation and by using fill bits to make the MAC block up to the required size. The required size is 60 bits for SCH/S, 124 bits for SCH/H, 268 bits for SCH/F and 124 bits for STCH.

For U-plane signalling on STCH, the MAC block shall comprise a single DMAC-U SIGNAL PDU. For TCH, the MAC block shall comprise a single DMAC-TRAFFIC PDU. (For TCH/S, this PDU contains one or two speech frames. For circuit mode data, it contains data equivalent to a full slot).

8.2.3 PDU mapping of the logical channels at the DMV-SAP

Table 19 defines the mapping of the MAC PDUs onto the various logical channels.

Table 19: Mapping of the MAC PDU onto the logical channels

SAP	MAC PDU	Logical channel(s)
DMA-SAP	DMAC-SYNC	SCH/S + SCH/H
DMA-SAP	DMAC-DATA	SCH/F, STCH
DMA-SAP	DMAC-FRAG	SCH/F
DMA-SAP	DMAC-END	SCH/F, STCH
DMD-SAP	DMAC-U SIGNAL	STCH
DMD-SAP	DMAC-TRAFFIC	TCH

8.2.4 Scrambling mechanism

The scrambling method applied in TETRA DM is defined in ETS 300 396-2 [2], subclause 8.2.5, and is based on a "seed" - the DM Colour Code (DCC).

The DCC for SCH/F, STCH and TCH shall be a 30 bit sequence e(1), e(2),.., e(30), generated as an algorithmic combination of the transmitting DM-MS's Short Subscriber Identity (or pseudo SSI) and the 6 Least Significant Bits of the Mobile Network Identity (MNI). The coding order shall be as follows:

e(1) = 6^{th} last bit of the MNI;

e(2) = 5^{th} last bit of the MNI;

…etc.

e(6) = least significant bit of the MNI;

e(7) = most significant bit of source address;

…etc.

e(30) = least significant bit of source address.

The scrambling sequence is generated from the 30 bit DCC and is applied within the lower DLL to all logical channels, except for the SCH/S and SCH/H of the DSB. SCH/S and SCH/H of the DSB are subjected to the same scrambling, but in their case, all 30 bits of the DCC are set equal to zero.

NOTE: The colour code for STCH or TCH is derived from the MNI and layer 2 source address elements in the DMAC-SYNC PDU that carried the DM-SETUP/DM-SETUP PRES or DM-OCCUPIED message for the current traffic transmission. The colour code for SCH/F is derived from the MNI and layer 2 source address elements in the DMAC-SYNC PDU that initiated the fragmentation; this may apply to DM-SDS UDATA, DM-SDS DATA and DM-SDS ACK messages.

8.2.5 PDU error detection

The purpose of the CRC added to a MAC block by the lower MAC is to enable the MAC at the receiving side of the air interface to detect whether errors have been introduced into the message during transmission. Therefore, the receiving lower MAC shall extract the decoded CRC and shall calculate a CRC on the remainder of the data as in the transmitting case. The two CRCs shall be compared. If they are not identical, the CRC fail parameter in the DMV-UNITDATA indication primitive shall inform the receiving upper MAC that an error has occurred.

Upon reception of a MAC block as indicated with the CRC fail parameter in the DMV-UNITDATA indication primitive, the upper MAC shall discard the incoming data. However, the upper MAC may use the CRC fail information to update its signal quality measurement.

Upon reception of a MAC block as indicated with the CRC pass parameter in the DMV-UNITDATA indication primitive, the upper MAC shall further check that the incoming PDU is valid by inspecting the header.

8.2.6 Modes of operation

8.2.6.1 DM-MS modes of operation

The DM-MS may operate in any one of the following modes when tuned to a radio frequency channel assigned for DM operation.

8.2.6.1.1 Idle mode

The DM-MS shall operate in idle mode when it is not currently involved in any on going transmission. The DM-MS in idle mode shall however monitor the selected DM channel frequency periodically in order to determine the current state of the channel and receive any new signalling messages addressed to it or a group of which it is a member.

8.2.6.1.2 Signalling mode

The DM-MS shall operate in signalling mode when it is currently receiving or transmitting either call set-up signalling, reservation signalling or short data messages. The configuration during signalling mode shall be as shown in figure 24 except in the case of a fragmented message when following fragments are sent in SCH/F as shown in figure 25.

8.2.6.1.3 Traffic mode

The DM-MS shall operate in traffic mode when it is currently receiving or transmitting circuit mode traffic during channel occupation.

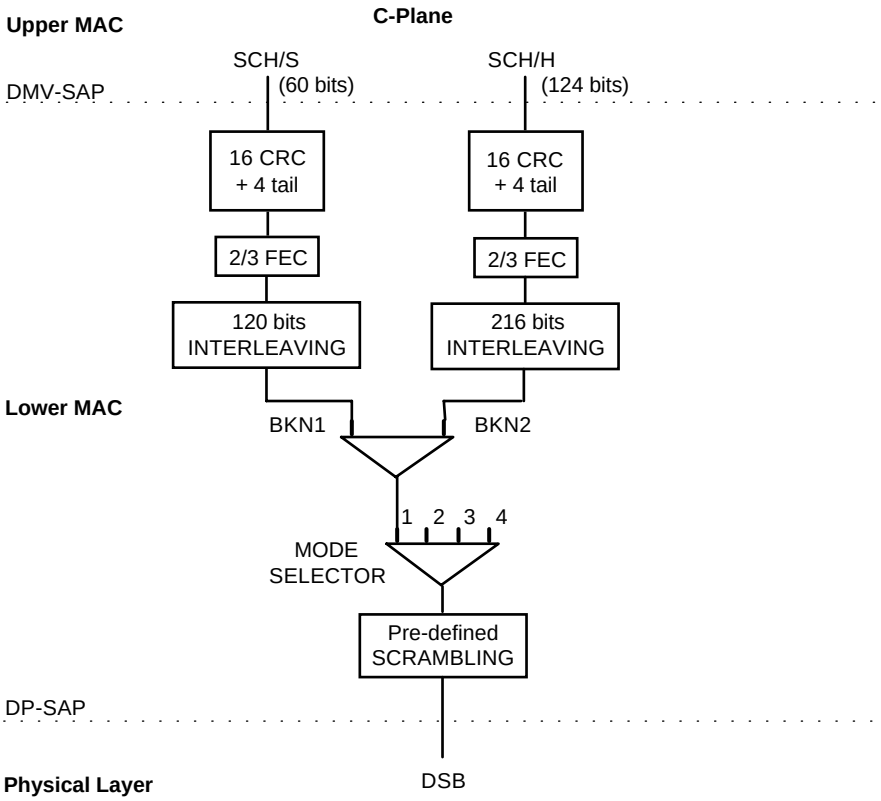


Figure 24: DM-MS Configuration in sync signalling mode (1)

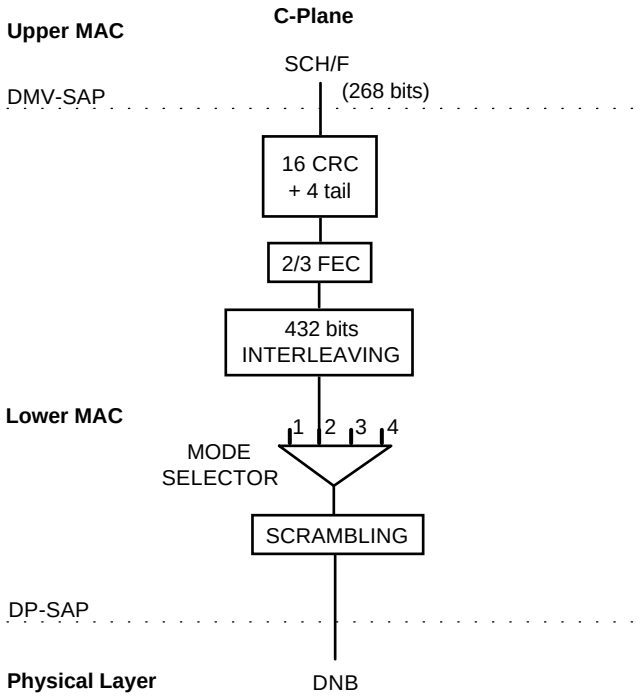


Figure 25: DM-MS Configuration in signalling mode (2)

8.2.6.2 Traffic mode

All transmissions in traffic mode shall be carried out over an entire timeslot. The distinction between full slot traffic and half slot signalling during traffic shall be indicated by the state of the slot flag SF. A slot flag change is indicated by a change in the training sequence used in burst transmission.

8.2.6.2.1 Normal operation

The traffic mode may be either circuit mode speech (TCH/S) or circuit mode data (TCH/7,2, TCH/4,8 or TCH/2,4) operation. The logical channels in use shall be TCH (traffic channels) for slot 1 of frames 1 to 17. Full slots (SF=0) shall normally be used for traffic. Frame 18 shall be used for sync signalling only.

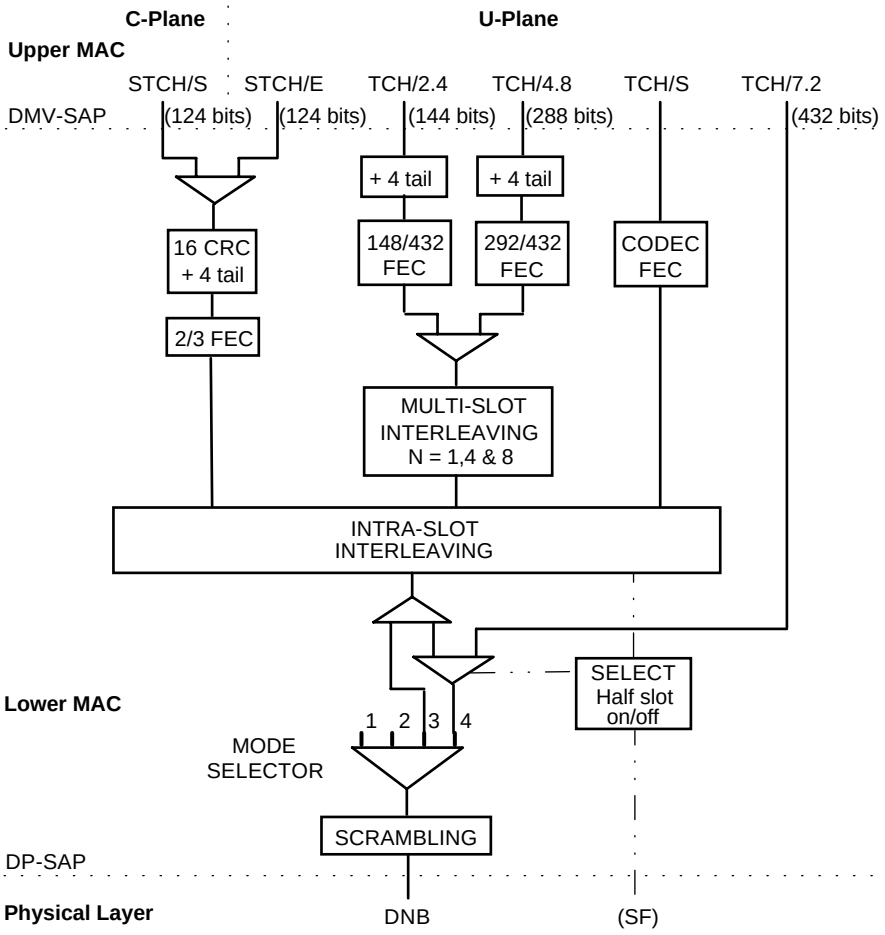


Figure 26: DM-MS Configuration in traffic mode for slot 1 of frames 1 to 17

8.2.6.2.2 Stealing mechanism

When in traffic mode (either circuit mode speech or circuit mode data), capacity may be stolen for signalling purposes. This stealing mechanism shall leave the current mode of operation unchanged. Reception and recognition of normal training sequence 2 shall indicate that stealing has occurred and shall cause the slot flag SF to be set to 1. The MAC header of the first half of the slot shall indicate whether the other half has also been stolen or if it belongs to the normal traffic circuit. The header shall contain information on the intended destination of the signalling message conveyed by the stolen channel: either C-plane or U-plane as indicated by STCH/S and STCH/E respectively in figure 26. Occurrence of stealing shall be locally reported to the U-plane application at the DMD-SAP.

8.2.6.3 Selection of the mode of operation

During a transaction, the MAC shall be considered to be switched into either signalling mode or traffic mode. The selection mechanism is presented in figure 27. The default mode of the MAC shall be sync signalling mode, corresponding to the selector in position 1 in figure 27.

When stealing is initiated in traffic mode operation, the logical channel shall be temporarily taken (fully or partially) on a half slot by half slot basis for signalling purposes.

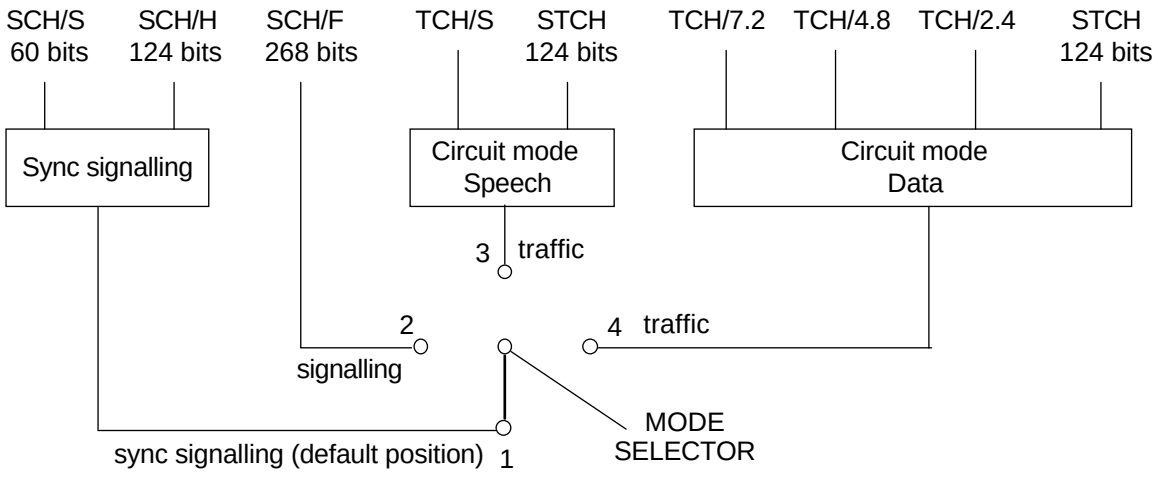


Figure 27: Selection of the configuration for the current mode of operation

If traffic mode is selected, then the mode selector switch is set accordingly.

Traffic mode and SCH/F signalling mode applies only to slot 1 of frames 1 to 17. The DM-MS shall always be in sync signalling mode on frame 18 and on slot 3 of frames 1 to 18.

8.3 Basic capabilities of the Physical Layer

8.3.1 DM-MS capabilities

The following subclauses describe the capabilities required of DM-MSs which are classified as either DM only DO-MS, dual mode capable DU-MS or dual watch capable DW-MS. In all cases the DM-MS shall be capable of supporting DM single frequency, simplex operation.

8.3.1.1 DM only and dual mode capable MS operation

A DM-MS shall be capable of either transmitting or receiving in simplex mode on a single frequency DMO channel. A DO-MS or DU-MS shall be capable of switching between DM transmit and receive within one timeslot duration, approximately 14ms. A DO-MS or DU-MS shall be capable of transmitting in alternate timeslots in consecutive frames.

NOTE: Improved operation maybe achieved if the DM-MS can transmit in all 4 timeslots typically within two consecutive frames, e.g. during call set-up signalling.

A DM-MS which is operating as a master MS shall be capable of adjusting its current transmit timing reference in accordance with the procedures defined in subclause 8.4.7.14 in steps of 0,5 ms up to a max. of 2 frame durations with an accuracy of 0,5 ms.

8.3.1.2 Dual watch capable MS operation

A DW-MS shall support all the operations described in subclause 8.3.1 and in addition shall be capable of switching between operating on the selected DM channel frequency and the V+D channel frequency within 0,5 of a timeslot duration (approximately 7ms). This is illustrated in figure 28.

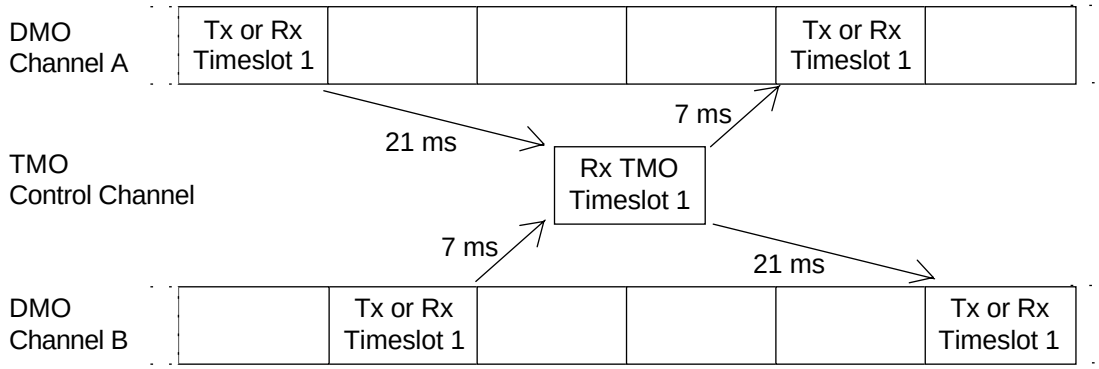


Figure 28: Illustration of Dual Watch on A and B channels

8.4 Usage of DM channel

A DM channel may exist in any one of three states, i.e. free, occupied or reserved.

Only when the DM channel is in occupation or reservation does there exist a timing structure which is divided into multiframes, frames and timeslots. In the channel free condition no overlying DM timing reference exists other than that which may be implicitly provided by an external network.

8.4.1 Definition of DM channel

A DM channel existing during occupation and reservation consists of two timeslots on a single radio frequency carrier, each timeslot lasting for 14,167ms. The end of one DM channel timeslot and the beginning of the other timeslot associated with a DM channel are separated in time by one timeslot duration (approx. 14ms). Time on the DM channel is further divided into frames and multiframes, each frame equal to 4 timeslots duration and each multiframe equal to 18 frames duration (see ETS 300 396-2 [2], clause 9 for further details).

8.4.1.1 DM channel A operation

A DM-MS wishing to begin a call and having determined that the selected DM channel is free shall begin master MS operation. The channel which is thus occupied is defined as DM channel A.

A call using the DM channel A shall primarily be conducted in timeslots 1 and 3 in each frame. See the following subclauses for exceptions to this rule.

When a DM-MS first becomes master on a free channel, it shall define the timing reference including slot and frame numbering. The frame numbering may be chosen arbitrarily. However, unless unsuitable for its dual watch operation, it is recommended that the master defines the frame numbering such that its final repetitions of the call set-up message are sent in frame 18.

8.4.1.2 DM channel B operation

DM channel B operation is conducted during the timeslot periods unused by channel A operation i.e. in timeslots 2 and 4 of each frame. When frequency efficient operation is supported a DM-MS, having determined that the DM channel A on the selected DM radio frequency carrier is occupied but that channel B is free, may begin master MS operations using the free timeslots in each frame. In order that inter DM channel interference on a frequency carrier is minimised the master MS on channel B shall monitor channel A in order to acquire timing synchronisation and subsequently re-align its transmission timing (see 8.4.4.8). From the perception of a DM-MS on channel B, operation shall be conducted in timeslot 1 (i.e. timeslot 2 as seen by channel A), and timeslot 3 (i.e. timeslot 4 as seen by channel A). This structure is illustrated in figure 29.

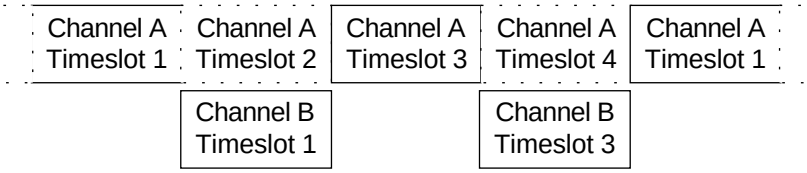


Figure 29: Illustration of DM channel A and B timeslots

8.4.2 DM channel states

The MAC layer of the DM-MS is responsible for monitoring activity on a selected DM channel in order to determine the current perceived state of that DM channel. Accurate DM channel state information is essential if a DM-MS is to employ the correct signalling and monitoring procedures. The perceived DM channel state combined with the current DM-MS mode of operation shall be used to update the DM-MAC state model. Refer also to subclause 7.3.2.1 and annex C.

8.4.2.1 DM channel state definitions

Channel free:

- no signalling or traffic activity detected on the selected DM channel.

Channel occupied or reserved:

- traffic or signalling activity detected on the selected DM channel (i.e. channel A and/or channel B in occupation or reservation). If frequency efficient operation is supported the DM-MS shall determine the state of channel B.

8.4.2.2 Determination of DM channel state

To determine the current state of the DM channel a DM-MS in idle mode shall continuously monitor the selected DM radio frequency in order to receive any DSB present on the channel and signal strength and channel conditions permitting decode any layer 2 information available.

In the case where DSBs are present and can be decoded and decrypted, the slave MS shall, dependent upon the content, enter the appropriate mode of operation and update the DM-MAC state model.

In the case where DSBs are present and can be decoded, but the message type cannot be decrypted, the DM-MS shall regard the channel as occupied by other DM-MSs.

In the case where DSB signalling cannot be detected the DM-MS shall having followed the procedure described in subclause 8.4.2.3.1, update the DM-MAC state model and begin idle mode operating procedures.

During a call, a DM-MS shall, based upon the signalling present on the channel, update the DM-MAC state model accordingly. Where no DSB signalling can be detected, and having followed either the procedure described in subclause 8.4.2.4 the DM-MS shall update the DM-MAC state model and begin idle mode operation procedures.

8.4.2.3 Criteria for occupying a free channel

The DM-MS may generally begin call set up procedures (circuit mode call or short data) when the result of the channel monitoring processes described in subclauses 8.4.2.2 and 8.4.2.3.1 indicate that the DMO channel is free. If fast call set-up is to be achieved, the DM-MS shall conduct those procedures in idle mode i.e. prior to Press-To-Talk (PTT) activation.

