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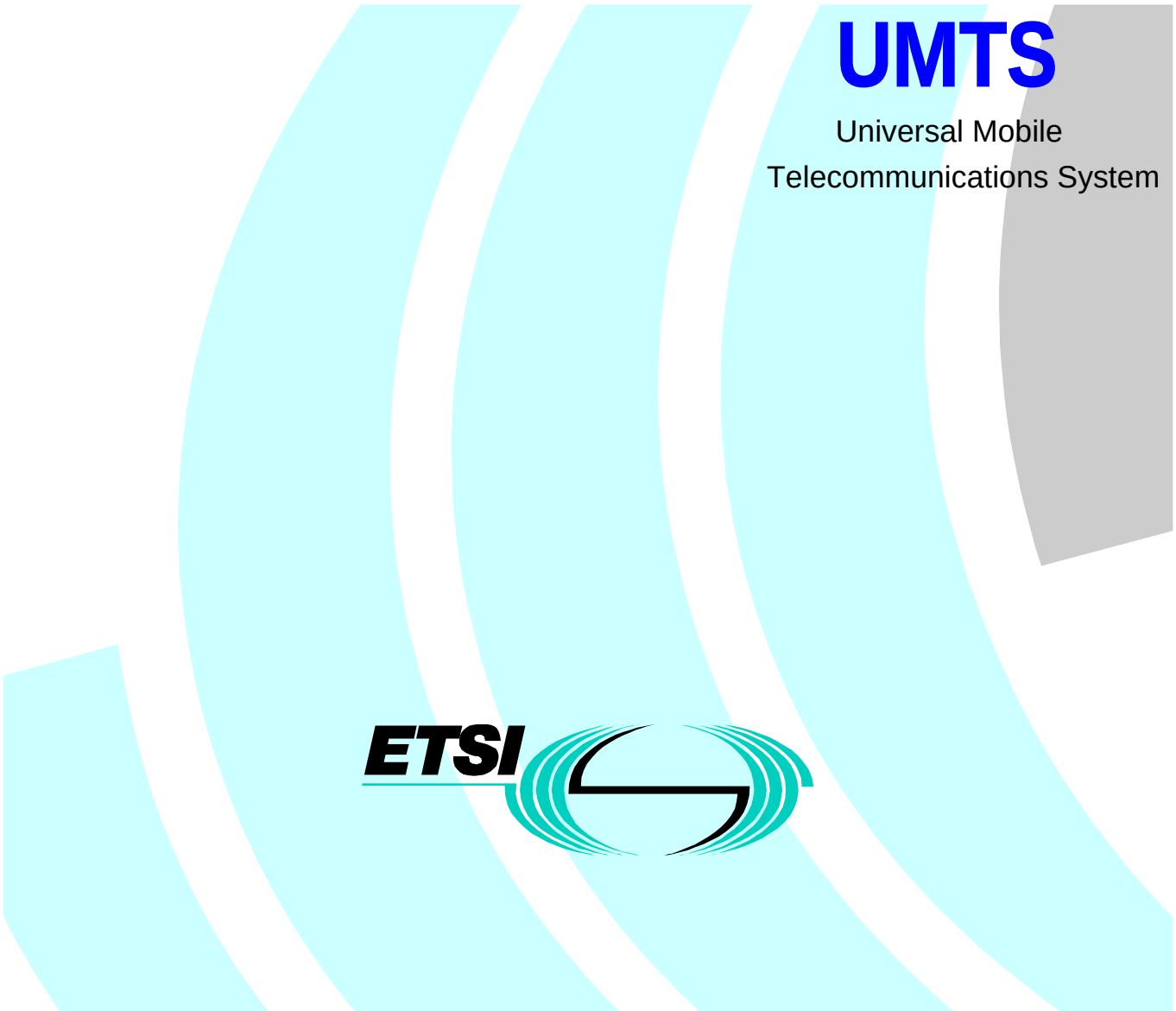
UMTS YY.21 V1.0.0 (1999-01)

Technical Report

UMTS Terrestrial Radio Access Network (UTRAN); Description of the MAC protocol (UMTS YY.21 version 1.0.0)



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Contents

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Foreword

This Technical Specification (TS) has been produced by the Special Mobile Group (SMG) of the European Telecommunications Standards Institute (ETSI).
The contents of this TS are subject to continuing work within TC-SMG and may change following formal TC-SMG approval.