Alternatively, if the DM-MS observes a channel change from occupied or reserved to free (i.e. if it receives DM-RELEASE or detects the end of circuit mode reservation or SDS occupation) and if, within the following time T.205, it wishes to set up a call then the DM-MAC shall choose a random value R from the range 1 to N.205 (using a uniform distribution) and plan to start sending the call set-up signalling after R frames. However, during the intervening time, the DM-MAC shall continue to monitor the channel as defined in subclauses 8.4.2.2 and 8.4.2.3.1. If, during this time, it detects traffic or signalling activity then it shall report to layer 3 that the call set-up message cannot be sent (DMA-REPORT indication).

NOTE: This randomisation is needed in case several users have been waiting for the channel to become free. At other times, it is assumed that the users themselves provide adequate randomisation.

The randomisation requirement applies also for a retransmission of DM-SETUP PRES by the DMCC or a non-immediate retransmission of DM-SDS DATA.

In frequency efficient DM operation further surveillance shall be required in order to determine whether the B channel is free and available for use.

8.4.2.3.1 Signal strength measurement to determine channel free condition

RSSI measurements shall be made during those periods where the DM-MS is determining whether the channel is free prior to becoming a master MS at the beginning of a new call or changing from channel B to channel A operation. The measurements shall be conducted over a period of at least 1 multiframe and consist of at least 6 measurements. The measurement sample duration shall be at least SD2 as defined in ETS 300 396-2 [2], clause 10. The DM channel shall be declared free when the RSSI level is less than a predetermined threshold value.

NOTE: Determination of appropriate threshold values are outside the scope of this ETS but this parameter should be configurable within the radio.

8.4.2.4 DM-MS channel surveillance procedures

A slave MS operating either in signalling or traffic mode on a DM channel may conduct the following or equivalent channel surveillance operations.

8.4.2.4.1 Signal quality measurement during call transaction

During a call a slave MS may conduct a measurement of the received RF signal strength and calculate a running average of at least 5 measurement samples. These samples shall be taken during at least the last 5 seconds and at most the last 60 seconds. The measurement sample duration shall be at least SD1 (see ETS 300396-2 [2], clause 10).

The quality of the radio link may also be determined by a slave MS using a signal quality measurement estimated from the success rate of decoding the relevant signalling messages received from the current master DM-MS. The "DM-RDC" (radio downlink counter as used in V+D) counter shall be incremented and decremented based upon the success or failure of decoding the SCH/S channel within the DSB in timeslot 3 of frames 6, 12 and 18. In the case where the SCH/S cannot be decoded the DM-RDC shall be decremented by 4 and when the SCH/S can be decoded the DM-RDC shall be incremented by 1. The maximum value of the DM-RDC counter shall be set to DM-RDC_Theshold value which is configurable in the DM-MS.

The following criteria shall be met prior to a slave MS which is operating in either signalling or traffic mode, relinquishing the DM channel and entering idle mode.

The channel relinquishing criteria are:

- RSSI below some pre-defined threshold value;

- DM-RDC value < 0.

8.4.3 DM-MAC states

The DM channel state information combined with the current DM-MS mode of operation define the current DM-MAC state and this shall be used to determine which procedure the DM-MAC should follow at any point in time. The DM-MAC states are defined as follows.

8.4.3.1 DM-MAC state definitions

Channel free - MS idle:

- the DM-MS is currently operating in idle mode on a DM channel which is perceived free.

Channel occupied - MS master:

- DM-MS is the current master transmitter which is active in a call transaction either in traffic or signalling mode. This may be either a circuit mode traffic transmission or a short data transmission (DM-SDS UDATA or DM-SDS DATA).

Channel reserved - MS master:

- DM-MS is the current master transmitter which is sending periodic channel reservation signalling.

Channel occupied - MS slave:

- DM-MS is actively receiving traffic and/or signalling information from the current master DM-MS and addressed to itself or a group of which it is a member.

Channel reserved - MS slave:

- DM-MS is receiving channel reservation signalling related to a call transaction from the current master DM-MS and addressed to itself or a group of which it is a member.

Channel occupied - MS idle:

- traffic or signalling information detected on channel which is not addressed to the DM-MS, or activity detected on channel.

Channel reserved - MS idle:

- channel reservation signalling information detected on channel which is not addressed to the DM-MS.

8.4.3.2 Criteria for changing DM-MAC state

The DM-MS MAC shall retain the current state condition until one of the following occurs:

- the master MS receives and acknowledges request for pre-emption or channel changeover and enters either idle or signalling mode of operation;

- the DM-MS obeys a channel state change command from the current or new master DM-MS. i.e. slave DM-MS successfully receives messages indicating change of channel state. e.g. end of channel reservation;

- the DM-MS is required to relinquish a call by one of the channel surveillance procedures described in subclause 8.4.2.4;

- the DM-MS is switched to an alternative mode of operation by the user.

8.4.4 DM-MS monitoring requirements

The monitoring procedures to be conducted by a DM-MS are dependent upon the current perceived state of the DM channel and the DM-MS operating mode. The following subclause defines the DM-MS monitoring requirements, the procedures for which are detailed in subclauses 8.4.2.2, 8.4.2.3 and 8.4.2.4.

8.4.4.1 Free DM channel

A DM-MS in idle mode shall monitor the selected DM channel frequency at least once every multiframe duration for DSBs in order to keep an up to date record of the current state of the channel. In order to reliably receive any signalling messages addressed to it or a group of which it is a member and achieve fast call set-up more frequent monitoring of the channel may be required.

8.4.4.2 DM channel in occupation during call set-up

For a circuit mode call set-up with presence check the master MS shall monitor timeslot 1 and 3 for a DSB in the frames allocated for acknowledgements transmitted from a slave MS.

8.4.4.3 DM channel in occupation during a circuit mode call

A master MS during an active call transaction shall monitor time slot 3 of frames 2, 5, 8, 11, 14 and 17 for a DSB containing pre-emption or time change request signalling by a slave MS.

A slave MS shall during channel occupation monitor and attempt to decode the DSB containing occupation signalling transmitted in timeslots 3 of frames 6, 12 and 18 by the current master MS.

8.4.4.4 DM channel in reservation during a circuit mode call

Following the end of a circuit mode call transaction the master MS shall monitor timeslot 3 for a DSB containing transmit request, timing change request or pre-emption request signalling. The master MS shall conduct this monitoring in all frames except:

- frame 3;

- those frames in which it is transmitting channel reservation signalling; and

- those frames which are precluded as indicated by the "change over requests" bit map.

A slave MS shall monitor timeslot 1 or 3 of frames 6, 12 and 18 in each multiframe for a DSB containing reservation information. Additional monitoring may be required in order to determine when a new call transaction has begun.

A slave MS wishing to become the new master on the channel shall following the transmission of the transmit request message monitor timeslot 1 and 3 in the following frames for a DSB indicating the result of the request.

8.4.4.5 DM channel in occupation during a SDS call

During SDS transmissions the master MS shall monitor timeslot 3 of frames 2, 5, 8, 11, 14 and 17 for a DSB carrying pre-emption requests.

For SDS transmissions that require an acknowledgement from a slave MS, the master MS shall monitor timeslots 1 and 3 in those frames assigned for acknowledgement messages.

NOTE: The DM channel during SDS is always in occupation i.e. no reservation, even during periods where acknowledgement messages are to be sent.

8.4.4.6 DM channel usage during pre-emption signalling

A DM-MS following the transmission of a request to pre-empt the channel shall monitor timeslots 1 and 3 in the following frames to determine the result of the pre-emption request . This information may be sent by the master MS using either a DSB or DNB with slot flag set (refer to subclause 8.5.7).

8.4.4.7 DM channel usage during timing change request signalling

A slave MS following the transmission of a request for timing change shall monitor timeslots 1 and 3 in the following frames to determine the result of the timing change request (refer to subclause 8.5.7).

However the actual timing change shall not occur before the end of the current call transaction.

8.4.4.8 Channel B master MS monitoring procedures

For frequency efficient operation a master MS operating on channel B shall at intervals not exceeding 2†multiframe duration's monitor the A channel transmissions in order to determine channel A state and acquire timing synchronisation information. The periods of time when the master MS on channel B shall conduct channel A monitoring is not defined in this ETS. If master B using the procedures described in subclauses 8.4.2.2 and 8.4.2.3.1 determines that channel A is now free it shall terminate channel B monitoring procedures immediately. It shall continue to use the current timing reference and timing counters, but shall indicate that the channel is now channel A (changing the "A/B channel usage" element in DMAC-SYNC PDUs).

For frequency efficient operation, a DM-MS may wish to make a call when the only ongoing communication is labelled as a B channel (i.e. before that master has determined that channel A is now free). The new calling DM-MS may use the free channel, also following B channel monitoring procedures and labelling the channel as a B channel.

8.4.5 Transmission of layer 3 messages by DM-MAC

8.4.5.1 Transmission of DMCC message by DM-MAC

A DM-MAC on receiving a DMA-UNITDATA request from the DMCC shall dependent upon the message type contained within the DMA-UNITDATA request and the current DM-MS state (as defined in subclause 8.4.3) use the following procedures to send the DMCC message. Refer also to subclauses 8.5.6 and 8.5.7.

DMA-UNITDATA request message type: **DM-SETUP**
DM-MAC state: **Channel free - MS idle**
DM-MAC PDU type: **DMAC-SYNC**

A DM-MS which is currently in idle mode shall, having determined that the current state of DM channel is free send the DM-SETUP message using a DSB. The DM-SETUP message shall be sent in timeslots 1 and 3 of frames FN and FN+1 up to a maximum of FN+3, where FN is the current or initial value of the DM-MS frame counter. The maximum number of frames in which the message is sent shall be determined by the frame countdown element value detailed in subclause 8.4.7.2.

As an option a DM-MS operating on channel A may also send the DM-SETUP messages in time slots 2 and 4 in each of the signalling frames.

DMA-UNITDATA request message type: **DM-SETUP**
DM-MAC state: **Channel reserved - MS master**
DM-MAC PDU type: **DMAC-SYNC**

A DM-MS which is currently operating as master on a reserved channel shall signal the resumption of transmission by sending a DM-SETUP message using a DSB. The DM-SETUP message shall be sent in timeslots 1 and 3 of frames FN and FN+1 up to a maximum of FN+3, where FN is the current value of the DM-MS frame counter. The maximum number of frames in which the message is sent shall be determined by the frame countdown element value detailed in subclause 8.4.7.2.

DMA-UNITDATA request message type:	**DM-SETUP PRES**
DM-MAC state:	**Channel free - MS idle**
DM-MAC PDU type:	**DMAC-SYNC**

A DM-MS which is currently in idle mode shall, having determined that the current state of DM channel is free send the DM-SETUP PRES message using a DSB. The DM-SETUP PRES message shall be sent in timeslots 1 and 3 of frames FN and FN+1 up to a maximum of FN+3, where FN is the current or initial value of the frame counter. The maximum number of frames in which the message is sent shall be determined by the frame countdown element value detailed in subclause 8.4.7.2.

As an option a DM-MS operating on channel A may also send the DM-SETUP PRES messages in time slots 2 and 4 in each of the signalling frames, except the final signalling frame where timeslot 4 shall not be used.

DMA-UNITDATA request message type:	**DM-CONNECT**
DM-MAC state:	**Channel occupied - MS slave**
DM-MAC PDU type:	**DMAC-SYNC**

A slave DMCC having successfully received a DM-SETUP PRES message from a master MS shall, if accepting the call send a DM-CONNECT message. The DM-MAC shall transmit the message using a DSB, in timeslots 1 and 3 or timeslot 3 only, in up to N.210 consecutive frames. The first transmission shall take place in the frame following the last signalling frame sent by the master MS. The slave MS response shall also contain the frame countdown element detailed in subclause 8.4.7.2 to indicate when traffic transmissions by the master MS can begin.

DMA-UNITDATA request message type:	**DM-DISCONNECT**
DM-MAC state:	**Channel occupied - MS slave**
DM-MAC PDU type:	**DMAC-SYNC**

A slave DMCC having successfully received a DM-SETUP PRES message from a master MS shall, if not accepting the call send a DM-DISCONNECT message. The DM-MAC shall transmit the message using a DSB, in timeslots 1 and 3 or timeslot 3 only, in up to N.210 consecutive frames. The first transmission shall take place in the frame following the last signalling frame sent by the master MS. The slave MS response shall also contain the frame countdown element detailed in subclause 8.4.7.2.

DMA-UNITDATA request message type:	**DM-RELEASE**
DM-MAC state:	**Channel occupied - MS master**
	Channel reserved - MS master
DM-MAC PDU type:	**DMAC-DATA**
	DMAC-SYNC

A master MS shall send a DM-RELEASE message using either a DNB with the slot flag set during occupation or a DSB during reservation. The master DM-MAC shall send the DM-RELEASE message in timeslot 1 and optionally in timeslot 3, in at least two frames. The transmission of a DM-RELEASE message may in some cases be combined with a DM-PRE EMPT ACCEPT message within the same burst in the case of pre-emption signalling.

DMA-UNITDATA request message type:	**DM-OCCUPIED**
DM-MAC state:	**Channel occupied - MS master**
DM-MAC PDU type:	**DMAC-SYNC**

A master MS shall send a DM-OCCUPIED message using a DSB in timeslot 3 of frames 6 and 12 and timeslots 1 and 3 of frame 18 during channel occupation. The DM-MAC shall continue to send the DM-OCCUPIED message until the DMCC requests transmission of a DM-TX CEASED or DM-RELEASE message. After transmitting the requisite number of DM-TX CEASED messages the DM-MAC shall begin sending the DM-RESERVED signal.

For channel B operation, the transmission of the DM-OCCUPIED message in timeslot 1 of frame 18 is optional.

DMA-UNITDATA request message type:	**DM-TX CEASED**
DM-MAC state:	**Channel occupied - MS master**
DM-MAC PDU type:	**DMAC-DATA**
	DMAC-SYNC

A master MS shall send the DM-TX CEASED message using a DNB with the slot flag set in timeslot 1 in the frames following the last traffic frame. It may send the message also in the corresponding timeslot 3 using a DSB. The DM-TX CEASED messages shall be retransmitted in several frames as indicated by the frame count down element as detailed in subclause 8.4.7.2.

DMA-UNITDATA request message type:	**DM-TX REQUEST**
DM-MAC state:	**Channel reserved - MS slave**
DM-MAC PDU type:	**DMAC-SYNC**

A slave MS shall using the procedure described in subclause 8.5.7.3, having successfully received the first DM-TX CEASED message send a DM-TX REQUEST message using a DSB in timeslot 3 in the pre-emption frames and those indicated by the "change over request" bit map sent by the master MS in the channel reservation signalling. If the slave MS is unsuccessful it may retransmit the transmit request using the procedure detailed in subclause 8.5.7.3.4.

NOTE: DM-TX REQUEST message is only transmitted during DM channel reservation.

DMA-UNITDATA request message type:	**DM-TX ACCEPT**
	DM-REJECT
DM-MAC state:	**Channel reserved - MS master**
DM-MAC PDU type:	**DMAC-SYNC**

A master DMCC having successfully received a DM-TX REQUEST message from a slave MS shall send either a DM-TX ACCEPT or DM-REJECT message. The DM-MAC shall transmit the message using a DSB in timeslot 1 in at least two frames for DM-TX ACCEPT, or at least one frame for DM-REJECT.

DMA-UNITDATA request message type:	**DM-PREEMPT**
DM-MAC state:	**Channel occupied - MS slave**
	Channel reserved - MS slave
DM-MAC PDU type:	**DMAC-SYNC**

A slave MS shall using the procedure described in subclause 8.5.7.3 send a DM-PREEMPT message using a DSB in timeslot 3 of either frame 2, 5, 8, 11, 15 or 17 of a multiframe. A slave MS which does not receive an acknowledgement within a prescribed time may retransmit the pre-emption request using the procedure detailed in subclause 8.5.7.3.4.

NOTE: During channel reservation DM-PREEMPT requests may also be sent in timeslot 3 of other frames indicated by the "changeover request" bit map, see subclause 8.4.7.9 for details.

DMA-UNITDATA request message type:	**DM-PREEMPT**
DM-MAC state:	**Channel occupied - MS idle**
	Channel reserved - MS idle
DM-MAC PDU type:	**DMAC-SYNC**

A DM-MS in idle mode having acquired the required synchronisation and call related information from the current master MS shall using the procedure described in subclause 8.5.7.3 send a DM-PREEMPT message using a DSB in timeslot 3 of either frame 2, 5, 8, 11, 15 or 17 of a multiframe. An idle MS which does not receive an acknowledgement within a prescribed time may retransmit the pre-emption request using the procedure detailed in subclause 8.5.7.3.4.

DMA-UNITDATA request message type:	**DM-PRE ACCEPT**
DM-MAC state:	**Channel occupied - MS master**
	Channel reserved - MS master

DM-MAC PDU type:	**DMAC-DATA** **DMAC-SYNC**

A master DMCC having successfully received a DM-PREEMPT message and decided to permit channel pre-emption shall send a DM-PRE ACCEPT message. The DM-MAC shall transmit the message using a DSB during reservation or short data occupation, or DNB with the slot flag set during circuit mode occupation, in timeslot 1 in at least two frames. It should send the message also in the corresponding timeslot 3's using a DSB.

DMA-UNITDATA request message type:	**DM-SDS UDATA** **DM-SDS DATA**
DM-MAC state:	**Channel free - MS master**
DM-MAC PDU type:	**DMAC-SYNC, FRAG, END**

A DM-MS which is currently in idle mode shall, having determined that the current state of DM channel is free, send the SDS call set-up message using a DSB. The SDS set-up message shall be sent in timeslots 1 and 3 of frames FN and FN+1 up to a maximum of FN+3, where FN is the current or initial value of the DM-MS frame counter. The maximum number of frames in which the message is sent shall be determined by the frame countdown element value detailed in subclause 8.4.7.2. Following the transmission of the SDS call set-up messages the master MS shall continue to send the SDS message in timeslot 1 of the next frame in the range 1-17. It may be possible to begin sending the first part of the SDS message in the call set-up frames, in which case this part of the message is sent several times. However the remainder of the SDS message are sent in timeslot 1 of the subsequent traffic frames and shall not be repeated within the transmission.

As an option a DM-MS operating on channel A may also send the SDS call set-up messages in time slots 2 and 4 in each of the signalling frames.

For DM-SDS UDATA, the complete SDS transmission may be repeated immediately, but not using timeslots 2 and 4 for the SDS call set-up messages.

DMA-UNITDATA request message type:	**DM-SDS ACK**
DM-MAC state:	**Channel occupied - MS slave**
DM-MAC PDU type:	**DMAC-SYNC**

A slave MS having received the DM-SDS DATA message shall using the procedures detailed in subclause 8.5.6.2 send a DM-SDS ACK message in timeslots 1 and/or 3 using a DSB in those frames indicated by the master MS .

8.4.5.2 Transmission of U-plane messages by DM-MAC

During channel occupation, a master DM-MAC on receiving a DMD-UNITDATA request from the U-plane application shall perform the procedures as defined in subclause 8.6.4.

8.4.6 Transmission of layer 2 messages generated by DM-MAC

The DM protocol has been designed such that some signalling messages are generated and transmitted by the DM-MAC without DMCC intervention e.g. short data occupation and reservation signalling plus timing change requests and acknowledgements. The following procedures detail how such DM-MAC signalling is handled.

In all cases signalling messages sent by a DM-MAC shall contain the correct slot and frame numbers, the current values of which are obtained from the slot and frame counters held within the DM-MS. The DM-MAC message types are;

DM-MAC message type:	**DM-RESERVED**
DM-MAC state:	**Channel reserved - MS master**
DM-MAC PDU type:	**DMAC-SYNC**

A master MS following the transmission of the requisite number of DM-TX CEASED messages shall send DM-RESERVED messages using a DSB in timeslots 1 and 3 of frames 6, 12 and 18. The DM-RESERVED messages shall contain the same "priority level" as the DM-TX CEASED messages. Transmission of the DM-RESERVED message shall continue until either the channel state returns to occupation or the channel reservation period expires or a DM-RELEASE message is sent.

A master MS shall also send DM-RESERVED messages following transmission of short data if that short data was sent as a transaction within a circuit mode call. The first DM-RESERVED messages shall be sent within the period last defined as the “SDS time remaining”.

For channel B operation, the transmission of the DM-RESERVED message in timeslot 1 of frame 18 is optional.

The channel reservation signal shall contain an element indicating how much longer the channel will remain reserved. The final DM-RESERVED messages sent on expiry of the channel reservation period shall indicate the end of the reservation time (element "reservation time remaining" set to 000000_2).

The DM-MAC shall in the DM-RESERVED message using the "change over request" bit map indicate in which frames (timeslot 3) the master MS shall monitor for DM-TX REQUEST or DM-PREEMPT request or timing change messages. The change over request bit map may be configured by a master MS in such a way that permits the master MS to conduct dual watch or employ some form of battery economy.

DM-MAC message type:	**DM-SDS OCC**
DM-MAC state:	**Channel occupied - MS master**
DM-MAC PDU type:	**DMAC-SYNC**

A master MS shall, during the transmission of SCH/F for a DM-SDS DATA or DM-SDS UDATA message, send using a DSB a DM-SDS OCC message in timeslot 3 of frames 6, 12 and 18. It shall not send DM-SDS OCC during the period when it is waiting for a DM-SDS ACK following the transmission of a DM-SDS DATA message.

DM-MAC message type:	**DM-TIMING REQUEST**
DM-MAC state:	**Channel occupied - MS slave**
	Channel reserved - MS slave
DM-MAC PDU type:	**DMAC-SYNC**

A master MS shall indicate whether timing requests shall be accepted during a call. In the cases where this is indicated the DM-MAC in the slave MS shall be responsible for the transmission of timing change requests. The DM-MAC shall send a DM-TIMING REQUEST message in a DSB in timeslot 3 of those frames reserved for pre-emption during channel occupation and additionally during reservation, those frames allocated for DM-TX REQUEST signalling. It shall use the random access protocol defined in subclause 8.5.7.

DM-MAC message type:	**DM-TIMING ACK**
DM-MAC state:	**Channel occupied - MS master**
	Channel reserved - MS master
DM-MAC PDU type:	**DMAC-SYNC**

A master MS, on successfully receiving a DM-TIMING REQUEST message, shall send an acknowledgement to the requesting slave using the DM-TIMING ACK message indicating whether the timing change request has been accepted or not.

Once a timing request has been accepted, the master DM-MAC shall indicate that no further timing requests are invited by setting the "timing flag" to 0 in the occupation and reservation signals.

8.4.7 Transmission of messages by DM-MAC

8.4.7.1 DM-MAC repeat transmissions

Many DMCC messages are sent several times by the DM-MAC to improve signalling reliability. For each type of signalling message sent by a DM-MS the respective DM-MAC shall know how many message transmissions are required and during transmission indicate using the frame count down element of how many more transmissions following the present one remain. The maximum value of the frame count down element for each message type are given in annex A.

8.4.7.2 DM-MAC frame count down procedure

The DM-MAC shall dependent upon message type set the frame count down element in the signalling messages up to the maximum permitted given in annex A. The DM-MAC shall decrement the frame count down element by 1 for each frame the message is sent. When the frame count down element = 0 this shall indicate that this is the last frame in which this information is contained (refer to subclause 8.5.6).

8.4.7.3 Timers

In the case of reservation and random access the DM-MAC shall use a set of timers to determine how long signalling or reservation signalling should be transmitted and how long a master DM-MS should wait for an acknowledgement to a signalling message. The range of timers and their maximum values are given in annex A.

8.4.7.4 Linearisation

During circuit mode occupation, a slave MS may only conduct linearization in frame 3 if permitted by the master MS. The DM-MAC in the master MS shall in order to permit transmitter linearization to be conducted on the selected channel allocate the use of timeslot 3 of frame 3 for linearization, by setting a flag within the call set-up and occupation signalling.

NOTE: The requirement on the master DM-MS to permit linearization during circuit mode occupation may be relaxed for some types of call in future editions of this ETS. Therefore, slave DM-MSs have to check the setting of the "LCH in frame 3" flag.

During reservation, a slave MS may conduct linearization in timeslot 3 of frame 3. During short data occupation, a slave MS may conduct linearization in timeslot 3 of frame 3 if timeslot 1 of frame 3 is an SCH/F slot (as indicated by the "number of SCH/F slots" element in the SDS call set-up message).

A DM-MS wishing to begin a call may, after determining that the selected channel is free, linearize its transmitter in the time prior to sending the call set-up signalling.

8.4.7.5 Fragmentation

In the case where the signalling message from the DMCC is larger than can be accommodated within a single DM-MAC PDU the DM-MAC shall sub divide and transmit the PDU in a number of fragments according to the procedures detailed in subclause 8.5.4.1. The DM-MAC shall indicate that fragmentation is in use by setting the appropriate flag in the set-up signalling message.

8.4.7.6 Fill bit indication

In the case where fill bits are added by the DM-MAC this shall be indicated by setting the appropriate flag in the DMAC PDUs as detailed in subclause 8.5.5.

8.4.7.7 Selection of pseudo address

In those cases where the master wishes to hide its true ISSI the DM-MAC using the procedures detailed in subclause 8.5.2 shall randomly select a pseudo ISSI address. The use of a pseudo address by the master MS shall be indicated in the call set-up, channel occupation and reservation signalling.

8.4.7.8 Slot flag indication

In the case where either the C-plane or U-plane application has stolen traffic capacity on the channel in order to send signalling information the DM-MAC shall indicate this by setting the slot flag. Slot flag is indicated in a timeslot by changing the preamble and training sequence from that used during traffic as detailed in ETS 300 396-2 [2], clause 9.

8.4.7.9 Change over requests bit map

In order that a master MS may conduct Dual Watch operation or some form of battery economy mode during channel reservation the DM-MAC may dictate which frames, in addition to those allocated for pre-emption, may be used for DM-TX REQUEST messages. The DM-MAC shall using an 8 bit field indicate in which frames the master MS shall monitor for DM-TX REQUEST messages. The eight bit field used shall relate to frames 1, 4, 7, 9, 10, 13, 15 and 16.

8.4.7.10 Dual watch operation

The DM-MAC supporting dual watch shall be responsible for periodically monitoring the control channel on the selected trunked system. The details of how the dual watch scheduling is managed within the DM-MS is outside the scope of this ETS.

8.4.7.11 Air interface encryption

When required the DM-MAC shall implement air interface encryption using the procedures detailed in subclause 8.5.3. The master MS shall indicate the use of air interface encryption using the appropriate element in the call set-up, channel occupation and reservation signalling.

8.4.7.12 Channel A or B operation

The DM-MAC shall indicate in the call set-up, occupation and reservation signalling whether channel A or B is being used.

8.4.7.13 SDS time remaining

DM-SDS UDATA, DM-SDS DATA and DM-SDS OCC messages shall contain the "SDS time remaining" element indicating how much longer the channel will remain in short data occupation.

For an unacknowledged short data message, the "SDS time remaining" element shall indicate the time for the current transmission and for any repetitions. Also, if sent as a transaction within a circuit mode call, it shall include an additional two frames to allow for DM-RESERVED to be sent in the frames following the end of the final short data transmission.

For an acknowledged short data message, the "SDS time remaining" element shall indicate the time for the current transmission and for the expected acknowledgement, and also an additional two frames to cover the possible start of an immediate retransmission (or to allow for DM-RESERVED in the case of a transaction within a circuit mode call).

8.4.7.14 Timing change procedure

A master MS during channel occupation shall, having successfully received a timing change request message from a slave MS active within that same call, send a DM-TIMING ACK message indicating whether the timing change request has been accepted or rejected. Acceptance or rejection of a timing change request is indicated using the timing acceptance flag. During channel occupation the master MS shall set the timing change announcement flag equal to 0 in the DM-TIMING ACK message, indicating to the slave MSs on the channel that the timing change will occur after the current call transaction is completed. During channel occupation the DM-TIMING ACK message shall be sent in a DNB with the slot flag set, in timeslot 1 of the next available frame.

If timing advance is to occur the master MS shall following the end of the current call transaction send the requisite number of DM-TX CEASED messages containing the timing change announcement flag set to 1

and the timing advance to be employed. The timing announcement flag equal to 1 indicates that the timing advance shall occur following the frame containing a DM-TX CEASED message with frame count down element equal to 0.

During channel reservation a master MS shall, having successfully received a timing change request message from a slave MS active within that same call, send a DM-TIMING ACK message indicating whether the timing change request has been accepted or rejected. In the case of acceptance the DM-TIMING ACK message shall also contain the timing advance to be employed. Acceptance or rejection of a timing change request is indicated using the timing acceptance flag.

During channel reservation the master MS shall on accepting the timing change request set the timing change announcement flag equal to 1 in the DM-TIMING ACK message. In this case timing advance shall occur following the frame containing a DM-TIMING ACK message with frame count down element equal to 0.

After the transmission of the requisite number of DM-TX CEASED or DM-TIMING ACK messages the master MS shall using the new timing reference transmit DM-RESERVED messages using a DSB in timeslots 1 and 3 of the next two frames (see figure 30). All channel signalling from a slave MS shall use the new timing reference following the first transmission of the DM-RESERVED message.

Timing advance shall not be conducted on a DM frequency supporting frequency efficient operation.

NOTE: Timing advance defines a delay relative to the current reference.

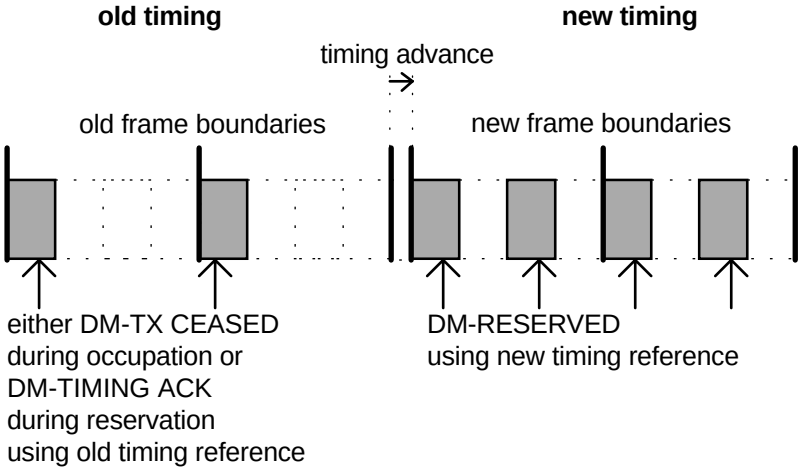


Figure 30: Timing adjustment Illustration

8.4.7.15 Timing change at changeover or pre-emption

When an MS requests changeover or pre-emption, it may include a "timing advance" element within the DM-TX REQUEST or DM-PREEMPT message (irrespective of the current setting of the "timing flag"). If the master MS accepts the changeover/pre-emption then, in the DM-TX ACCEPT or DM-PRE ACCEPT messages (and DM-TX CEASED if appropriate), it shall announce the timing change to the other MSs on the channel. After successful changeover or pre-emption, the new master shall use the new timing reference for sending its call set-up messages (DM-SETUP, DM-SETUP PRES, DM-SDS UDATA or DM-SDS DATA). Also, if necessary for its dual watch operation, it may define a new frame numbering in its call set-up messages.

If the MS does not include a "timing advance" element within the DM-TX REQUEST or DM-PREEMPT message then, when sending its call set-up messages, it shall adopt the timing reference and state of the timing counters (QN, SN, TN, FN) indicated by the old master. Refer also to ETS 300 396-2 [2], subclause 7.2.

The timing change procedure shall not be conducted on a DM frequency supporting frequency efficient operation.

8.5 MAC Procedures for transfer of signalling messages

8.5.1 Formation of MAC PDU

MAC PDUs may be sent in either the DSB or the DNB.

The DSB comprises two blocks, coded as SCH/S + SCH/H. In the DM protocol, the content of these two blocks is directly linked. The MAC PDU type is indicated in the SCH/S block and is always DMAC-SYNC for direct MS-MS operation. The content of the SCH/S block gives synchronisation information and also encryption information relating to the SCH/H block (and to any following traffic or short data). Refer to clause 9 for a full description of the PDUs.

The DNB is used by the master DM-MAC when transmitting traffic or when transmitting short data messages that do not fit within the DSB.

a) In traffic transmission, training sequence 1 is generally used for transmitting TCH (represented as the DMAC-TRAFFIC PDU). Training sequence 2 shall be used when the master steals from the circuit to send signalling information, stealing either one or both half slots of a slot. The DMAC-DATA PDU shall be used for sending C-plane signalling on the stealing channel STCH, or the DMAC-U-SIGNAL PDU for sending U-plane signalling. On STCH, fragmentation is permitted within one slot; then the first half slot contains the DMAC-DATA PDU and the second half slot contains the DMAC-END PDU. Refer to subclause 8.6 for the MAC procedures in traffic mode.

b) For short data messages, if the entire message does not fit within the DSB, the remainder of the data shall be sent on SCH/F using training sequence 1, and obeying the fragmentation procedure (refer to subclause 8.5.4). Each SCH/F block shall contain a single MAC PDU, with a MAC PDU type to indicate the usage of the PDU: DMAC-DATA, DMAC-FRAG or DMAC-END. Continuations and end of a fragmented DM-SDU shall be sent in DMAC-FRAG and DMAC-END respectively. DMAC-DATA may be used on SCH/F if it is required to abort a fragmented message e.g. in case of pre-emption.

   NOTE: Temporary interruption of a short data message is not supported.

The DMAC-SYNC PDU and the DMAC-DATA PDU contain:

1) a MAC header comprising:

   - for DMAC-SYNC only, synchronisation and encryption information (sent in SCH/S);
   - general layer 2 elements such as information about fragmentation and fill bits, and the frame count-down;
   - addressing information;
   - the "message type" indicating the purpose of the message (e.g. DM-SETUP for call set-up or DM-PREEMPT for pre-emption); and
   - message-dependent elements that are visible at layer 2; some of the message-dependent elements are generated by layer 2 (e.g. the timing flag in DM-SETUP) whereas others are passed from layer 3 (e.g. priority);

2) purely layer 3 information (the DM-SDU) which is not visible at layer 2 and which is transported by layer 2 as a service to layer 3.

The DMAC-FRAG, DMAC-END and DMAC-U-SIGNAL PDUs contain a short MAC header (comprising only a few purely layer 2 elements) and a DM-SDU element.

When the DM-MAC is required to send a C-plane message generated by layer 3, it receives a DMA-UNITDATA request primitive from layer 3. The primitive contains, as parameters: addressing information, the DM-SDU, the message type and any other layer 3 elements to be included in the

transmitted message (and also parameters to be used within layer 2). The DM-MAC shall then prepare the appropriate MAC PDU(s), using elements as defined in clause 9, and including the general layer 2 elements and also any layer 2 elements dependent on the message type. The method to be used for the transmission of the message may depend on the DM-MS's current state and on the message type. After addition of fill bits (if required), the PDU shall be passed to the lower MAC in a DMV-UNITDATA request primitive for coding, scrambling and transmission over the air.

When the DM-MAC receives a message (delivered by the lower MAC in a DMV-UNITDATA indication primitive), the SCH/S information, general layer 2 elements, addressing information, message type and message-dependent elements are all visible at layer 2 and may be used by any DM-MAC, irrespective of whether the DM-MS is addressed by the message. Only the addressed DM-MS(s) may deliver the message (i.e. message type, message-dependent layer 3 elements and DM-SDU) to layer 3. When delivering a message to layer 3, the DM-MAC shall use the DMA-UNITDATA indication primitive.

Some DM messages (message types DM-RESERVED, DM-SDS OCC, DM-TIMING REQUEST and DM-TIMING ACK) are generated by layer 2 itself; refer to subclause 8.4.6. These messages are then carried within a DMAC-SYNC or DMAC-DATA PDU, where the MAC PDU comprises only a MAC header (as defined in i) above) and where the message type element is generated by layer 2.

8.5.2 Addressing

The MAC header in an SCH/H block or in a DMAC-DATA PDU generally contains a 24-bit MNI, a 24-bit destination SSI and a 24-bit source SSI (see clause 9). The setting of these elements is described in this subclause. See ETS 300 396-1 [1], clause 6 for a description of the usage of DM addresses and identities.

8.5.2.1 Transmission of message

When the DM-MAC receives a DMA-UNITDATA request primitive from layer 3, the primitive contains the destination address and the destination address type as parameters. The precise usage of addressing in the MAC PDUs depends on whether the message is sent in a DSB or DNB, and on whether the message is initiating a call.

8.5.2.1.1 Addressing in synchronisation burst

In a message initiating a call set-up or short data message, and in group-addressed occupation and reservation messages, the master DM-MAC shall set the MNI and destination SSI elements to the TETRA Subscriber Identity (TSI) of the called party - as provided by layer 3. The "destination address type" element shall be set to 0.

The DM-MAC shall then supply the source SSI as follows:

- for an intra-MNI call, and if the master DM-MS is prepared to supply its own ISSI as a layer 2 address, the DM-MAC shall set the source address element to the ISSI and shall set the "source address type" element to 0;

- for an intra-MNI call if the master DM-MS does not wish to use its ISSI as a layer 2 address, or for an inter-MNI call, the DM-MAC shall make a random choice of a 24-bit "pseudo SSI" for use by layer 2 during that transaction (choosing any value except all zeros or all ones). This shall be indicated by setting the "source address type" element to 1. The pseudo SSI may then be used in other messages sent by that DM-MS and shall temporarily be used as a destination address by other DM-MSs wishing to address that DM-MS (with "destination address type" set to 1);

  the pseudo SSI has a limited lifetime. For a master DM-MS in a group call, the pseudo SSI becomes invalid when the DM-MS ceases to be master. A DM-MS shall not have more than one pseudo SSI valid at one time.

NOTE: The pseudo SSI mechanism is similar to the Alias SSI in V+D, except that it is randomly chosen by the DM-MS when it is required and is valid for only a short period. It is used for inter-MNI calls. Also, for intra-MNI calls, it may be useful if TPNI is disabled; or if air-interface encryption state 10_2 is used and the DM-MS wishes the TPNI to be encrypted. If a pseudo SSI is used and TPNI is required for a circuit mode call then the talking party's TSI may be sent on STCH (DM-INFO message); or the source address may be sent within the DM-SDU for a short data message.

The use of pseudo source addressing at layer 2 gives rise to a remote possibility of address ambiguity in addressing that DM-MS as destination. This possibility is reduced to the minimum by the limited time validity of recognition of the pseudo SSI.

A random access request message (i.e. pre-emption, changeover or timing change request) shall include the current master DM-MS's layer 2 address as the destination address. This shall be the address that the master DM-MS has been using as its source address - whether true or pseudo. The requesting DM-MS may either use its own ISSI as source address or choose a pseudo SSI as above, but not equal to the master's pseudo SSI if applicable. If used then, for a group call, the pseudo SSI becomes invalid when the DM-MS receives an acceptance or rejection of the request or if the transmission attempt fails. (In the case of acceptance of a pre-emption or changeover request, the DM-MS may choose to use the same pseudo SSI in the call set-up messages, in which case the pseudo SSI is re-enabled with the DM-MS as master.)

A response message to a random access request or to a short data message shall contain the same addresses as in the invoking message but with source and destination addresses reversed.

For an individual circuit mode call, if the master DM-MS uses a pseudo SSI as the source address, then that SSI remains valid for the duration of the call and becomes invalid at the end of the call. A DM-CONNECT message responding to a call set-up with presence check may use a pseudo SSI as the source address in that response message. That SSI then remains valid for the duration of the call, and may be used by the master DM-MS for addressing that DM-MS. It becomes invalid at the end of the call.

In some messages, pseudo addressing may be used for both the source and destination address. However, an MNI element shall still be present within the DMAC-SYNC PDU, though it need not be a true MNI.

The MNI and source address elements in a DM-OCCUPIED message shall be the same as in the DM-SETUP or DM-SETUP PRES message that initiated the current traffic transmission.

8.5.2.1.2 Addressing in normal burst

The mechanisms for addressing in the DMAC-DATA PDU are similar to those in the SCH/H block of the synchronisation burst except that, when a normal burst is sent, there has already been a synchronisation burst to define the source address and the colour code for the scrambling of normal bursts. It is therefore optional whether the DMAC-DATA PDU includes a source address. If it does not then the recipient DM-MAC shall assume the layer 2 source address from the call set-up message (or short data message header).

NOTE: For example, TPNI in DM-INFO can be sent within a single stolen half slot if the master DM-MS does not include a layer 2 source address within the DMAC-DATA PDU.

8.5.2.2 Reception of message

When the DM-MAC receives a DMAC-SYNC or DMAC-DATA PDU, it shall check whether it is addressed by the message i.e.:

- for destination address type = 0: whether the MNI + destination SSI corresponds to the DM-MS's Individual TSI (ITSI) or to one of its Group TSIs (GTSIs);

- for destination address type = 1: whether the DM-MS has a currently valid pseudo SSI, and that pseudo SSI is equal to the destination SSI.

If the DM-MS is addressed by the message then the DM-MAC shall process all the contents of the PDU and, for a layer 3 message, shall pass the message and any DM-SDU to layer 3 using the DMA-UNITDATA indication primitive (unless this is a repetition, as defined in subclause 8.5.6). It shall indicate the source address and source address type and the address on which the message was received. The DM-MAC may also perform actions itself, based on the message type and message-dependent elements.

If the DM-MS is not addressed by the message then the DM-MAC may use the elements visible at layer 2 (e.g. to update its channel state model) but shall not pass the message to layer 3.

NOTE 1: There is no distinction between an ITSI or GTSI in the PDU.

NOTE 2: In addition to the DM-MS's allocated group addresses, the predefined "open" group address defines a group to which all DM-MSs belong. This allows calls to be made to all users who have selected the same DM channel. The content of the open SSI comprises all ones. To obtain complete openness, a special TSI is used, with the open MNI (all ones) combined with the all ones SSI. Openness within one MNI can be obtained by combining that MNI with the all ones SSI.

8.5.3 Use of air interface encryption

The support of air interface encryption is optional. If this mode is supported, the DM-MAC shall encrypt signalling messages as instructed by the higher layers on a message basis. Encrypted messages shall be indicated in the MAC header in order to enable the receiving end to decrypt the message content. The DM-MAC may in addition perform air-interface encryption on the content of the half slots coming from the DMD-SAP. This may apply to both TCH and U-plane signalling, and it may apply to U-plane traffic information that has already been end-to-end encrypted.

The "air interface encryption state" element in the DMAC-SYNC and DMAC-DATA PDUs defines whether air interface encryption applies. If it applies, it may be invoked from one of two places in the PDU:

1) so that the addressing information, message type, message-dependent elements and DM-SDU (and any related TCH) are all encrypted; or

2) so that only the DM-SDU (and any related TCH) are encrypted; the addressing information, message type and message-dependent elements are un-encrypted.

NOTE 1: The first method gives more secure operation. However, it means that pre-emption is not possible between user groups that do not share the same encryption keys, since the members of other security groups cannot read either the current call priority or the master DM-MS's address. Also, there can be a remote possibility that a DM-MS in another security group may occasionally recognise its own address in the encrypted destination field (though it will not understand the rest of the information).

NOTE 2: The SCH/S block in the synchronisation burst is always un-encrypted.

The setting of the "air-interface encryption state" element in the DMAC-SYNC PDU containing the call set-up message defines also whether air-interface encryption applies to the related TCH and to the DM-SDU in any DMAC-U-SIGNAL PDUs sent on STCH. (The MAC header of the DMAC-U-SIGNAL PDU shall not be encrypted.) When C-plane signalling is sent on STCH, the MAC header of the DMAC-DATA PDU shall indicate independently whether that message is encrypted; this setting applies only to that message and does not affect TCH or STCH in subsequent slots.

In the case of fragmentation, the setting of the "air-interface encryption state" element in the DMAC-SYNC or DMAC-DATA PDU defines also whether encryption applies to the other fragments of the DM-SDU. The MAC headers of DMAC-FRAG and DMAC-END PDUs shall not be encrypted.

8.5.4 Fragmentation and reconstruction

Fragmentation is the subdivision procedure that shall be used by the DM-MAC in the case that a DM-SDU received from layer 3 exceeds the available capacity in a MAC block. The DM-MAC subdivides the

DM-SDU into a number of fragments, where each fragment is sent within one MAC PDU. This procedure is illustrated in figure 31. Fragments are not numbered, and so they shall be sent in sequence. There is no selective retransmission procedure; if an error occurs during the transmission then the MAC procedure fails and the whole DM-SDU has to be retransmitted. From the point of view of the higher layers, the process is the same as if the DM-SDU had been transmitted in a single MAC block.

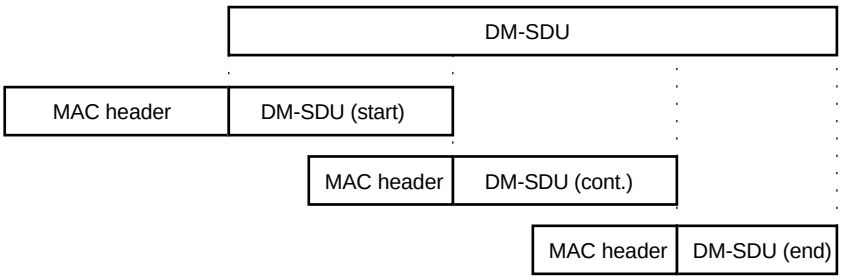


Figure 31: MAC fragmentation of a long DM-SDU

The first fragment of a DM-SDU shall be sent with a full MAC header - in either a DMAC-SYNC or DMAC-DATA PDU. Whereas continuation fragments (DMAC-FRAG PDU) and the final fragment (DMAC-END PDU) shall be sent with a reduced header (see clause 9). In particular, only the full MAC header contains addressing information.

The DM-MAC shall not interleave any other signalling with a fragmented DM-SDU.

8.5.4.1 Fragmentation

When the DM-MAC wishes to send a C-plane message that does not require fragmentation, it shall send the entire DM-SDU within the DMAC-SYNC or DMAC-DATA PDU.

The DM-MAC may perform fragmentation of a DM-SDU using either of the following transmission forms:

1) DMAC-SYNC + n * DMAC-FRAG + DMAC-END (where $n \geq 0$);

   This is the fragmentation method most generally used (e.g. for sending a short data message). The DMAC-SYNC PDU shall be sent in the DSB and the DMAC-FRAG and DMAC-END PDUs shall be sent on SCH/F. The DMAC-FRAG PDU carries 264 bits of DM-SDU and the DMAC-END PDU can carry up to 264 bits of DM-SDU;

2) DMAC-DATA + DMAC-END, sent on STCH + STCH in one DNB;

   This form may be used if a master DM-MS sending circuit mode traffic wishes to steal a complete slot from the circuit e.g. to send a short data message.

The procedure for method 2) is specified in subclause 8.6. The procedure for method 1) is described in this subclause.

The DM-MAC shall send the first fragment in the DMAC-SYNC PDU on the DSB. It should set the "fill bit indication" to indicate that no fill bits are present. The "fragmentation flag" shall be set to indicate start of fragmentation and the "number of SCH/F slots" element shall be set to indicate the number of following fragments i.e. n+1. The DMAC-SYNC shall be repeated the appropriate number of times, using the frame count-down mechanism to indicate when the repetitions of the DMAC-SYNC have been completed.

The DM-MAC shall then send the n DMAC-FRAG PDUs and the DMAC-END PDU on SCH/F, in consecutive slot 1's of frames 1 to 17 and without repetition. It shall send these PDUs in the correct sequence. For the DMAC-FRAG PDU(s), the DM-MAC should include fragments of 264 bits of the DM-SDU with no fill bits. The DMAC-END PDU shall then contain the remaining part of the DM-SDU, with the "fill bit indication" set to indicate whether or not fill bits are used within the MAC block. The DM-MAC shall then regard the current message transmission as complete.

For an acknowledged data message, layer 3 is responsible for requesting a retransmission if a response is not received from the called party. The DM-MAC shall therefore issue a final DMA-REPORT indication primitive to the higher layers after a single transmission of the complete message.

For an unacknowledged data message, the DM-MAC may repeat the message transmission immediately (without re-checking that the channel is free), and starting again with synchronisation bursts. It shall issue an interim DMA-REPORT indication to the higher layers after the first complete transmission of the message and shall issue a final report when the message has been sent the required number of times.

The DM-MAC may abort a fragmented transmission at any time before transmission of DMAC-END by sending a DMAC-DATA PDU (e.g. in case of pre-emption). That DMAC-DATA PDU may be a Null PDU, or may contain a non-fragmented message.

NOTE: The DM procedures do not support fragmentation headed by a DMAC-DATA PDU sent on SCH/F.

8.5.4.2 Reconstruction

This procedure is the reverse process to fragmentation (which is performed by the sender as described above) whereby a fragmented message is reassembled by the recipient.

On receipt of a DMAC-SYNC PDU containing one of its addresses, the DM-MAC shall perform the following actions relating to the DM-SDU. (Other actions may be performed relating to other elements in the MAC header):

a) if the "fragmentation flag" is set to 0 indicating no fragmentation, and if this is a layer 3 message and has not already been received (see subclause 8.5.6), then the DM-MAC shall deliver the message (and any DM-SDU) to the higher layers using the DMA-UNITDATA indication primitive;

b) if the "fragmentation flag" is set to 1 indicating the start of fragmentation, then the DM-MAC shall store the DM-SDU fragment. Then, after waiting for the number of frames corresponding to the "frame count-down" element, the DM-MAC shall look for normal bursts (SCH/F) containing continuation fragments or the end of the fragmented data in consecutive slot 1's in frames 1 to 17;

   on receipt of a DMAC-FRAG PDU, the DM-MAC shall append the DM-SDU fragment to the already received fragment(s). The DM-MAC shall then continue to look for further DMAC-FRAG PDUs or for the DMAC-END PDU;

   on receipt of a DMAC-END PDU, the DM-MAC shall append the DM-SDU fragment to the already received fragment(s). The DM-MAC shall then deliver the reconstructed DM-SDU to the higher layers using the DMA-UNITDATA indication primitive. The DM-MAC shall then stop looking for normal bursts in slot 1 of frames 1 to 17.

   NOTE: The length of each fragment is indicated by the fill bit indication and any fill bits.

   The DM-MAC shall continue the process of looking for DMAC-FRAG/DMAC-END until it receives the DMAC-END PDU, or until one of the following occurs:

   i) it receives a DMAC-DATA PDU in slot 1 of a frame in the range 1 to 17; or

   ii) it fails to decode a MAC block in slot 1 of a frame in the range 1 to 17.

   In both cases i) and ii), the DM-MAC shall stop looking for normal bursts in slot 1 of frames 1 to 17;

   In case i), the DM-MAC shall discard the partially reconstructed message (without an indication to the higher layers) and shall process the DMAC-DATA PDU. If the DMAC-DATA PDU contains one of its own addresses, the DM-MAC shall deliver the message and any DM-SDU to the higher layers using a DMA-UNITDATA indication primitive;

In case ii), and if the partially received message was a DM-SDS DATA or a DM-SDS ACK, the DM-MAC shall deliver the message type to the higher layers in a DMA-UNITDATA indication primitive but shall indicate that the DM-SDU was not fully received. For other message types, the DM-MAC shall discard the partially reconstructed message without an indication to the higher layers.

8.5.5 Fill bit addition and deletion

8.5.5.1 Fill bit addition

When the DM-MAC prepares a PDU, it shall place the relevant MAC header in front of the DM-SDU.

Fill bits shall be added when the actual size of a MAC PDU sent on SCH/H, SCH/F or STCH is less than the available capacity of the MAC block. They are used to make up the difference between the actual PDU content and the capacity of the MAC block, and they also show the exact end of the DM-SDU. Fill bit addition applies only to DMA-SAP PDUs (DMAC-SYNC, DMAC-DATA, DMAC-FRAG or DMAC-END PDU). For the DMAC-SYNC PDU, fill bit addition applies only to the SCH/H block, not to the SCH/S block.

If fill bits are added, the DM-MAC shall set the "fill bit indication" in the MAC header to 1. In order to add fill bits, the DM-MAC shall:

- add a fill bit "1" immediately following the last bit of the DM-SDU data (or following the last bit of the MAC header if there is no DM-SDU);

- complete the remainder of the MAC block with fill bits set to "0".

NOTE: The V+D procedures for PDU association and dissociation are not supported in the DMO standard. Only one MAC PDU can be sent per MAC block.

8.5.5.2 Fill bit deletion

On receipt of a DMA-SAP PDU (DMAC-SYNC, DMAC-DATA, DMAC-FRAG or DMAC-END PDU), the DM-MAC shall decode the MAC header and shall check whether fill bits are present within the MAC block ("fill bit indication" set to 1 in the PDU header):

- if no fill bits are present then the PDU shall be further processed by the DM-MAC;

- if fill bits are present, the DM-MAC shall inspect the last bit of the MAC block:

  - if the last bit is "1", remove this bit; then the rest of the data is the true PDU content;

  - if the last bit is "0", remove this bit and all preceding zeros until a "1" is found; remove this bit "1"; then the rest of the data is the true PDU content.

8.5.5.3 Null PDU

The "Null PDU flag" in the DMAC-DATA PDU may be used to indicate a Null PDU. If a Null PDU is indicated, there shall be no further information in the PDU after the "Null PDU flag". Fill bits inserted after a Null PDU to complete the MAC block shall be set to "0" except for the first bit after the Null PDU which shall be set to "1".

A receiving DM-MAC shall recognise the Null PDU and shall not look for further information in the MAC block. (Though, for a Null PDU sent on STCH in the first half slot, the receiving DM-MAC shall use the "second half slot stolen flag" to discover whether the second half slot is also stolen).

NOTE : The Null PDU may be used as a dummy C-plane message when required. For example, it may be sent on STCH in a circuit mode call if TCH is not available, or it may be used to abort a short data message.

8.5.6 Transmission and reception of messages by layer 2 unacknowledged service

When the DM-MAC receives a DMA-UNITDATA request primitive from layer 3, it shall use its current state and the message type parameter to decide how to send the message:

a) for the initiation of a new call, or for non-immediate retransmission, the DM-MAC shall check whether the channel is free (as defined in subclause 8.4) before transmitting the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message using the DSB;

b) for a call continuation after changeover, or for a call set-up after pre-emption, the DM-MAC shall transmit the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message using the DSB and timing its message using the frame countdown element from the received DM-TX ACCEPT or DM-PRE ACCEPT;

c) if the DM-MS is already a master, the DM-MAC may transmit the message and shall use the appropriate burst. For example, this may apply to DM-SETUP, DM-SETUP PRES, DM-SDS DATA, DM-SDS UDATA, DM-OCCUPIED, DM-TX CEASED, DM-RELEASE, DM-TX ACCEPT, DM-PRE ACCEPT, DM-REJECT and DM-INFO messages;

d) if the DM-MS is not the master and if the message is a response to a message from the master (i.e. if the message is DM-CONNECT, DM-DISCONNECT, DM-SDS ACK or DM-REJECT), the DM-MAC shall transmit the message using the DSB and timing the response using the frame countdown element from the invoking message;

e) if the message is a DM-PREEMPT or DM-TX REQUEST, the DM-MAC shall use the random access protocol for sending the message.

In the random access protocol, the DM-MAC sends retries until a response is received or the access attempt fails. The random access protocol is described in subclause 8.5.7.

For the other message types, the service provided by the DM-MAC to layer 3 is an unacknowledged service. The DM-MAC transmits the message the appropriate number of times and shall then report to layer 3 when the message has been sent (DMA-REPORT indication primitive). The acknowledgement protocol (if any) and any resulting retransmission is under the control of layer 3. If the DM-MAC is unable to send the message (e.g. in case a. above if the channel becomes busy) then it shall report the failure to layer 3.

This subclause describes the tools for the layer 2 unacknowledged service.

8.5.6.1 Transmission of message

In the DM protocol, most non-fragmented messages are repeated for reliability, even if there is an acknowledgement protocol at layer 3. These messages are generally repeated several times over the duration of a few frames.

When carried in the DSB, the message may be sent in both slot 1 and slot 3 (or, in the case of initiation of a circuit mode call or short data on a completely free channel, it may also be sent in slot 2 and/or slot 4). The protocol allows the message to be sent in up to four consecutive frames. The "frame count-down" element indicates the number of frames in which the message will be repeated; for example, if the message is sent in two consecutive frames then the "frame count-down" shall be set to 01_2 in the first frame and to 00_2 in the second frame. This enables correct action by the recipient; see subclause 8.5.6.2.

NOTE 1: The frame countdown mechanism applies to the repetition of messages (except DM-OCCUPIED) transmitted as a result of a DMA-UNITDATA request primitive from layer 3. It may also apply to DM-TIMING ACK messages, which are generated by layer 2. The DM-OCCUPIED message (and also short data occupation and reservation messages generated by layer 2) are sent at regular intervals as described in subclause 8.4, and do not use the frame countdown mechanism.

NOTE 2: Even on a completely free channel, the DM-MS should not transmit a DM-SETUP PRES or DM-SDS DATA message in slot 4 of the frame with "frame count-down" set to 00_2 (since it is required to be able to receive a response which may be sent in slot 1 of the next frame).

If transmitting a DM-SETUP message in slot 4 of the frame with "frame count-down" set to 00_2, the DM-MAC should issue the DMA-REPORT indication to layer 3 before that last transmission (enabling an exchange of primitives before sending traffic in slot 1 of the next frame).

For a fragmented message, the "frame count-down" element refers only to repetitions of the DMAC-SYNC PDU. The first DMAC-FRAG PDU (or DMAC-END PDU) shall be sent in slot 1 of the first frame in the range 1 to 17 following the frame with "frame count-down" element set to 00_2.

Messages shall be sent in the DNB only in slot 1 of frames 1 to 17. A message may be sent in up to four consecutive frames. The "frame count-down" element indicates the number of frames in which the message may be repeated (i.e. the number of frames until the final transmission). The frame count-down mechanism shall be used for sending repetitions of DM-PRE ACCEPT, DM-TX CEASED and DM-RELEASE messages. It need not be used for sending repetitions of general information sent on STCH e.g. short data messages or the DM-INFO PDU; in these cases, the repetitions may be sent singly and when convenient.

The DMAC-DATA PDU sent in the DNB indicates the absolute number of frames until the final repetition, irrespective of whether the message transmission crosses frame 18. Where transmission of DM-TX CEASED/DM-RELEASE or DM-PRE ACCEPT crosses frame 18, the DM-MAC shall send the same message in frame 18 but using the DMAC-SYNC PDU in a DSB (replacing the channel occupation messages). The "frame count-down" element in the DMAC-SYNC shall continue the ongoing count-down.

If the DM-MAC is transmitting DM-TX CEASED and has sent the message in slot 1 in at least two frames, and if layer 3 then issues a DM-TX ACCEPT message (or a DM-PRE ACCEPT if it is required to be sent in a DSB), then the DM-MAC may stop transmitting the DM-TX CEASED irrespective of the frame count-down value and start transmitting the DM-TX ACCEPT or DM-PRE ACCEPT.

NOTE: Thus, for example, the DM-MAC may plan to send the DM-TX CEASED in four frames for reliability, but may cut short the retransmission on reception of a changeover request from a DM-MS that received one of the first transmissions of the DM-TX CEASED.

8.5.6.2 Reception of message

The recipient DM-MAC may use the "frame count-down" element F in received messages in several ways:

a) suppression of duplicates:

- when the DM-MAC first receives a non-fragmented layer 3 message (in frame X), it shall deliver the message to layer 3 in a DMA-UNITDATA indication primitive. If the DM-MAC receives a message containing the same addresses and message type either later in the same frame or within the next F frames then the DM-MAC shall assume that the message is a duplicate and shall not deliver it to layer 3;

b) delaying switch into traffic mode:

- when the DM-MS receives a message indicating that it should change into traffic mode (i.e. DM-SETUP or DM-CONNECT), it shall delay the switch for F frames. Refer to subclause 8.6.3;

c) timing of set-up signalling for pre-emption or changeover:

- when the DM-MS receives a DM-PRE ACCEPT or DM-TX ACCEPT message from the master DM-MS (received in frame X), giving it permission to send call set-up signalling or a

short data message, the DM-MAC shall use the "frame count-down" element F in the master's message to deduce when the signalling can be sent without colliding with the master's repeat transmissions. The signalling shall not be sent until at least frame (X+F) mod 18 + 1;

d) timing of immediate SDS retransmission:

- when the DM-MAC is required to send an immediate retransmission of a DM-SDS DATA message, it shall use the "frame count-down" element F from the previously received DM-SDS ACK message to deduce when the DM-SDS DATA can be sent without colliding with the repetitions. The DM-SDS DATA shall not be sent until at least frame (X+F) mod 18 + 1;

e) timing of response to message from master DM-MS:

- when the DM-MS sends a response to a non-fragmented message from the master DM-MS (received in frame X), the DM-MAC shall use the "frame count-down" element F in the master's message to deduce when the response can be sent without colliding with the master's repeat transmissions. The response DSB shall be sent in frame (X+F) mod 18 + 1, either in both slot 1 and slot 3 of that frame or only in slot 3. The response DSB may be sent in up to N.210 frames, with the "frame count-down" element set to the appropriate values. If the response is fragmented (i.e. DMAC-SYNC + DMAC-END) then the frame count-down refers only to the DMAC-SYNC PDU; the DMAC-END shall then be sent, without repetition, in slot 1 of the next frame in the range 1 to 17;

NOTE: This mechanism allows multiple transmissions of the response. For example, if the DM-MAC is not ready to send a DM-CONNECT message in response to a DM-SETUP PRES message until slot 3 of frame (X+F) mod 18 + 1, it can set the "frame count-down" element to 01_2 and repeat the DM-CONNECT in slots 1 and 3 of the following frame (with "frame count-down" element set to 00_2).

f) timing of response to fragmented message from master DM-MS:

- for a fragmented message headed by the DMAC-SYNC PDU, the "frame count-down" element F refers only to the DMAC-SYNC. This then indicates where the first DMAC-FRAG PDU (or DMAC-END PDU) shall be expected. If the DM-MAC receives a DMAC-SYNC PDU in frame X indicating start of fragmentation then it shall look for the first fragment in slot 1 of frame Y = (X+F) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1;

- there is no frame count-down mechanism for the DMAC-END PDU. If the DM-MS requires to send a response to a fragmented message then the response DSB shall be sent in the frame following the frame that contained the DMAC-END, either in both slot 1 and slot 3 of that frame or only in slot 3. The response DSB may be sent in up to N.210 frames, with the "frame count-down" element set to the appropriate values. If the response is fragmented (i.e. DMAC-SYNC + DMAC-END) then the frame count-down refers only to the DMAC-SYNC PDU; the DMAC-END shall then be sent, without repetition, in slot 1 of the next frame in the range 1 to 17;

- if the DM-MAC did not receive the DMAC-END PDU terminating a fragmented DM-SDS DATA message (i.e. in case ii) of subclause 8.5.4.2), then the DM-MAC shall use the "number of SCH/F slots" element from the DMAC-SYNC PDU to deduce when the DMAC-END was sent. It shall transmit the response DM-SDS ACK in both slot 1 and slot 3 of the next frame but not in any subsequent frames. However, during the time since the reconstruction failure, the DM-MAC shall monitor slot 1 of each frame looking for DSBs. If, during that time, it receives any DM-PRE ACCEPT, DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message then it shall refrain from transmitting and shall discard the response;

- there is no layer 2 mechanism for suppressing duplicates of fragmented messages (or duplicates of messages sent intermittently on STCH).

Points e) and f) above define when the first transmission of a response message must be sent. According to the protocol description, it is assumed that, when the DM-MS has received a DM-SDS DATA message

addressed to itself, and if layer 3 does not immediately return a response DM-SDS ACK, then the DM-MAC shall issue a DMC-REPORT indication primitive as a prompt to layer 3 in time to allow transmission in the correct slot(s).

8.5.7 Random access protocol

8.5.7.1 Introduction

During both the occupation and reservation periods, any other DM-MS that wishes to transmit traffic or short data must first request and be granted permission by the current master before performing a set-up procedure and becoming master of the channel itself.

The DM-MS requests permission by sending the DM-PREEMPT or DM-TX REQUEST message (for requesting pre-emption or changeover respectively). Since more than one DM-MS may be attempting to request use of the channel, a random access protocol is used. The protocol is based on slotted Aloha with a binary exponential back-off mechanism used to control collision of messages from different DM-MSs and to avoid protocol instability. The random access protocol is also used if the DM-MS wishes to send a timing change request to the master DM-MS (refer to subclause 8.4).

Only pre-emption requests may be sent during short data occupation. Only pre-emption and timing change requests may be sent while the channel is in circuit mode occupation. Pre-emption, timing change and changeover requests may be sent during the circuit mode reservation period.

8.5.7.2 Procedures for master DM-MS

8.5.7.2.1 Indicating frames available for requests

When the DM-MAC transmits DM-SETUP, DM-SETUP PRES and DM-OCCUPIED messages, it shall set the pre-emption flag to indicate that slot 3 of frames 2, 5, 8, 11, 14 and 17 is available for random access requests (e.g. pre-emption requests) during the occupation period.

NOTE: This requirement may be relaxed for some types of call in future editions of this ETS.

When the master DM-MAC transmits DM-TX CEASED and DM-RESERVED, it shall set the "requests flag" to indicate that random access requests may be sent, unless it has already received and is accepting a pre-emption or changeover request or is changing the channel timing. It shall also set the "changeover requests bitmap" element to indicate whether random access requests may be sent in slot 3 of frames 1, 4, 7, 9, 10, 13, 15 and 16 during the reservation period (in addition to the pre-emption slots). It should allow random access requests in slot 3 of all these frames except any frames in which it will be performing dual watch (unless it is performing a battery economy procedure).

8.5.7.2.2 Monitoring frames available for requests

During occupation for a circuit mode call, the master DM-MAC shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 for pre-emption or timing change requests addressed to itself.

During reservation for a circuit mode call, the master DM-MAC shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17, and also slot 3 of the frames indicated in the "changeover requests bitmap", looking for pre-emption, timing change or changeover requests addressed to itself.

When sending SCH/F for a fragmented DM-SDS UDATA or DM-SDS DATA message, the master DM-MAC shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 for pre-emption requests addressed to itself.

8.5.7.2.3 Response to pre-emption or changeover request

On receipt of a pre-emption or changeover request, the master DM-MAC shall deliver the message to layer 3 in a DMA-UNITDATA indication primitive. Layer 3 will then issue a response to the message in a DMA-UNITDATA request primitive. For a changeover request, the DM-MAC shall send the response in the synchronisation burst. For a pre-emption request, and when sending the response in slot 1 of a frame in

the range 1-17, the DM-MAC shall use either the normal burst or synchronisation burst according to the "perceived channel state" element in the request: DNB for circuit mode occupation, DSB for reservation, DSB for short data occupation:

a) if the master DM-MS accepts the request then it shall send the response several times, for reliability, using the "frame count-down" mechanism. It shall send the first response within a time T.211 minus 1 frame following receipt of the request for circuit mode occupation/reservation, or within a time T.212 minus 1 frame for short data occupation;

   - if using the DNB, the master DM-MS shall send the response in slot 1 in at least two frames; if currently transmitting circuit mode traffic, it shall send the DM-PRE ACCEPT in the same slot as the DM-TX CEASED or DM-RELEASE, one in each of two stolen half slots. The master DM-MS shall also send DM-PRE ACCEPT (using the DSB) in each corresponding slot 3, unless it is a linearization or dual watch frame. If the message transmission crosses frame 18 then the master DM-MS shall also send DM-PRE ACCEPT (using the DSB) in slot 1 and/or slot 3 of that frame;

   - if using the DSB, the master DM-MS shall send the response in slot 1 in at least two frames and shall repeat it in each corresponding slot 3 unless it is a linearization or dual watch frame. Optionally, the master DM-MS may send the response also in the preceding slot 3. (This may apply if the response is first ready to be sent in a slot 3);

   if accepting a pre-emption request during short data occupation:

   - for a DM-SDS UDATA message, the DM-MAC may finish its current message transmission if it can do so within the T.212 constraint. Otherwise it shall send the Null PDU once on SCH/F to terminate its current transmission and then send the DM-PRE ACCEPT using the DSB;

   - for a DM-SDS DATA message, and if the DM-MAC still has three or more SCH/F slots to send to complete its message transmission, it shall send the Null PDU once on SCH/F to terminate its current transmission and then send the DM-PRE ACCEPT using the DSB. Otherwise the DM-MAC shall complete the current message transmission; then it shall not send the DM-PRE ACCEPT until after the T.210 frames following the frame that contained the DMAC-END (since those frames are available for an acknowledgement from the short data recipient);

   the DM-MS shall then stop being master;

   NOTE: The additional repetitions in slot 3 are defined to increase reliability. However, it is possible that collision may occur in these slots and so the slot 1 transmissions should be regarded as the principal transmissions. The transmissions in slot 3 always use the DSB, irrespective of the value of the "perceived channel state" element.

   A acceptance response should be repeated several times because, for simplicity, the DM-MS resigns its role of master after sending the response; there is no interim "caretaker" role. If the requester does not receive any of the transmissions of the response then the channel will time out on inactivity.

b) if the master DM-MS rejects the request then it may send the DM-REJECT in a slot 1 when convenient. It need not repeat the message.

8.5.7.2.4 Response to timing change request

On receipt of a timing change request, the master DM-MAC shall decide whether to accept the request (refer to subclause 8.4) and shall send a response in an appropriate slot 1 (or slot 1's).

If sending the response DM-TIMING ACK during occupation, the master DM-MAC shall use the DNB (STCH); it need not repeat the message (since the actual timing change is not announced until the end of the current call transaction, in the DM-TX CEASED messages). If sending the response DM-TIMING ACK during reservation, and if it is accepting the timing change request, the master DM-MAC shall send the

DM-TIMING ACK message in a DSB in slot 1 in at least two frames and shall repeat it in each corresponding slot 3 (unless this is a linearization or Dual Watch frame); in this case the DM-TIMING ACK also announces the timing change to the other DM-MSs on the channel - refer to subclause 8.4.7.14.

8.5.7.3 Procedures for requesting DM-MS

8.5.7.3.1 Preparing for random access

During channel occupation for a circuit mode call, the DM-MAC shall note whether requests may be sent in slot 3 of frames 2, 5, 8, 11, 14 and 17 (pre-emption flag). During channel reservation, a DM-MAC involved in the ongoing call shall note in which additional frames requests may be sent in slot 3 ("changeover requests bitmap" element).

The DM-MS shall only make one random access attempt at a time, per DM channel. A random access attempt refers to the period from receipt of the DMA-UNITDATA request primitive from layer 3 (or initiation of the timing change request procedure) until a response is received or the procedure is abandoned.

8.5.7.3.2 First transmission of request

For a pre-emption request, the DM-MAC shall transmit its request in the first valid access slot.

For a changeover request, the DM-MAC shall transmit its request in the first valid access slot unless the request has been held in the DMCC during occupation in which case, at the start of the reservation period, the DM-MAC shall choose a slot as follows:

- if the DM-TX CEASED message had the "recent user priority" flag set to 1, and if this is a recent user changeover request, then the DM-MAC shall transmit its request in the first valid access slot;

- if the DM-TX CEASED message had the "recent user priority" flag set to 1, and if this is not a recent user changeover request, then the DM-MAC shall choose an integer J randomly from the range 2 to 4 (using a uniform distribution) and shall transmit the request in the J'th valid access slot;

- if the DM-TX CEASED message had the "recent user priority" flag set to 0, then the DM-MAC shall choose an integer J randomly from the range 1 to 4 (using a uniform distribution) and shall transmit the request in the J'th valid access slot.

For a timing change request, the DM-MAC shall choose an integer K randomly from the range 1 to 8 (using a uniform distribution) and shall transmit the request in the K'th valid access slot.

The request shall be sent in a DSB using the DMAC-SYNC PDU.

For random access to send a pre-emption request, the "valid access slots" as used in the above (and in subclause 8.5.7.3.4) are as follows:

- during circuit mode occupation: slot 3 of frames 2, 5, 8, 11, 14 and 17, if allowed by the "pre-emption flag";

- during circuit mode reservation and if the "requests flag" is set to 1: slot 3 of frames 2, 5, 8, 11, 14 and 17, and optionally also the slot 3's indicated by the "changeover requests bitmap". It is a DM-MS choice whether to change the pattern of valid access slots in reservation;

- during short data occupation: slot 3 of frames 2, 5, 8, 11, 14 and 17, but restricted to those frames in which the master DM-MS intends to send SCH/F in slot 1. Those frames were indicated by the combination of the "frame count-down" and "number of SCH/F slots" elements in the DMAC-SYNC PDU that contained the DM-SDS DATA or DM-SDS UDATA header.

For random access to send a changeover request during channel reservation, and if the "requests flag" is set to 1, the "valid access slots" are slot 3 of frames 2, 5, 8, 11, 14 and 17 and those slot 3's indicated by the "changeover requests bitmap" element. (Changeover requests shall not be sent during short data or circuit mode occupation).

For random access to send a timing change request, the "valid access slots" are as for pre-emption requests during circuit mode occupation or reservation. (Timing change requests shall not be sent during short data occupation).

However if, during channel reservation or short data occupation, the DM-MAC receives any message in slot 1 in a DSB, then it shall regard the corresponding slot 3 as not being a valid access slot.

If the DM-MAC has not successfully decoded an occupation or reservation message from the master DM-MS within the previous time T.214 then it shall regard all slots as not being valid access slots until it decodes an occupation or reservation message.

8.5.7.3.3 Waiting for response

After sending a request, the DM-MAC shall wait for a valid response from the master DM-MS, containing the same addresses as in the request but with source and destination addresses reversed. It shall look for the response in both slot 1 and slot 3 of the following frames. The first slot in which the response may be received is slot 1 of the first frame following the request.

Valid response message types are as follows:

- for a pre-emption request: DM-PRE ACCEPT or DM-REJECT;
- for a changeover request: DM-TX ACCEPT or DM-REJECT;
- for a timing change request: DM-TIMING ACK.

On receipt of a valid response to a pre-emption or changeover message, the DM-MAC shall report the success of the random access procedure to layer 3 using the DMA-REPORT indication primitive. It shall also deliver the received message to layer 3 using the DMA-UNITDATA indication primitive.

If a response is not received within a time T.211 after transmission of the request for circuit mode occupation/reservation, or within a time T.212 for short data occupation, the DM-MAC shall assume that the transmission has failed. Then it shall either:

a) abandon its random access attempt (see 8.5.7.3.5); or

b) select an access slot randomly for a retry, as defined in 8.5.7.3.4; however, if the DM-MAC receives a response before sending a repeat message, it shall accept the response and not retransmit.

8.5.7.3.4 Subsequent transmission of request

When the DM-MAC requires to select an access slot for a retry (the N'th transmission of the request, where $N \geq 2$), it shall choose an integer K randomly from the range 1 to 2^M, using a uniform distribution, and shall transmit the request in the K'th valid access slot (unless the random access attempt is abandoned - see subclause 8.5.7.3.5):

- if the first transmission was sent without randomisation then $M = N - 1$;
- for a pre-emption or changeover request and if the first transmission was sent with randomisation, then $M = N$;
- for a timing change request, $M = N + 1$.

The DM-MAC shall then wait for a response, as defined in subclause 8.5.7.3.3.

NOTE: In most cases, for pre-emption and changeover requests, the first request can be sent in the first valid access slot. Then, for subsequent retries, the DM-MAC chooses randomly from 2 access opportunities, then from 4, then from 8 etc. If randomisation was needed for the first transmission then, for subsequent retries, the DM-MAC chooses randomly from 4 access opportunities, then from 8, then from 16 etc.

Retries for timing change requests are delayed more than this because there is a possibility that several DM-MSs may be asking for a timing change, and also because timing change requests can contend with pre-emption requests.

8.5.7.3.5 Abandoning random access attempt

The DM-MAC shall cease attempting random access if it receives a response from the master DM-MS (as described in subclause 8.5.7.3.3 above), or if any of the following occurs:

a) the DM-MAC has sent the maximum permitted number of random access transmissions without receiving a response. The maximum number of transmissions is N.213 for a message with priority 00_2, 01_2 or 10_2, and 2 * N.213 for an emergency message (priority 11_2);

b) a time T.213 has elapsed since layer 3 issued the DMA-UNITDATA request primitive (or since the timing change request procedure was initiated);

c) the DM-MAC receives a DM-PRE ACCEPT or DM-TX ACCEPT message with the current master DM-MS as source but addressed to another DM-MS;

d) the DM-MAC receives a message (e.g. DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA) indicating that there is now a new master DM-MS;

NOTE 1: If the DM-MAC receives a DM-SETUP or DM-SETUP PRES message indicating that the current master is re-starting transmission then it may continue a pre-emption or timing change random access attempt when the traffic starts. If it receives a DM-SDS DATA or DM-SDS UDATA message from the same master then it may continue a pre-emption random access attempt after the initial DSBs).

e) the channel leaves occupation/reservation and becomes free;

f) the user indicates that the random access attempt is to be abandoned;

g) for a timing change request: the DM-MAC receives a message indicating that the master is no longer prepared to accept requests to change the channel timing ("timing flag" set to 0);

h) for a timing change request: the DM-MAC receives a DM-TIMING ACK message with “timing acceptance flag” set to 1, with the current master DM-MS as source but addressed to another DM-MS.

In all cases a) to e), for a pre-emption or changeover request, the failure of the random access procedure shall be reported to layer 3 using the DMA-REPORT indication primitive.

NOTE 2: For a pre-emption or changeover request, the DM-MAC reports failure of the transmission by layer 2. Layer 3 may then decide to issue a further DMA-UNITDATA request. For example, in case c) or d), it may attempt to pre-empt the new master; or, in case e), it may attempt to set up a call directly e.g. sending DM-SETUP on the free channel.

NOTE 3: A zero setting of the “requests flag” stops random access requests temporarily but does not force the random access attempt to be abandoned (unless one of the criteria a) to g) also occurs).

8.6 MAC procedures in traffic mode

8.6.1 Introduction

During traffic transmission in DM, the master DM-MS transmits traffic TCH in slot 1 of frames 1 to 17. Slot 3 of frames 1 to 17, and slots 1 and 3 of frame 18, are available for synchronisation and signalling purposes e.g. occupation messages and pre-emption requests; refer to subclause 8.4.

In traffic mode, in slot 1 of frames 1 to 17, the master DM-MS may steal capacity from the circuit for signalling purposes, without changing the current mode of operation. For example: U-plane signalling (user-to-user signalling and/or encryption synchronisation) is only ever sent on STCH; the DMCC message DM-TX CEASED is sent on STCH; DM-RELEASE and DM-PRE ACCEPT may be sent on STCH; and C-plane signalling messages unrelated to the call may also be sent on STCH (e.g. unacknowledged short data messages). The STCH steals a part or all of the TCH bits within a burst, stealing the first half of the burst first. The half-slot training sequence (T2) indicates when stealing has occurred and the MAC header in the first half slot indicates whether the second half slot is also stolen.

Refer to subclause 8.2 for the configuration of the lower MAC in synchronisation, signalling and traffic mode.

8.6.2 Criteria for transmission and reception of traffic

During a circuit mode call:

- a sending DM-MS needs to decide when to start sending traffic (and when to stop);

- a receiving DM-MS needs to know when to process any received TCH (and when to stop).

The basic process is performed by DMCC messages DM-SETUP, DM-SETUP PRES, DM-CONNECT, DM-TX CEASED and DM-RELEASE. Also, a receiving DM-MS may enter a call by late entry after receiving a DM-OCCUPIED message addressed to itself. The "message type" is visible at layer 2 for both transmission and reception, and shall be used by the DM-MAC to decide when to switch in and out of traffic mode; refer to subclause 8.6.3.

The information about the circuit mode call type is not visible at layer 2, and shall be passed from the DMCC to the DM-MAC at the start of the traffic: after transmission or reception of DM-SETUP if there is no presence check; or after transmission or reception of DM-CONNECT if there is a presence check; or after reception of DM-OCCUPIED for late entry. (For reception of DM-SETUP and DM-OCCUPIED, the call type information is passed to the DM-MAC only if the user application decides to accept the incoming call.) For the purposes of the protocol description, it is assumed that the DMCC passes the call type information to the DM-MAC in a DMC-CONFIGURE request primitive containing parameter "circuit mode information", which may comprise the following sub-parameters:

- type of circuit (i.e. TCH/S, TCH/2,4, TCH/4,8, TCH/7,2);

- interleaving depth N;

- encryption flag (i.e. whether end-to-end encryption applies);

- user device.

The upper MAC shall inform the lower MAC of the appropriate type of TCH logical channel for transmission and/or reception (since this affects the coding/decoding method).

After starting to transmit traffic, the master DM-MS may continue to transmit traffic (TCH and/or STCH) in slot 1 of frames 1 to 17 until termination of the transmission by sending the DM-TX CEASED or DM-RELEASE message. The master DM-MS shall transmit in slot 1 of every frame in the range 1 to 17.

After starting to receive traffic, a slave DM-MAC may remain in traffic mode, processing received TCH and STCH, until one of the following occurs:

i) it receives a DM-TX CEASED or DM-RELEASE message for the call; or

ii) it receives a DMC-CONFIGURE request primitive from the DMCC containing parameter "call release" (i.e. the user has indicated that he wishes to stop receiving traffic); or

iii) it receives a DM-RESERVED message for the call; or

iv) a time T.221 elapses without receipt of a DM-OCCUPIED message for the call; or

v) the channel surveillance procedures defined in subclause 8.4.2.4 indicate that channel reception has been lost.

In case iii), the DM-MAC shall report to the higher layers that the channel is now in reservation for the call (using the DMC-REPORT indication primitive). In cases iv) and v), the DM-MAC shall report that the call has been lost.

NOTE: In case i) above: on reception of a DM-TX CEASED or DM-RELEASE message from the master, the DM-MAC performs an action itself (in this case, leaving traffic receive mode). Also, since the MS is addressed by the message, the DM-MAC delivers the received message and DM-SDU to layer 3 in a DMA-UNITDATA indication primitive. This principle applies also to reception of other messages.

8.6.3 Change of U-plane mode

8.6.3.1 Set-up without presence check

At call set-up (or for a call continuation), the DMCC issues a DM-SETUP message in a DMA-UNITDATA request primitive. If a channel is available, the DM-MAC shall become master and shall send the message the appropriate number of times using the frame count-down mechanism to indicate the number of frames in which the message has still to be repeated. The master DM-MAC shall then switch to traffic mode in the frame following the frame with "frame count-down" element set to zero. It shall start sending traffic (TCH and/or STCH) in slot 1 of that frame (if it is in the range 1 to 17) or otherwise in slot 1 of frame 1.

On receipt of a DM-SETUP message for one of its addresses, received in frame X and with "frame count-down" element set to F, and if the DMCC issues a DMC-CONFIGURE request primitive, a slave DM-MAC shall assume that traffic will start in slot 1 of frame Y = (X+F) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1.

8.6.3.2 Set-up with presence check

At call set-up (or for a call continuation), the DMCC issues a DM-SETUP PRES message. If a channel is available, the DM-MAC shall send the message the appropriate number of times, as master. It shall then wait for a response (DM-CONNECT or DM-DISCONNECT) from the addressed DM-MS or for the DMCC to issue a DM-RELEASE message:

- if it receives a DM-CONNECT message in frame X, with "frame count-down" element set to F, the DM-MAC shall start traffic transmission in slot 1 of frame Y = (X+F) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1;

- if it receives a DM-DISCONNECT message then the DM-MAC shall not switch into traffic mode. (The DMCC then issues a DM-RELEASE message, to be sent in the DSB);

- if the DMCC issues a DM-RELEASE message then the DM-MAC shall switch into traffic mode to send the message on STCH.

After receiving a DM-SETUP PRES message, the addressed slave DM-MS shall send DM-CONNECT or DM-DISCONNECT; refer to clause 6. This message shall be sent the appropriate number of times (using the frame count-down mechanism):

- after sending DM-CONNECT, the slave DM-MAC shall switch to traffic receive mode. It shall attempt to receive traffic in slot 1 of the next frame (if it is in the range 1 to 17) or otherwise in slot 1 of frame 1;

  NOTE: In some cases, traffic may not be received in the first few frames.

- after sending DM-DISCONNECT, the slave DM-MAC shall not switch into traffic mode.

8.6.3.3 Late entry

On receipt of a DM-OCCUPIED message for one of its addresses, and if the DMCC issues a DMC-CONFIGURE request primitive, a slave DM-MAC shall assume that traffic is ongoing in slot 1 of frames 1 to 17.

8.6.3.4 End of traffic transmission

At the end of traffic transmission, the master DMCC issues a DM-TX CEASED or DM-RELEASE message. The DM-MAC shall send the message on STCH, sending the message once per slot in successive traffic slots (i.e. slot 1 of frames 1 to 17) up to the appropriate number of transmissions. It shall then switch out of traffic mode.

If the DM-TX CEASED or DM-RELEASE message is sent in slot 1 of frame 6 or 12 then the master DM-MAC should send the message also in slot 3 of that frame using the DSB (replacing the channel occupation message). If the STCH message transmission crosses frame 18 then the master DM-MAC should send the message also in slot 1 and slot 3 of frame 18 (using the DSB).

NOTE: The exception is that, if the master DM-MS is also sending DM-PRE ACCEPT, then the DM-PRE ACCEPT takes precedence in slot 3 of frames 6 and 12 and may take precedence in frame 18.

On receipt of a DM-TX CEASED or DM-RELEASE message from the master, a slave DM-MAC shall switch out of traffic reception immediately.

8.6.4 Exchange of information at the DMD-SAP

In the protocol model, the actual user traffic is transferred between the U-plane application (e.g. the speech CODEC or circuit mode data application) and the DM-MAC via the DMD-SAP. The DMD-SAP is used for the transfer of speech frames or circuit mode data. It is also used if the U-plane application steals from the traffic capacity to send U-plane signalling.

For the purposes of the protocol description, the following services primitives are used.

NOTE: This does not imply any implementation. The word "shall" is used with the primitives for traceability reasons in the protocol model, but the primitives are not testable.

- The DMD-UNITDATA request primitive shall be used when the U-plane application wishes to send information to the peer entity.

- The DMD-UNITDATA indication primitive shall be used for the DM-MAC to deliver information from the peer entity.

- The DMD-REPORT indication shall be used by the sending DM-MAC to issue reports to the U-plane application e.g. at the start and stop of traffic transmission, and when the DM-MAC has stolen from the traffic capacity. It shall also be used by the receiving DM-MAC at the start of traffic reception.

For the purposes of the protocol description, the unit of exchange at the DMD-SAP shall be a half slot. Under normal circumstances in traffic mode, two primitive exchanges each containing the equivalent of half a slot capacity are required to fill the physical MAC block that is to be transmitted over the air interface.

The parameters specific to the DMD-UNITDATA primitive are as follows (see also clause 7):

a) half slot content:

the unit of information in the DMD-UNITDATA primitive shall be one half slot. The U-plane application shall provide a DM-SDU of the correct size for the appropriate logical channel (so that the DM-MAC does not have to insert filler bits to complete the DM-MAC block nor have to remove filler bits on reception);

in particular, when the U-plane application steals from the traffic capacity for U-plane signalling, the DM-SDU shall always be 121 bits. The upper DM-MAC shall then add a 3-bit MAC header, making the MAC block up to the 124 bits required for STCH. The U-plane signalling may be for user-to-user signalling or for encryption synchronisation. However, the DM-MAC is not aware the intended purpose of the U-plane signalling. (Any necessary discrimination shall be included within the DM-SDU);

user traffic TCH does not have a MAC header;

b) half slot position:

each transferred half slot (in either direction) should be accompanied by a marker identifying it as the first or second half slot of a timeslot;

in both transmitting and receiving DM-MS, half slots should be grouped in pairs, equivalent to the data transmitted over the air interface in one slot. The binding between these pairs shall remain intact and the correct timing/ordering relationships with adjacent half slots preserved, even when a half slot is stolen and the half slots are processed separately by the DM-MAC;

c) stolen indication:

at the transmitting side, this parameter shall indicate whether the half slot is stolen for U-plane signalling or not stolen;

at the receiving side, this parameter shall indicate whether the half slot was stolen for C-plane signalling, stolen for U-plane signalling or not stolen;

d) half slot importance:

this parameter may be used only in the DMD-UNITDATA request primitive. It indicates the importance of the U-plane information, enabling the sending DM-MAC to decide when and whether to steal from the traffic capacity;

e) half slot condition:

this parameter may be used only in the DMD-UNITDATA indication primitive. It indicates to the receiving U-plane application whether a half traffic slot was received successfully. It may take the following values:

- "Good" if the half slot was decodeable;
- "Bad" if a valid training sequence was detected but the CRC check failed;
- "Null" if no valid training sequence was detected.

The distinction between "Good" and "Bad" is not appropriate for TCH/7,2.

NOTE 1: For the purposes of the protocol description, channel encoding and decoding are performed in the lower MAC. However, this does not imply any particular implementation. If, for example, the implementers were to choose to perform the channel coding of TCH directly in the CODEC, then the descriptions of half slot transfer generally still apply (though the distinction between "Good" and "Bad" in the "half slot condition" parameter is no longer relevant).

NOTE 2: For the purposes of the protocol description, the unit of exchange at the DMD-SAP is always a half slot (corresponding to one speech frame). However, this does not imply any particular implementation. For example, an implementer may prefer to use a full slot of data as the unit of exchange for circuit mode data TCH.

NOTE 3: It is assumed that the U-plane application provides valid data in the "half slot content" parameter even if the "half slot importance" is set to "no importance". U-plane Discontinuous Traffic transmission (DTX) is not to be used in DM.

8.6.4.1 Interface at transmitting DM-MS

At the start of a traffic transmission, the DM-MAC shall issue a report to the U-plane application to supply the traffic type, the interleaving depth, a flag indicating whether end-to-end encryption applies and the user device parameter. The report shall also indicate the initial half slot synchronisation i.e. whether the first valid U-plane half slot is a first or second half slot; that half slot may then be used either for TCH or for U-plane signalling.

NOTE 1: An initial half slot synchronisation of "second half slot" applies only if the DM-MAC steals the first half slot for C-plane signalling e.g. to send encrypted transmitting party number identification (DM-INFO message).

A report should also be issued to the U-plane application at the end of traffic transmission.

When transmitting a slot in traffic mode, the sending DM-MAC is generally given the first half slot by the U-plane application, in a DMD-UNITDATA request primitive. That half slot may be either TCH, or U-plane signalling in the case of stealing by the U-plane application.

If the DM-MAC decides to steal the first half slot for C-plane signalling then the MAC should issue a DMD-REPORT indication, enabling the U-plane application to revise the intended use of the second half slot.

The DM-MAC is then given the second half slot in another DMD-UNITDATA request primitive. Again, if the DM-MAC decides to steal the half slot for C-plane signalling then the MAC should issue a DMD-REPORT indication.

In the case of circuit mode data with low or high protection: if the U-plane application steals the first half slot but not the second half slot then it should issue two DMD-UNITDATA request primitives for the first half slot (one containing the stealing information and the other containing TCH) and one DMD-UNITDATA request primitive for the second half slot (containing TCH). In the case of circuit mode data with interleaving depth N = 4 or 8: if the U-plane application steals both half slots then it should issue two DMD-UNITDATA request primitives for each half slot (one containing the stealing information and the other containing TCH).

At this time, the MS-MAC has the contents of one slot. Permitted combinations for the two half slots are as follows:

a) Not stolen i.e. TCH / Not stolen i.e. TCH;

b) Stolen for C-plane / Not stolen i.e. TCH;

c) Stolen for U-plane / Not stolen i.e. TCH;

d) Stolen for C-plane / Stolen for C-plane;

e) Stolen for C-plane / Stolen for U-plane;

f) Stolen for U-plane / Stolen for C-plane;

g) Stolen for U-plane / Stolen for U-plane.

In case a), the MS shall transmit in the slot using the full-slot training sequence, with a full slot of TCH (DMAC-TRAFFIC PDU). In all the other cases, the half-slot training sequence shall be used and the stealing procedure described in subclause 8.6.5 shall apply.

In cases b) and c), for a speech call or unprotected data, the upper MAC shall issue a half slot of STCH and a half slot of TCH to the lower MAC. In cases d), e), f) and g), for a speech call or unprotected data, the upper MAC shall issue two half slots of STCH to the lower MAC.

In cases b) and c), for a circuit mode data call with low or high protection, the upper MAC shall issue both a half slot of STCH and a full slot of TCH to the lower MAC. In cases d), e), f) and g), for a circuit mode data call with N = 4 or 8, the upper MAC shall issue two half slots of STCH and also a full slot of TCH to the lower MAC.

NOTE 2: Not stolen + Stolen for C-plane is not a permitted combination.

If the MAC receives Not stolen + Stolen for U-plane from the U-plane application, it could use case e), replacing the traffic with a null C-plane message. However, this would make inefficient use of the channel. It is recommended that the U-plane application does not request this form.

NOTE 3: In an implementation, it may be preferred that (when practicable) the MAC informs the U-plane application as soon as it knows that it will perform C-plane stealing. For example, for a high priority C-plane message, the MAC may intend to steal irrespective of the U-plane half slot importance.

NOTE 4: The above procedure specifies that, for protected circuit mode data with stealing in a slot, the upper MAC may issue both the STCH and a full slot of TCH to the lower MAC. This is because, for protected circuit mode data, the lower MAC replaces traffic bits with STCH bits after normal coding and interleaving of the TCH (refer to ETS 300 396-2 [2], clause 8). This contrasts with the method for speech, where the second half slot is half-slot interleaved if the first half slot is stolen.

8.6.4.2 Interface at receiving DM-MS

At the start of traffic reception, the DM-MAC shall issue a report to the U-plane application to supply the traffic type, the interleaving depth and a flag indicating whether end-to-end encryption applies.

The following procedures in this subclause shall apply for reception in slot 1 of frames 1 - 17 by a DM-MS that is authorised to receive TCH, i.e. if the DM-MS was addressed by the DM-SETUP, DM-SETUP PRES or DM-OCCUPIED message and if the user application accepted the call.

TCH shall be passed to the U-plane application.

U-plane signalling shall be passed to the U-plane application after removal of the 3-bit MAC header.

C-plane STCH shall be processed by the MAC, and any suitably addressed messages shall be passed to layer 3.

In all cases, for each half slot, the DM-MAC shall issue the DMD-UNITDATA indication primitive to the U-plane application containing any U-plane information (TCH or STCH) and indicating whether the half slot was stolen for C-plane signalling, stolen for U-plane signalling or not stolen.

For protected circuit mode data, in the case of a slot in which only the first half slot was stolen, the upper MAC should receive a half slot of STCH and a full slot of TCH from the lower MAC. The upper MAC shall issue two DMD-UNITDATA indication primitives to the U-plane application containing TCH (one for each half slot) and also, for U-plane stealing, one DMD-UNITDATA indication primitive containing the stealing information in the first half slot. For circuit mode data with N = 4 or 8, in the case that both half slots are stolen, the upper MAC should receive two half slots of STCH and a full slot of TCH from the lower MAC. The upper MAC shall issue two DMD-UNITDATA indication primitives to the U-plane application containing

TCH and also, for U-plane stealing, the appropriate DMD-UNITDATA indication primitive(s) containing the stealing information.

In the case of un-decodeable TCH, the DM-MAC may pass the received data to the U-plane application, but shall set the "half slot condition" parameter appropriately in the DMD-UNITDATA indication primitive.

8.6.5 Stealing from circuit mode capacity

8.6.5.1 Transmission on STCH

Stealing from circuit mode capacity shall only be used by a DM-MS that is currently transmitting traffic.

The appropriate PDUs for C-plane STCH shall be:

DMAC-DATA PDU: first or second half slot;

DMAC-END PDU: second half slot only (final fragment).

The appropriate PDU for U-plane STCH shall be:

DMAC-U-SIGNAL PDU: first or second half slot.

The MAC header of a DMAC-DATA or DMAC-U-SIGNAL PDU sent in a first half slot shall indicate whether the second half slot is also stolen (using the second half slot stolen flag). The MAC header of a DMAC-DATA PDU shall also indicate whether this is the start of fragmentation (using the fragmentation flag) or whether this is a Null PDU (using the Null PDU flag).

- If the second half slot is not stolen then it shall contain TCH (DMAC-TRAFFIC PDU).

- If the second half slot is stolen, it may contain either U-plane or C-plane signalling (as indicated by the MAC header in the second half slot).

- If the MAC header of a DMAC-DATA PDU indicates start of fragmentation then it shall also indicate that the second half slot is stolen (and that this is not a Null PDU). The final fragment shall be sent in the second half slot, using the DMAC-END PDU.

After the first transmission of a C-plane message, the DM-MAC shall issue an interim report to the higher layers (DMA-REPORT indication primitive). After transmitting the message the required number of times, the DM-MAC shall report to the higher layers that the message transmission has been completed. If the traffic transmission stops before the DM-MAC has sent the message the required number of times, the DM-MAC shall report the failure of the message transmission.

NOTE: The MS may use the Null PDU as a dummy C-plane message on STCH, in either the first half slot, second half slot or both. For example, if the master MS sends DM-SETUP but then TCH from the U-plane application is not ready immediately, the DM-MAC may send C-plane STCH + STCH e.g. containing Null PDUs.

8.6.5.2 Criteria for C-plane stealing

When a DM-MS is transmitting, the DM-MAC may steal from the traffic capacity to send C-plane signalling. The DM-MAC then sends C-plane signalling instead of the data received from the U-plane application. The DM-MAC shall not move the replaced U-plane data (neither traffic nor signalling) to a different half slot or slot.

The DM-MAC should report C-plane stealing to the U-plane application, enabling the application to revise the intended use of subsequent half slots, or to retransmit any U-plane signalling that has been overwritten by the MAC.

The following rules apply for the transmission of C-plane messages:

a) for C-plane messages other than DM-TX CEASED, DM-RELEASE and DM-PRE ACCEPT (e.g. for short data messages and DM-INFO messages), the MS designer should choose suitable criteria for deciding when the DM-MAC may steal, based on the stealing priority of the C-plane message, the half slot importance and the time since the last stealing occurrence. It is recommended that the DM-MAC does not re-steal over U-plane signalling. Also, the MS designer should note that frequent stealing would degrade the quality of the circuit;

   if the message is sent more than once then the DM-MAC should use the stealing criteria independently for each repetition;

b) for DM-TX CEASED and DM-RELEASE, the DM-MAC shall send the message at the first opportunity - without regard to the half slot importance. The DM-MAC shall repeat the message the appropriate number of times, sending the message on STCH once per slot in successive traffic slots (i.e. slot 1 of frames 1 to 17). It shall then switch out of traffic mode;

c) for DM-PRE ACCEPT sent on STCH during traffic transmission, the DM-MAC shall send the message in the same traffic slots as the DM-TX CEASED or DM-RELEASE PDU, with the two messages sent in the two halves of the same traffic slots.

   NOTE: The DM-TX CEASED (or DM-RELEASE) PDU terminates the traffic transmission. Note therefore that, for a circuit mode data call with an interleaving depth of N = 4 or 8, the DMCC in the transmitting MS should ensure that the MS has been able to issue N-1 slots containing tail bits (zeros) to the lower MAC at the end of the required data transmission before sending the termination PDU. These tail bits are needed to complete the interleaving of the real data.

8.6.5.3 Reception on STCH

This procedure may be used by all DM-MSs that are receiving the DM channel and shall be used by DM-MSs that are receiving traffic.

DM-MSs obeying this procedure shall inspect slots containing STCH and shall check whether the STCH contains C-plane or U-plane signalling. The parts of C-plane signalling messages that are visible at layer 2 may be used by all DM-MSs that are receiving the DM channel. Only those DM-MSs addressed by a C-plane message shall deliver the DM-SDU to layer 3. Only DM-MSs that are currently permitted to process received traffic shall pass the TCH, and the DM-SDU in U-plane signalling (DMAC-U-SIGNAL PDU), to the U-plane application.

The training sequence in each slot shall indicate whether stealing has occurred.

For the full slot training sequence (T1), the receiving DM-MS shall assume that the slot contains only TCH.

For the half slot training sequence (T2), the first half slot shall be assumed to be STCH. Then the MAC PDU type shall indicate whether the first half slot was stolen for C-plane signalling (DMAC-DATA PDU) or for U-plane signalling (DMAC-U-SIGNAL PDU). The receiving DM-MAC shall inspect the "second half slot stolen flag" in the MAC header to discover whether the second half slot is also stolen. Also, for the DMAC-DATA PDU, if the MAC header contains "fragmentation flag" set to 1, the addressed DM-MS(s) shall assume the start of fragmentation and shall store the DM-SDU fragment.

If the first half slot is not decodeable, the MS designer should choose an appropriate method for processing the second half of the slot.

   NOTE: For example, the MS might make a first assumption that the second half slot is stolen, but revise that decision if the CRC fails. (This method could be particularly useful at the start of an encrypted transmission when encryption synchronisation might be sent in both halves of the slot.) Otherwise the MS could treat the second half slot as "CRC fail" TCH.

If the second half slot is not stolen, the receiving DM-MS shall interpret the second half slot as TCH.

If the second half slot is stolen, the DM-MS shall interpret the second half slot as STCH. Then the MAC PDU type shall indicate whether the second half slot was stolen for C-plane signalling (DMAC-DATA or DMAC-END PDU) or for U-plane signalling (DMAC-U-SIGNAL PDU). If the second half slot is not decodeable, the DM-MS should regard the MAC block as C-plane signalling with CRC failure.

If the second half slot is not decodeable, or if the second half slot does not include a DMAC-END PDU, a DM-MAC that received a first fragment in the first half slot shall discard that fragment. Otherwise, it shall append the fragment from the DMAC-END PDU to the already received fragment, and shall deliver the complete message to the higher layers.

9 PDU descriptions

This clause describes the PDUs which apply to the DM Air Interface layers 2 and 3.

The following subclauses contain descriptions of the PDUs and the information elements contained within them. The structure of the PDU definitions represented by the tables is as follows:

- the information element column gives the name of the contained element(s);
- the element length column defines the length of the element in bits;
- the element types (C/O/M) are:

  Mandatory (M): these elements shall always be present and shall appear in the position and order shown;
  Optional (O): these elements are optional in the PDU and if they are used, then they shall appear in the position and order shown;
  Conditional (C): these elements are conditional depending on other preceding elements. If they are included then they shall appear in the position and order shown;

- the remarks column contains other information on the information element.

The elements shall be transmitted in the order specified by the table with the top element being transmitted first (before interleaving). The content of an information element is represented by a binary value and the most significant bit of that binary value shall be transmitted first (before interleaving).

9.1 Layer 2 PDUs sent in DSB

9.1.1 DMAC-SYNC PDU

The DMAC-SYNC PDU shall always be transmitted using the 60 available bits of the logical channel SCH/S and the 124 available bits of the logical channel SCH/H. Its purpose is to enable MSs to synchronise to the transmissions of the master MS in order to establish the DM channel in the desired configuration. It may also be used for transmissions of a slave MS. Its content shall be as follows:

Table 20: DMAC-SYNC PDU contents in SCH/S

Information element	Length	Type	Remark
System code	4	M	
SYNC PDU type	2	M	value 00_2 indicates DMAC-SYNC PDU
Repeater Flag	1	M	
Slot Number	2	M	
Frame number	5	M	
AI Encryption State	2	M	determines interpretation of following 39 bits
Time Variant Parameter	29	C	Included if AI Encryption State $\neq 00_2$
Timestamp flag	1	C	Included if AI Encryption State $\neq 00_2$
KSG No.	4	C	Included if AI Encryption State $\neq 00_2$
Encryption Key No.	5	C	Included if AI Encryption State $\neq 00_2$
Reserved	39	C	Included if AI Encryption State = 00_2, default value all zeroes
Communication Type	2	M	Set to 00_2 for direct MS-MS operation
A/B Channel Usage	2	M	
Reserved	1	M	Default value = 0

Table 21: DMAC-SYNC PDU contents in SCH/H

Information element	Length	Type	Remark
Repeater or Gateway address	10	C	see Parts 4 and 5. Not present for Communication Type =00_2
Fill bit indicator	1	M	
Fragmentation flag	1	M	
Number of SCH/F Slots	4	C	Included if Fragmentation flag = 1
Frame countdown	2	M	
Destination address type	1	M	
Destination address	24	M	
Source address type in SYNC	1	M	
Source address	24	M	
Mobile Network Identity	24	M	see clause 6 of Part 1 of this ETS
Message Type	5	M	
Message Dependent Elements	varies	C	
DM-SDU	varies	C	

9.2 Layer 2 PDUs sent in DNB

The following subclauses describe the content of layer 2 PDUs transmitted in the DM Normal burst either in the logical channel SCH/F or the stealing channel STCH.

9.2.1 DMAC-DATA PDU

The DMAC-DATA PDU may be used to send C-plane signalling data in a full slot (SCH/F). It may also be used to send C-plane signalling data in the first half slot of a burst using the stealing channel (STCH). If the second half of a slot is also stolen, the DMAC-DATA PDU may also be used to send another C-plane PDU in the second half slot using the stealing channel (STCH). Its contents shall be as follows:

Table 22: DMAC-DATA PDU contents

Information element	Length	Type	Remark
MAC PDU type	2	M	value 00_2 indicates DMAC-DATA PDU
Fill bit indicator	1	M	
Second halfslot stolen flag	1	M	note 1
Fragmentation flag	1	M	note 2
Null PDU flag	1	M	
Frame countdown	2	M	
AI Encryption State	2	M	
Destination address type	1	M	
Destination address	24	M	
Source address type in DATA	2	M	
Source address	24	C	Included if Source address type = 00_2 or 01_2
Mobile Network Identity	24	M	
Message Type	5	M	
Message Dependent Elements	varies	C	
DM-SDU	varies	C	
NOTE 1: If DMAC-DATA is sent on SCH/F or in the second half of a slot, the second halfslot stolen flag shall still be present but its content shall be ignored.			
NOTE 2: If DMAC-DATA is sent on SCH/F or in the second half of a slot, the fragmentation flag shall be set to 0			

9.2.2 DMAC-FRAG PDU

The DMAC-FRAG PDU shall be used to send continuation fragments of fragmented C-plane signalling data using SCH/F in a full timeslot. Its contents shall be as follows:

Table 23: DMAC-FRAG PDU contents

Information element	Length	Type	Remark
MAC PDU type	2	M	value 01_2 indicates DMAC-FRAG or DMAC-END PDU
MAC PDU Subtype	1	M	value 0 indicates DMAC-FRAG PDU
Fill bit indicator	1	M	
DM-SDU	varies	M	

NOTE: The first two bits of the MAC header distinguish between the possible MAC PDU types which can be sent using a full slot. A PDU subtype bit distinguishes between DMAC-FRAG and DMAC-END which share the same PDU type.

9.2.3 DMAC-END PDU

The DMAC-END PDU shall be used to send the final fragment of fragmented C-plane signalling data using SCH/F in a full timeslot. It shall also be used to send the last fragment of fragmented C-plane signalling in the second half of a stolen full slot. Its contents shall be as follows:

Table 24: DMAC-END PDU contents

Information element	Length	Type	Remark
MAC PDU type	2	M	value 01_2 indicates DMAC-FRAG or DMAC-END PDU
MAC PDU Subtype	1	M	value 1 indicates DMAC-END PDU
Fill bit indicator	1	M	
DM-SDU	varies	M	

NOTE: The first two bits of the MAC header distinguish between the possible PDU types which can be sent on the SCH/F or STCH. A PDU subtype bit distinguishes between DMAC-FRAG and DMAC-END which share the same PDU type.

9.2.4 DMAC-U SIGNAL PDU

The DMAC-U SIGNAL PDU shall be transmitted in the DM Normal burst. It shall be used to send U-plane signalling data using STCH in a half-slot. Its contents shall be as follows:

Table 25: DMAC-U SIGNAL PDU contents

Information element	Length	Type	Remark
MAC PDU type	2	M	value 11_2 indicates DMAC-U SIGNAL
Second half slot stolen flag	1	M	note 1
U-plane DM-SDU	121	M	note 2

NOTE 1: If DMAC-U-SIGNAL is sent in the second half of a full slot, the second half slot stolen flag shall still be present but its content shall be ignored.

NOTE 2: The U-plane DM-SDU contains the user information which is received from the U-plane for transmission in this PDU or passed to the U-plane on receipt of this PDU. It shall be the responsibility of the U-plane application to specify the meaning of the contents of the DM-SDU. The DM-SDU length shall always be 121 bits. If the U-plane application requires fewer bits, it is the responsibility of that application to insert filler bits to ensure a 121 bit DM-SDU length.

9.2.5 DMAC-TRAFFIC PDU

The DMAC-TRAFFIC PDU shall be used for sending U-plane traffic data using TCH/S, TCH/7,2, TCH/4,8 or TCH/2,4. This PDU has no header and all capacity shall be devoted to traffic information passed to and from the U-plane application. When the MAC is in traffic mode, this PDU type shall be assumed unless the slot flag indicates the presence of the STCH.

When stealing does not occur, the DMAC-TRAFFIC PDU shall occupy the full slot.

If stealing occurs and only the first half of the slot is stolen then, for TCH/S or TCH/7,2, the DMAC-TRAFFIC PDU shall occupy the second half of the slot. (In the case of TCH/4,8 or TCH/2,4, refer to subclause 8.6.4.1).

9.3 Layer 2 information element coding

The following subclauses contain descriptions of the information elements contained within the layer 2 PDUs, and provides a description of what they represent in relation to their bit representation. The structure of the tables is as follows:

- the information element column gives the name of the element;

- the element length column defines the length of the element in bits;

- the value column denotes fixed values or a range of values;

- the remarks column defines the meaning of the information element against each of its bit represented values.

9.3.1 A/B channel usage

The A/B channel usage element is used to indicate whether the call is taking place on an A or B channel.

Information element	Length	Value	Remark
A/B channel usage	2	00_2	Reserved
		01_2	A channel
		10_2	B channel
		11_2	Reserved

9.3.2 Air interface encryption state

The air interface encryption state element indicates whether the current PDU includes encryption and if so at what point in the PDU the encryption is applied.

Information element	Length	Value	Remark
Air interface encryption state	2	00_2	PDU not encrypted, and traffic not encrypted
		01_2	PDU encrypted from destination address type element and onwards and any related traffic is AI encrypted
		10_2	The DM-SDU and any related traffic is AI encrypted
		11_2	Reserved

9.3.3 Communication type

The communication type element is used to indicate whether the call is a direct communication between MSs, or whether it is being routed via a DM-REP, gateway or repeater/gateway combination. The setting of this element affects how the address information is to be handled.

Information element	Length	Value	Remark
Communication type	2	00_2	MS-MS
		01_2	via repeater
		10_2	via gateway
		11_2	via repeater/gateway

9.3.4 Destination address

The destination address element is a SSI used to identify the intended recipient(s) of the message. The destination address can be either an ISSI or a Group SSI (GSSI), or a pseudo (false) address may be used in some cases.

9.3.5 Destination address type

The destination address type element is used to indicate the status of the 24 bit destination address which follows this element in the PDU.

Information element	Length	Value	Remark
Destination address type	1	0	True SSI, with MNI as given in PDU
		1	Pseudo SSI

9.3.6 DM-SDU

The DM-SDU is the service user data message from the DMCC.

9.3.7 Encryption key number

The encryption key number element selects the currently valid SCK from a set of 32 SCKs.

Information element	Length	Value	Remark
Encryption key number	5	00000_2	SCK Number 1
		00001_2	SCK Number 2
		...etc.	...etc.
		11111_2	SCK Number 32

9.3.8 Fill bit indication

The fill bit indication element shall indicate if there are any fill bits in the MAC block, which shall be added whenever the combined size of the MAC PDU header and the DM-SDU is less than the available capacity of the MAC block.

Information element	Length	Value	Remark
Fill bit indication	1	0	No fill bits present
		1	Fill bits are present

9.3.9 Fragmentation flag

The fragmentation flag shall indicate whether the DM-SDU has been fragmented across a number of MAC blocks.

Information element	Length	Value	Remark
Fragmentation flag	1	0	No fragmentation
		1	Start of fragmentation

9.3.10 Frame countdown

The frame countdown element indicates the relative position of the current message in relation to the final repeat(s) of the same message. It indicates the number of frames in which the PDU may be repeated.

Information element	Length	Value	Remark
Frame countdown	2	00_2	Final transmission frame
		01_2	One transmission frame to follow
		10_2	Two transmission frames to follow
		11_2	Three transmission frames to follow

9.3.11 Frame number

The frame number element indicates in which frame within the multiframe structure the synchronisation message occurs in order that the slave MS(s) may set their frame counter appropriately.

Information element	Length	Value	Remark
Frame number	5	00000_2	Reserved
		00001_2	Frame 1
		...etc.	...etc.
		01010_2	Frame 18
		others	Reserved

9.3.12 Key Stream Generator (KSG) number

The KSG number is used as a means to identify which air interface encryption algorithm applies to the current message.

Information element	Length	Value	Remark
KSG number	4	0000_2	TETRA standard algorithm
		others	User definable algorithm

9.3.13 MAC PDU subtype

The MAC PDU subtype flag indicates whether DMAC-FRAG or DMAC-END is being sent when MAC PDU type $=01_2$.

Information element	Length	Value	Remark
MAC PDU subtype	1	0	DMAC-FRAG
		1	DMAC-END

9.3.14 MAC PDU type

The MAC PDU type element indicates which MAC PDU is being sent in a DNB.

Information element	Length	Value	Remark
MAC PDU type	2	00_2	A-SAP, DMAC-DATA
		01_2	A-SAP, DMAC-FRAG or DMAC-END
		10_2	Reserved
		11_2	D-SAP, DMAC-U SIGNAL

9.3.15 Message dependent elements

The message dependent elements element in the PDU varies in content depending on which of the layer 3 messages are subsequently sent in the PDU, i.e. it varies with the message type element. The content of this element for each of the layer 3 messages is specified along with the layer 3 PDUs in subclause 9.5.

9.3.16 Message type

The message type element shall be included to indicate the type of DMCC PDU or layer 2 message sent over the air interface. The interpretation of subsequent elements in the PDU is dependent on the value of the message type element.

Information element	Length	Value	Remark
Message type	5	00000_2	DM-RESERVED
		00001_2	DM-SDS OCC
		00010_2	DM-TIMING REQUEST
		00011_2	DM-TIMING ACK
		00100_2	Reserved
		00101_2	Reserved
		00110_2	Reserved
		00111_2	Reserved
		01000_2	DM-SETUP
		01001_2	DM-SETUP PRES
		01010_2	DM-OCCUPIED
		01011_2	DM-CONNECT
		01100_2	DM-DISCONNECT
		01101_2	DM-RELEASE
		01110_2	DM-TX CEASED
		01111_2	DM-TX REQUEST
		10000_2	DM-TX ACCEPT
		10001_2	DM-PREEMPT
		10010_2	DM-PRE ACCEPT
		10011_2	DM-REJECT
		10100_2	DM-INFO
		10101_2	DM-SDS UDATA
		10110_2	DM-SDS DATA
		10111_2	DM-SDS ACK
		others	Reserved

9.3.17 Mobile Network Identity (MNI)

The MNI element provides the mobile network identity of either the source or destination MS, dependent on the content of the source address type and destination address type elements. The MNI element shall be sent MSB first.

9.3.18 Null PDU flag

The null PDU flag indicates whether this is a Null PDU. If a Null PDU is indicated then there shall be no further information in the PDU after the Null PDU flag.

Information element	Length	Value	Remark
Null PDU flag	1	0	Not a Null PDU
		1	Null PDU

9.3.19 Number of SCH/F slots

The number of SCH/F slots element is a 4 bit element used in the case of fragmentation to indicate the number of following SCH/F slots.

Information element	Length	Value	Remark
Number of SCH/F slots	4	0000_2	Reserved
		0001_2	1 SCH/F slot
		…etc.	…etc.
		1001_2	9 SCH/F slots
		others	Reserved

9.3.20 Repeater flag

The repeater flag indicates whether this transmission is intended for reception by MSs. Its inclusion is in order to avoid erroneous detection of uplink transmissions to a repeater. The repeater flag shall always be set to 0 for direct MS-MS operation.

Information element	Length	Value	Remark
Repeater flag	1	0	Message to DM-MS(s)
		1	Uplink message to Repeater

9.3.21 Repeater or gateway address

The repeater or gateway address element shall be a 10 bit address by which a particular repeater or gateway is addressed in order to provide a distinct and specific routing of a call via a DM-REP or DM-GATE.

9.3.22 Second half slot stolen flag

The second half slot stolen flag shall indicate whether the second half of the full slot is also stolen. If the second half is stolen it may contain U-plane or C-plane signalling as indicated by the MAC header.

Information element	Length	Value	Remark
Second half slot stolen flag	1	0	Second half slot not stolen
		1	Second half slot stolen

9.3.23 Slot number

The slot number element indicates in which timeslot of a particular frame the synchronisation message occurs in order that the slave MS(s) may set their timeslot counter appropriately.

Information element	Length	Value	Remark
Slot number	2	00_2	Slot 1
		01_2	Slot 2
		10_2	Slot 3
		11_2	Slot 4

9.3.24 Source address

The source address element is a SSI used to identify the originator of the message. The source address is always an ISSI, but a pseudo (false) address may be used in some cases.

9.3.25 Source address type in DATA

The source address type in DATA element is used to indicate the status of the 24 bit source address which may follow this element in the DMAC-DATA PDU.

Information element	Length	Value	Remark
Source address type in DATA	2	00_2	True SSI, with MNI as given in PDU
		01_2	Pseudo SSI
		10_2	No Source Address
		11_2	Reserved

9.3.26 Source address type in SYNC

The source address type in SYNC element is used to indicate the status of the 24 bit source address which follows this element in the DMAC-SYNC PDU.

Information element	Length	Value	Remark
Source address type in SYNC	1	0	True SSI, with MNI as given in PDU
		1	Pseudo SSI

9.3.27 SYNC PDU type

The SYNC PDU type PDU indicates which of the synchronisation PDUs is being sent in the DSB.

Information element	Length	Value	Remark
SYNC PDU type	2	00_2	DMAC-SYNC
		01_2	Reserved
		10_2	Reserved
		11_2	Reserved

9.3.28 System code

The system code element indicates to which TETRA system the transmission belongs.

Information element	Length	Value	Remark
System code	4	0000_2	First release of ETS 300 392 (V+D)
		$0xxx_2$	V+D reserved
		$10yy_2$	PDO system
		1100_2	First release of ETS 300 396 (DMO)
		$11zz_2$	DMO reserved

9.3.29 Time Variant Parameter (TVP)

The TVP is a 29 bit element used to initialise the KSG at the start of every slot. The TVP shall be represented as TVP(0)....TVP(28), where TVP(0) shall be the least significant bit and TVP(28) the most significant bit of TVP.

The TVP is transmitted in the synchronisation messages by the current call master.

NOTE: TVP is independent of FN and SN

9.3.30 Timestamp flag

The timestamp flag is used to show whether the TVP contains a real time clock element.

Information element	Length	Value	Remark
Timestamp flag	1	0	TVP is a counter
		1	TVP contains a real time clock element

9.3.31 U-plane DM-SDU

The U-plane DM-SDU is the service user data message from the U-plane application.

9.4 Messages generated by layer 2

The messages detailed in the following subclauses are generated by layer 2.

9.4.1 DM-RESERVED

Message Name: DM-RESERVED
Response to: -
Response Expected: -
Short Description: DM-RESERVED shall be the message sent in DSB during the channel reservation period (following the DM-TX CEASED messages) in frames 6, 12 and 18 holding the channel for the MS(s) indicated by the destination address.

Table 26: DM-RESERVED message dependent elements

Information element	Length	Type	Remark
Reservation time remaining	6	M	
Timing flag	1	M	
Requests flag	1	M	
Changeover requests bitmap	8	M	
Priority level	2	M	

9.4.2 DM-SDS OCC

Message Name: DM-SDS OCC
Response to: -
Response Expected: -
Short Description: DM-SDS OCC shall be the message sent during short data in frames 6, 12 and 18 to indicate that the channel is in use.

Table 27: DM-SDS OCC message dependent elements

Information element	Length	Type	Remark
SDS time remaining	4	M	
SDS transaction type	1	M	
Priority level	2	M	

9.4.3 DM-TIMING REQUEST

Message Name: DM-TIMING REQUEST
Response to: -
Response Expected: DM-TIMING ACK
Short Description: DM-TIMING REQUEST shall be the message used to request master timing advance.

Table 28: DM-TIMING REQUEST message dependent elements

Information element	Length	Type	Remark
Timing advance	8	M	

9.4.4 DM-TIMING ACK

Message Name: DM-TIMING ACK
Response to: DM-TIMING REQUEST
Response Expected: -
Short Description: DM-TIMING ACK shall be the message used to indicate whether timing advance request is accepted or rejected.

Table 29: DM-TIMING ACK message dependent elements

Information element	Length	Type	Remark
Timing acceptance flag	1	M	
Timing change announcement	1	M	
Timing advance	8	C	Included if timing change announcement = 1

9.5 Layer 3 PDUs

Due to the nature of TETRA DMO, with close interaction between layers 2 and 3, and with a high degree of information about the state of the DM channel being needed, the layer 3 messages detailed in the following subclauses may include two element types.

- **message dependent elements:**

  - are visible to layer 2 and can be used by any MS (that is able to decrypt them if encrypted), irrespective of addressing. These elements depend on the message type element. Some are generated by layer 2 when it constructs the complete message whereas others are generated by layer 3;

- **DM-SDU elements:**

  - which are "true" layer 3 elements and are encrypted (except for when air interface encryption state = 00_2 in the MAC PDU). They are only processed by the MS(s) to which they are addressed.

Where both types exist in the PDU they are shown separately.

9.5.1 DM-SETUP

Message Name: DM-SETUP
Response to: -
Response Expected: -
Short Description: The DM-SETUP PDU shall be the call set-up message sent to the called MS(s) for Direct call set-up.

Table 30: DM-SETUP PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing flag	1	M	
LCH in frame 3	1	M	
Pre-emption flag	1	M	
Reserved	4	M	default value = 0000_2
Priority level	2	M	
DM-SDU elements			
Basic service information	5	M	
Reserved	5	M	default value = 00000_2

9.5.2 DM-SETUP PRES

Message Name: DM-SETUP PRES
Response to: -
Response Expected: DM-CONNECT or DM-DISCONNECT
Short Description: The DM-SETUP PRES PDU shall be the call set-up message sent to the called MS for call set-up with presence check (Individual Calls only).

Table 31: DM-SETUP PRES PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing flag	1	M	
LCH in frame 3	1	M	
Pre-emption flag	1	M	
Reserved	4	M	default value = 0000_2
Priority level	2	M	
DM-SDU elements			
Basic service information	5	M	
Reserved	5	M	default value = 00000_2

9.5.3 DM-CONNECT

Message Name: DM-CONNECT
Response to: DM-SETUP PRES
Response Expected: -
Short Description: The DM-CONNECT PDU shall be the message sent by the destination MS to accept a DM-SETUP PRES message requesting a presence check acknowledgement for an Individual Call.

Table 32: DM-CONNECT PDU contents

Information element	Length	Type	Remark
DM-SDU elements			
Basic service information	5	M	
Reserved	5	M	default value = 00000_2

9.5.4 DM-DISCONNECT

Message Name: DM-DISCONNECT
Response to: DM-SETUP PRES
Response Expected: -
Short Description: The DM-DISCONNECT PDU shall be the message sent by the destination MS to reject a DM-SETUP PRES message requesting a presence check acknowledgement for an Individual Call.

Table 33: DM-DISCONNECT PDU contents

Information element	Length	Type	Remark
DM-SDU elements			
Disconnect cause	3	M	

9.5.5 DM-OCCUPIED

Message Name: DM-OCCUPIED
Response to: -
Response Expected: -
Short Description: The DM-OCCUPIED PDU shall be the message sent during channel occupation in Frames 6, 12 and 18 to indicate details of the current call on the channel.

Table 34: DM-OCCUPIED PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing flag	1	M	
LCH in frame 3	1	M	
Pre-emption flag	1	M	
Reserved	4	M	default value = 0000_2
Priority level	2	M	
DM-SDU elements			
Basic service information	5	M	
Reserved	5	M	default value = 00000_2

9.5.6 DM-RELEASE

Message Name: DM-RELEASE
Response to: -
Response Expected: -
Short Description: The DM-RELEASE PDU shall be the message sent by the master MS to indicate premature call termination.

Table 35: DM-RELEASE PDU contents

Information element	Length	Type	Remark
DM-SDU elements			
Release cause	3	M	

9.5.7 DM-TX CEASED

Message Name: DM-TX CEASED
Response to: -
Response Expected: -
Short Description: The DM-TX CEASED PDU shall be the message sent as indication that transmission of the current call transaction is ceasing.

Table 36: DM-TX CEASED PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Reservation time remaining	6	M	
Timing flag	1	M	
Requests flag	1	M	
Changeover requests bitmap	8	M	
Recent user priority flag	1	M	
Timing change announcement	1	M	
Timing advance	8	C	Included if timing change announcement = 1
Priority level	2	M	
DM-SDU elements			
Cease cause	3	M	

9.5.8 DM-TX REQUEST

Message Name: DM-TX REQUEST
Response to: -
Response Expected: DM-TX ACCEPT or DM-REJECT
Short Description: The DM-TX REQUEST PDU shall be the message sent as a request for changeover of the channel.

Table 37: DM-TX REQUEST PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing change request	1	M	
Timing advance	8	C	Included if timing change request = 1
Priority level	2	M	

9.5.9 DM-TX ACCEPT

Message Name: DM-TX ACCEPT
Response to: DM-TX REQUEST
Response Expected: -

Short Description: The DM-TX ACCEPT PDU shall be the message sent to accept a changeover request.

Table 38: DM-TX ACCEPT PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing change announcement	1	M	
Timing advance	8	C	Included if timing change announcement = 1

9.5.10 DM-PREEMPT

Message Name: DM-PREEMPT
Response to: -
Response Expected: DM-PRE ACCEPT or DM-REJECT
Short Description: The DM-PREEMPT PDU shall be the message sent addressed to the current master DM-MS to request pre-emption of the DM channel.

Table 39: DM-PREEMPT PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Perceived channel state	3	M	
Timing change request	1	M	
Timing advance	8	C	Included if timing change request = 1
Priority level	2	M	
DM-SDU elements			
Type of pre-emption	1	M	
New call pre-emption	1	M	

9.5.11 DM-PRE ACCEPT

Message Name: DM-PRE ACCEPT
Response to: DM-PREEMPT
Response Expected: -
Short Description: The PDU shall be the message sent by the current master DM-MS addressed to the requester for pre-emption of the DM channel accepting the pre-emption request.

Table 40: DM-PRE ACCEPT PDU contents

Information element	Length	Type	Remark
Message Dependent Elements			
Timing change announcement	1	M	
Timing advance	8	C	Included if Timing change announcement = 1

9.5.12 DM-REJECT

Message Name: DM-REJECT
Response to: DM-PREEMPT or DM-TX REQUEST or DM-SDS DATA
Response Expected: -
Short Description: The PDU shall be the message sent by the current master DM-MS addressed either to the requester for pre-emption of the DM channel or to a DM-MS requesting changeover rejecting their request. It may also be used by a called DM-MS to reject a short data message.

Table 41: DM-REJECT PDU contents

Information element	Length	Type	Remark
DM-SDU elements			
Reject cause	3	M	

9.5.13 DM-INFO

Message Name: DM-INFO
Response to: -
Response Expected: -
Short Description: The PDU shall be sent to indicate address and any other details which are not available at call set-up.

Table 42: DM-INFO PDU contents

Information element	Length	Type	Remark
DM-SDU Elements			
Information type	3	M	
Calling party TSI	48	C	True calling party address, included for information type = 000_2

9.5.14 DM-SDS UDATA

Message Name: DM-SDS UDATA
Response to: -
Response Expected: -
Short Description: The PDU shall be the message used for sending unacknowledged precoded status messages or user defined data.

Table 43: DM-SDS UDATA PDU contents

Information element	Length	Type	Remark
Message dependent elements			
SDS time remaining	4	M	
SDS transaction type	1	M	
Priority level	2	M	
FCS flag	1	M	
DM-SDU Elements			
Additional address type(s)	3	M	
Calling party TSI	48	C	conditional on additional address type(s)
Short data type identifier	3	M	SDTI
User Defined Data 1	16	C	conditional on SDTI
User Defined Data 2	32	C	conditional on SDTI
User Defined Data 3	64	C	conditional on SDTI
Length indicator	11	C	conditional on SDTI
User Defined Data 4	variable	C	conditional on SDTI
Precoded status	16	C	conditional on SDTI
FCS	32	C	conditional on FCS Flag

9.5.15 DM-SDS DATA

Message Name: DM-SDS DATA
Response to: -
Response Expected: DM-SDS ACK or DM-REJECT
Short Description: The PDU shall be the message used for sending acknowledged precoded status messages or user defined data.

Table 44: DM-SDS DATA PDU contents

Information element	Length	Type	Remark
Message dependent elements			
SDS time remaining	4	M	
SDS transaction type	1	M	
Priority level	2	M	
FCS flag	1	M	
DM-SDU elements			
Additional address type(s)	3	M	
Calling party TSI	48	C	conditional on additional address type(s)
Short Data Type Identifier	3	M	SDTI
User Defined Data 1	16	C	conditional on SDTI
User Defined Data 2	32	C	conditional on SDTI
User Defined Data 3	64	C	conditional on SDTI
Length indicator	11	C	conditional on SDTI
User Defined Data 4	variable	C	conditional on SDTI
Precoded status	16	C	conditional on SDTI
FCS	32	C	conditional on FCS Flag

9.5.16 DM-SDS ACK

Message Name: DM-SDS ACK
Response to: DM-SDS DATA
Response Expected: -
Short Description: The PDU shall be sent to acknowledge reception of short data or status messages.

Table 45: DM-SDS ACK PDU contents

Information element	Length	Type	Remark
Message dependent elements			
FCS flag	1	M	
DM-SDU elements			
Acknowledgement type	4	M	
Short Data Type Identifier	3	C	included for Acknowledgement Type = 0001_2
User Defined Data 1	16	C	conditional on SDTI
User Defined Data 2	32	C	conditional on SDTI
User Defined Data 3	64	C	conditional on SDTI
Length indicator	11	C	conditional on SDTI
User Defined Data 4	variable	C	conditional on SDTI
Precoded status	16	C	conditional on SDTI
FCS	32	C	conditional on FCS Flag

9.6 Message dependent elements coding

9.6.1 Changeover requests bitmap

The changeover requests bitmap is an 8 bit bitmap used to indicate the frames in which random access requests will be allowed (in addition to the pre-emption frames).

Information element	Length	Value	Remark
Timeslot 3 of Frame 1	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 4	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 7	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 9	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 10	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 13	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 15	1	0	Random Access requests not allowed
		1	Random Access requests allowed
Timeslot 3 of Frame 16	1	0	Random Access requests not allowed
		1	Random Access requests allowed

9.6.2 FCS flag

The FCS flag is used to indicate whether a FCS is applied to the DM-SDU.

Information element	Length	Value	Remark
FCS flag	1	0	No FCS
		1	FCS applied

9.6.3 LCH in frame 3

The LCH in frame 3 flag indicates whether timeslot 3 of frame 3 is available for MSs to carry out linearization.

Information element	Length	Value	Remark
LCH in frame 3	1	0	TN3 of FN3 not available for LCH
		1	TN3 of FN3 available for LCH

9.6.4 Perceived channel state

The perceived channel state element is used by a pre-empting MS to indicate whether it regards the DM channel as being in circuit mode occupation or reservation mode, or in short data occupation mode, and as such whether it is expecting a response to its pre-emption request to appear in either the DNB or the DSB.

Information element	Length	Value	Remark
Perceived as channel A or B	1	0	Perceived as channel A
		1	Perceived as channel B
Perceived channel state	2	00_2	Circuit mode occupation
		01_2	Circuit mode reservation
		10_2	Short data occupation
		11_2	Reserved

9.6.5 Pre-emption flag

The pre-emption flag is used to indicate whether pre-emption is allowed in the pre-assigned pre-emption frames during circuit mode occupation.

Information element	Length	Value	Remark
Pre-emption flag	1	0	Pre-emption not allowed
		1	Pre-emption allowed

9.6.6 Priority level

The priority level element is used to indicate the priority level which applies to the current call or call set-up attempt.

Information element	Length	Value	Remark
Priority level	2	00_2	Normal priority call
		01_2	High priority call
		10_2	Pre-emptive priority call
		11_2	Emergency pre-emptive priority call

9.6.7 Recent user priority flag

The Recent User Priority flag is used to give the previously transmitting DM-MS the possibility to start a new transmission after the current master DM-MS, with priority over other group DM-MS(s).

Information element	Length	Value	Remark
Recent user priority flag	1	0	Not invoked
		1	Invoked

9.6.8 Requests flag

The requests flag indicates whether requests may currently be sent during the reservation period

Information element	Length	Value	Remark
Requests flag	1	0	Requests not invited
		1	Requests invited

9.6.9 Reservation time remaining

The reservation time remaining element is used by a master MS to indicate how long the DM channel will be held in reservation mode following completion of a call transaction.

Information element	Length	Value	Remark
Reservation time remaining	6	000000_2	End of reservation time
		000001_2	6 frames remaining
		000010_2	12 frames remaining
		000011_2	18 frames remaining
		000100_2	24 frames remaining
		…etc.	…etc.
		111111_2	378 frames remaining

9.6.10 SDS time remaining

The SDS time remaining element is used by a MS transmitting an SDS message to indicate the channel occupation time for the SDS message, in frames, including any necessary re-transmissions and acknowledgements. In the DM-SDS OCC message, it indicates the occupation time remaining. For an SDS message sent on STCH, the SDS time remaining element is set to 0000_2 (null value).

Information element	Length	Value	Remark
SDS time remaining	4	0000_2	End of SDS occupation
		0001_2	1 frame remaining
		0010_2	2 frames remaining
		0011_2	3 frames remaining
		0100_2	4 frames remaining
		…etc.	…etc.
		1111_2	15 or more frames remaining

9.6.11 SDS transaction type

The SDS transaction type element is used to indicate whether the short data is stand alone or whether it is sent as a transaction within a circuit mode call.

Information element	Length	Value	Remark
SDS transaction type	1	0	SDS sent as stand alone transaction (or on STCH)
		1	SDS sent as transaction within a circuit mode call

9.6.12 Timing acceptance flag

The Timing Acceptance Flag is supplied by the master MS to inform a slave MS which submitted a timing change request whether the timing change request is accepted.

Information element	Length	Value	Remark
Timing acceptance flag	1	0	Timing change request rejected
		1	Timing change request accepted

9.6.13 Timing advance element

The timing advance element is used by a slave MS to indicate its wish to reset the absolute timing of the synchronisation provided by the master MS. This may be used for example where the slave MS was able to Dual Watch and wishes to align the timing instants of the V+D and DM channels so that it can continue to Dual Watch. The element is also used by the master MS to announce the timing change.

Information element	Length	Value	Remark
Timing advance	8	00000000_2	Change of frame number only (note)
		00000001_2	Timing advance of 0,5 ms
		00000010_2	Timing advance of 1,0 ms
		00000011_2	Timing advance of 1,5 ms
		00000100_2	Timing advance of 2,0 ms
		…etc.	…etc.
		11100100_2	Timing advance of 114,0 ms
		others	Reserved
NOTE: Applies only in case of pre-emption or changeover			

9.6.14 Timing change announcement flag

The timing change announcement flag is used to inform MSs of an upcoming adjustment in the timing of the DM channel, which will require their re-synchronisation.

Information element	Length	Value	Remark
Timing change announcement flag	1	0	Timing change not announced
		1	Timing change announced

9.6.15 Timing change request flag

The timing change request flag is used to indicate whether a timing advance element is included within a pre-emption or changeover request.

Information element	Length	Value	Remark
Timing change request flag	1	0	Timing change not required
		1	Timing change required

9.6.16 Timing flag

The timing flag is used to indicate whether the master MS is prepared to accept requests for changes in the DM channel absolute timing.

Information element	Length	Value	Remark
Timing flag	1	0	Channel timing change not allowed
		1	Channel timing change allowed

9.7 DM-SDU elements coding

9.7.1 Acknowledgement type

The acknowledgement type element provides information relating to the reception of short data.

Information element	Length	Value	Remark
Acknowledgement type	4	0000_2	Data message fully received, no data in acknowledgement
		0001_2	Data message fully received, data in acknowledgement (as indicated by SDTI)
		0010_2	Message received but FCS failed
		0011_2	Message not fully received
		others	Reserved

9.7.2 Additional address type(s)

The additional address type(s) element indicates the type of addressing that may follow it in the PDU.

Information element	Length	Value	Remark
Additional address type(s)	3	000_2	No additional addressing
		001_2	Calling party TSI
		others	Reserved

9.7.3 Basic service information

The purpose of the basic service information element shall be to indicate the basic service which is requested.

Information sub-element	Length	Value	Remark	
Circuit Mode type	3	000_2	Speech:	TCH/S
(note)		001_2	Unprotected:	TCH/7,2
		010_2	Low protection:	TCH/4,8, N=1
		011_2	Low protection:	TCH/4,8, N=4
		100_2	Low protection:	TCH/4,8, N=8
		101_2	High protection:	TCH/2,4, N=1
		110_2	High protection:	TCH/2,4, N=4
		111_2	High protection:	TCH/2,4, N=8
End-end encryption Flag	1	0	Clear mode	
		1	With end-to-end encryption	
Call type flag	1	0	Group call	
		1	Individual call	
NOTE: The circuit mode type element is used to inform the MS of the basic service which is being carried. It indicates the traffic channel (TCH) type and the interleaving depth N (See ETS 300 396-2 [2], clause 8).				

9.7.4 Calling party TSI

The calling party TSI element is used to convey the ITSI of the originator of a circuit mode call transaction in the case where the intrinsic service "Talking Party Number Identification" is required and if full (true)

addressing is not provided at layer 2. It is also used to identify the originator of a short data message if full (true) addressing is not provided at layer 2.

9.7.5 Cease cause

The Cease Cause element is used to indicate the reasons why the current call transaction is terminating.

Information element	Length	Value	Remark
Cease cause	3	000_2	Cause not defined or unknown
		001_2	Normal end of transmission
		010_2	Pre-empted use of resource
		011_2	Transmission time limit reached
		others	Reserved

9.7.6 Disconnect cause

The disconnect cause element is used to indicate the reasons why a call set-up with presence check has been unsuccessful.

Information element	Length	Value	Remark
Disconnect cause	3	000_2	Cause not defined or unknown
		001_2	Called party does not support end-end encryption
		010_2	Called party does not support requested service
		011_2	Call rejected by the called party
		others	Reserved

9.7.7 FCS

This element is 32 bits long.

These bits shall be placed in decreasing order for the power of x. The coefficient of x^{31} shall be mapped onto the most significant bit. The coefficient of x^0 shall be mapped onto the least significant bit. The FCS calculation is defined in annex B.

When included, the FCS shall be calculated over the preceding DM-SDU elements.

9.7.8 Information type

The information type element is used to indicate which type of information follows this element in the PDU.

Information element	Length	Value	Remark
Information type	3	000_2	Transmitting Party Number Identifier
		others	Reserved

9.7.9 Length indicator

The length indicator element shall define the length of the User Defined Data 4 (UDD4) element.

Information element	Length	Value	Remark
Length indicator	11	0	UDD4 is 0 bits long
		1	UDD4 is 1 bit long
		...etc.	...etc.
		$(2^{11}-1)$	UDD4 is 2047 bits long

9.7.10 New call pre-emption

The new call pre-emption element is used to indicate whether the pre-emption relates to the ongoing call or to a new call.

Information element	Length	Value	Remark
New call pre-emption	1	0	Pre-emption to continue ongoing call
		1	Pre-emption relates to a new call

9.7.11 Pre-coded status

The pre-coded status element is used to define general purpose status messages known to all TETRA systems.

Information element	Length	Value	Remark
Pre-coded status	16	0	Emergency
		1	Reserved
		...etc.	...etc.
		32767	Reserved
		32768	Available for TETRA network and user specific definitions
		...etc.	...etc.
		65535	Available for TETRA network and user specific definitions

9.7.12 Reject cause

The reject cause element is used to indicate the reasons why a changeover or pre-emption request is being denied, or why short data is being rejected.

Information element	Length	Value	Remark
Reject cause	3	000_2	Cause not defined or unknown
		001_2	Request Invalid
		010_2	Master to start another transmission
		011_2	Called party does not support short data
		100_2	Reserved
		101_2	Reserved
		110_2	Reserved
		111_2	Reserved

9.7.13 Release cause

The release cause element is used to indicate the reason why the current call is terminating prematurely.

Information element	Length	Value	Remark
Release cause	3	000_2	Cause not defined or unknown
		001_2	Pre-empted use of resource
		010_2	Calling user initiated release
		011_2	Called party offered unacceptable service
		100_2	Call set-up failed
		101_2	Called party is not reachable
		110_2	Called party rejected call
		others	Reserved

9.7.14 Short Data Type Identifier (SDTI)

The SDTI element is used to indicate the type of the short data sent.

Information element	Length	Value	Remark
SDTI	3	000_2	UDD 1
		001_2	UDD 2
		010_2	UDD 3
		011_2	Length Indicator + UDD 4
		100_2	Precoded status
		101_2	Reserved
		110_2	Reserved
		111_2	Reserved

9.7.15 Type of pre-emption

The type of pre-emption element is used to indicate whether the pre-emptor wishes to make a circuit mode call or send short data.

Information element	Length	Value	Remark
Type of pre-emption	1	0	Circuit mode call
		1	Short data

9.7.16 User Defined Data (UDD) type 1

The UDD 1 element shall be a user defined fixed length message field of 16 bits, the value or content of which is defined in the user application.

9.7.17 UDD 2

The UDD 2 element shall be a user defined fixed length message field of 32 bits, the value or content of which is defined in the user application.

9.7.18 UDD 3

The UDD 3 element shall be a user defined fixed length message field of 64 bits, the value or content of which is defined in the user application.

9.7.19 UDD 4

The UDD 4 element shall be a user defined variable length message field of between 0 and 2 047 bits, the value or content of which is defined in the user application.

Annex A (normative): Timers and constants in DM-MS

This annex lists the timers and constants in a DM-MS when operating in direct MS-MS mode, the values of these timers and constants shall be configurable within the DM-MS.

Where indicated, a value should be chosen by the MS designer from within the specified range or given at subscription to the DM channel. For other timers and constants, a default value is specified. The default value shall be used by the MS unless it received a different value at subscription.

A.1 Layer 3 timers

T.303 Time-out waiting for response to DM-SETUP PRES.
Default value = 200 ms.

T.311 Call transaction timer.
Value to be chosen by MS designer or given at subscription.
Maximum permitted value = 300 seconds.

T.314 Time-out for reporting SDS failure after sending DM-PRE ACCEPT.
Default value = 500 ms.

T.316 Time-out waiting for response to DM-SDS DATA.
Default value = 300 ms.

A.2 Layer 3 constants

N.303 Maximum number of attempts to send DM-SETUP PRES.
MS designer choice from the range 1 to 3.

N.314 Number of transmissions of DM-SDS UDATA.
Value may be chosen by MS designer, or may be message dependent, from the range 1 to 6.

N.315 Maximum number of attempts to send DM-SDS DATA if negative response received.
MS designer choice from the range 2 to 6.

N.316 Maximum number of attempts to send DM-SDS DATA if no response received.
MS designer choice from the range 1 to 3.

A.3 Layer 2 timers

T.205 Time when randomisation is required after channel becomes free.
Default value = 36 frames.

T.210 Channel time allowed for acknowledgement to DM-SDS DATA.
Default value = 3 frames if the third frame is not a frame 18, or
4 frames if the third frame is a frame 18.

T.211 Time-out waiting for random access response (circuit mode occupation/reservation).
Default value = 3 frames.

T.212 Time-out waiting for random access response (short data occupation).
Default value = 7 frames.

T.213 Random access time-out.
MS designer choice from the range 5 to 60 multiframes.

T.214 Validity time-out when attempting random access.
Default value = 36 frames.

T.221 Inactivity time-out for reception of traffic.
Default value = 90 frames.

A.4 Layer 2 constants

N.205 Maximum randomisation after channel becomes free.
Default value = 6.

N.210 Maximum number of frames containing response DSB.
Default value = 2 if fragmentation needed, or
3 if fragmentation not needed.

N.213 Maximum number of non-emergency random access transmissions.
Default value = 8.

A.5 Maximum number of frame transmissions

The following table shows the minimum and maximum number of frames in which each message may be sent.

Table A.1: Number of frame transmissions

Message type	Min to Max no. of frames in which message sent
DM-SETUP	1 to 4
DM-SETUP PRES	1 to 4
DM-CONNECT	1 to 3
DM-DISCONNECT	1 to 3
DM-TX CEASED	2 to 4
DM-RELEASE	2 to 4
DM-TX ACCEPT	2 to 4
DM-PRE ACCEPT	2 to 4
DM-REJECT	1 to 4
DM-TIMING ACK	1 to 4 during occupation 2 to 4 during reservation
DM-SDS DATA (DSB)	1 to 4
DM-SDS UDATA (DSB)	1 to 4
DM-SDS ACK	1 to 2 if fragmentation needed 1 to 3 if fragmentation not needed

Annex B (normative): Mathematical definition of Frame Check Sequence (FCS)

The FCS value corresponding to a given frame is defined by the following procedure:

1) the first 4 octets (first 32 bits) of the frame are complemented. If there are less than 32 bits, then those bits will be complemented;

2) the n bits of the frame are then considered to be the coefficients of a polynomial M(x) of degree n-1;

3) M(x) is multiplied by x^{32} and divided by G(x), producing a remainder R(x) of degree less than 31;

4) the coefficients of R(x) are considered to be a 32-bit sequence;

5) the 32-bit sequence is complemented and the result is the FCS.

The generator polynomial is defined as:

$$G(x) = 1 + X + X^2 + X^4 + X^5 + X^7 + X^8 + X^{10} + X^{11} + X^{12} + X^{16} + X^{22} + X^{23} + X^{26} + X^{32}$$

Annex C (informative): DMC-SAP boundary state model illustrations

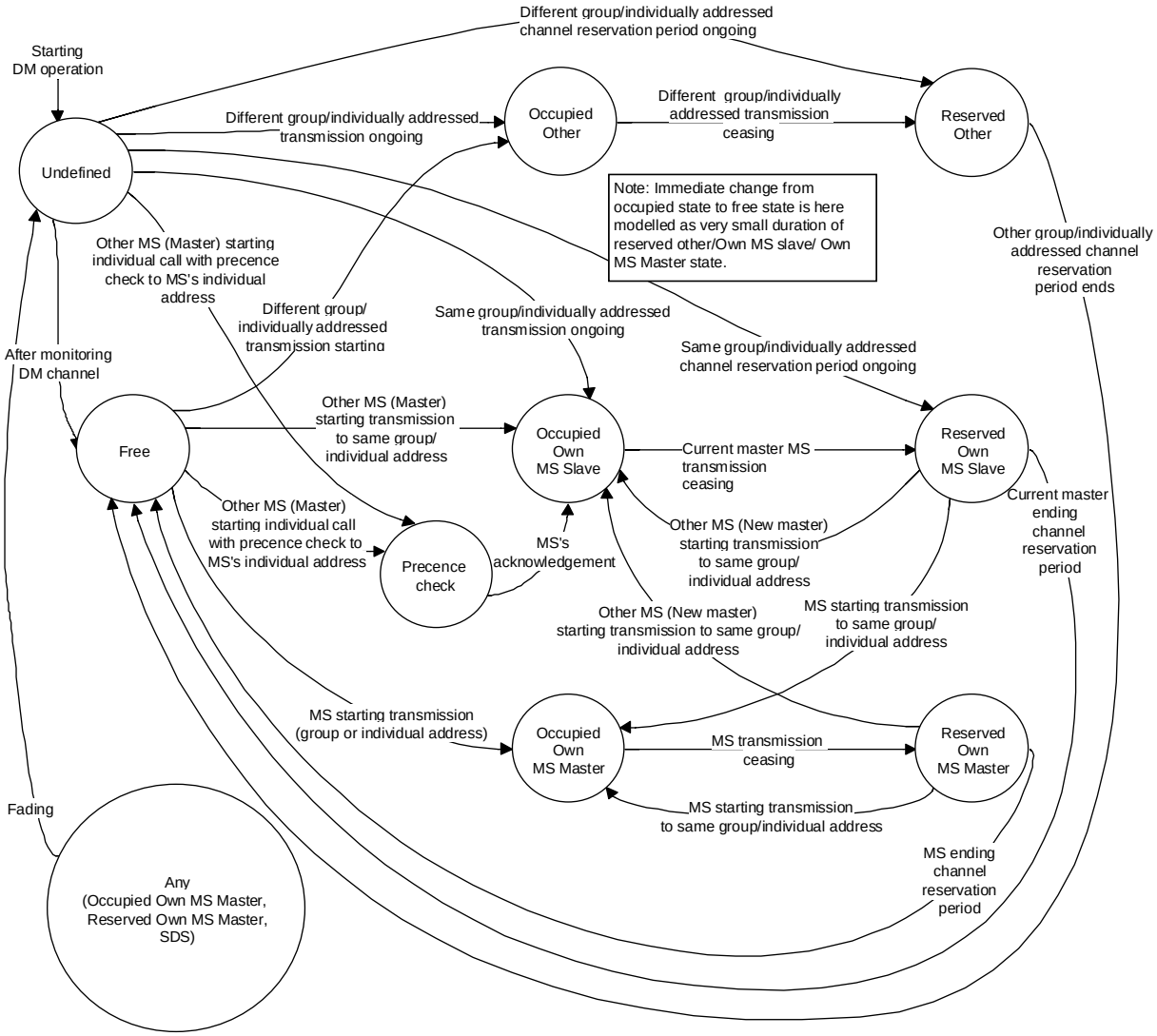


Figure C.1: Illustration of basic DM-MS to DM-MS operation

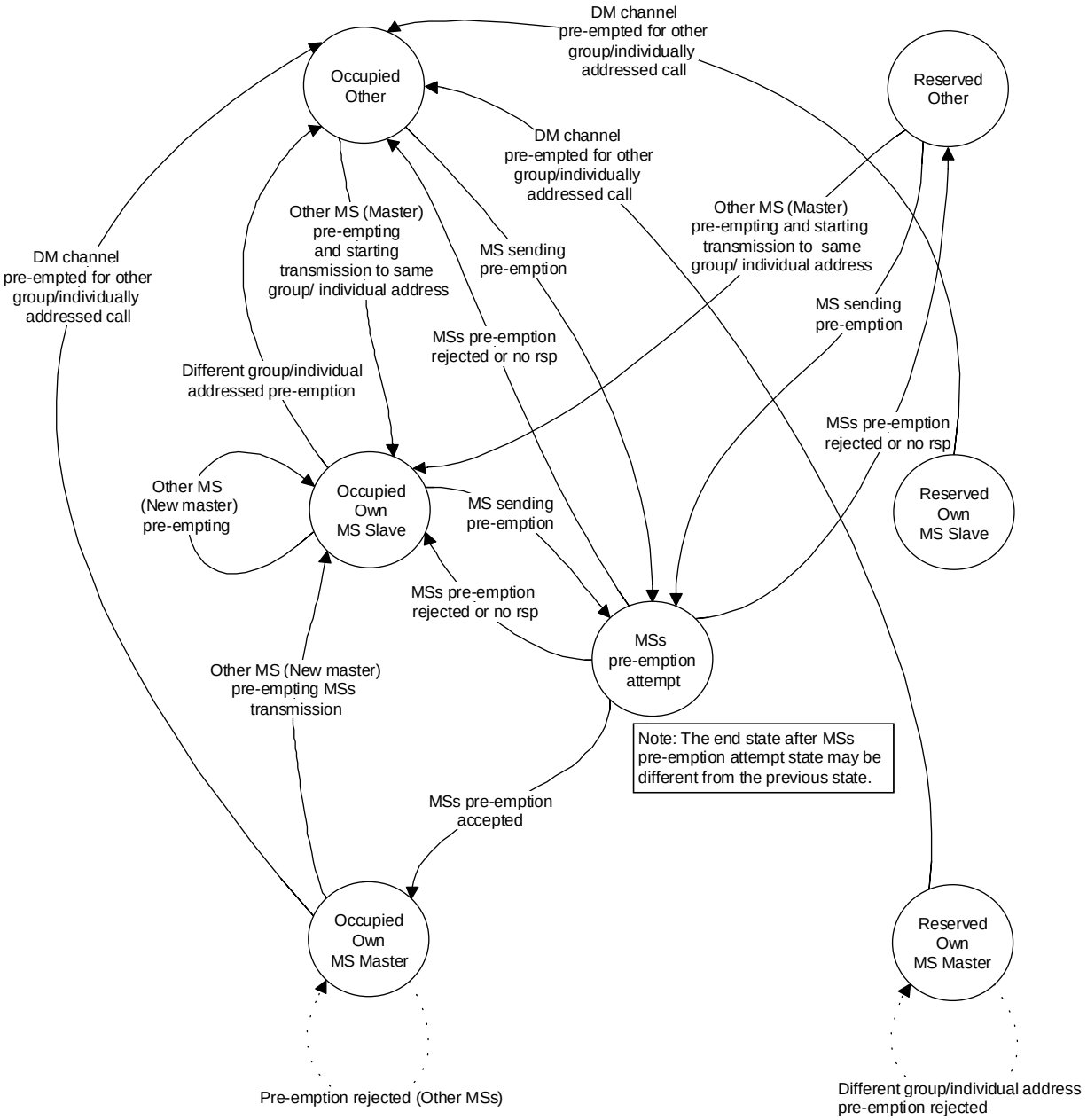


Figure C.2: Illustration of pre-emption

History

Document history			
July 1996	Public Enquiry	PE 109:	1996-07-08 to 1996-11-01