1 Scope

The scope of this description is to describe the MAC protocol. A description document is intermediate between a stage 2 document and a protocol specification. Once completed, it should be sufficient for manufacturers to start some « high level design » activities. It should allow as well to assess the complexity of the associated protocol. After the completion of a description document, the drafting of the protocol specification should not have to face difficulties which would impact the other protocols i.e. the radio interface protocol architecture should be stable. This means that some procedures which are felt critical in terms of complexity will need to be studied in more details in the description document so that no problem is faced in the writing of the final protocol.

The following lists typical contents for a description document:

1) list of procedures
2) logical flow diagrams for normal procedures
3) logical description of message (where it should be possible to guess roughly the size of the various information elements)
4) principles for error handling
5) some exceptional procedures which are felt criteria
6) It should, as far as possible, have the same format and outline as the final specification

The following is not covered

1) exact message format
2) all scenarios

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] UMTS XX.XX, UTRAN Architecture description
[2] Vocabulary used in the UMTS L2&L3 Expert Group
[3] UMTS YY.01, UE-UTRAN Radio Interface Protocol Architecture ;Stage 2
[4] UMTS YY.02, Layer 1; General requirements
[5] UMTS YY.03, UE States and Procedures in Connected Mode
[6] UMTS YY.04, Description of procedures in idle Mode
[7] UMTS YY.22, Description of RLC protocol
[8] UMTS YY.31, Description of RRC protocol
[9] UMTS YY.40, Description of principles for error handling and message description

3. Definitions and Abbreviations

ARQ	Automatic Repeat Request
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
Control-	
CC	Call Control
CCCH	Common Control Channel
CCH	Control Channel
CCTrCH	Coded Composite Transport Channel
CN	Core Network
CRC	Cyclic Redundancy Check
DC	Dedicated Control (SAP)
DCCH	Dedicated Control Channel
DCH	Dedicated Channel

DL	Downlink
DSCH	Downlink Shared Channel
DTCH	Dedicated Traffic Channel
FACH	Forward Link Access Channel
FAUSCH	Fast Uplink Signalling Channel
FCS	Frame Check Sequence
FDD	Frequency Division Duplex
GC	General Control (SAP)
HO	Handover
ITU	International Telecommunication Union
kbps	kilo-bits per second
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
LAC	Link Access Control
MAC	Medium Access Control
MM	Mobility Management
Nt	Notification (SAP)
OCCCH	ODMA Common Control Channel
ODCCH	ODMA Dedicated Control Channel
ODCH	ODMA Dedicated Channel
ODMA	Opportunity Driven Multiple Access
ORACH	ODMA Random Access Channel
ODTCH	ODMA Dedicated Traffic Channel
PCCH	Paging Control Channel
PCH	Paging Channel
PDU	Protocol Data Unit
PHY	Physical layer
PhyCH	Physical Channels
RACH	Random Access Channel
RLC	Radio Link Control
RNTI	Radio Network Temporary Identity
RRC	Radio Resource Control
SAP	Service Access Point
SCCH	Synchronization Control Channel
SCH	Synchronization Channel
SDU	Service Data Unit
TCH	Traffic Channel
TDD	Time Division Duplex
TFI	Transport Format Indicator
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
U-	User-
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
URA	UTRAN Registration Area
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

4 General

4.1 Objective

4.2 Overview on MAC architecture

The following provides an overview of a common MAC architecture that encompasses both UMTS-FDD and UMTS-TDD. There are differences of detail between the two systems but their architectures are sufficiently similar for a common overview to be adopted. Followed by section 4.2.1 MAC entities, where the different MAC entities are summarised, the sections 4.2.2-4 contain a more detailed description of the MAC architecture.

4.2.1 MAC Entities

The diagrams that describe the MAC architecture are constructed from MAC entities. The entities are assigned the following names. The functions completed by the entities are different in the UE from those completed in the UTRAN:

- MAC-b, which identifies the MAC entity that handles the broadcast channel (BCH). There is one MAC-b entity in each UE and one MAC-b in the UTRAN for each cell.
- MAC-p, which identifies the MAC entity that handles the paging channel (PCH). There is one MAC-p entity in each UE and one MAC-p in the UTRAN for each cell.
- MAC-c, which identifies the MAC entity that handles the forward access channel (FACH) and the random access channel (RACH). There is one MAC-c entity in each UE and one in the UTRAN for each cell.
- MAC-d, denotes the MAC entity that is responsible for handling of dedicated logical channels and dedicated transport channels (DCH) allocated to a UE. There is one MAC-d entity in the UE and one MAC-d entity in the UTRAN for each UE. Note: *When a UE is allocated resources for exclusive use by the bearers that it supports the MAC-d entities dynamically share the resources between the bearers and are responsible for selecting the TFI/ TFCI that is to be used in each transmission time interval.*
- MAC-sh, denotes the MAC entity that handles downlink shared channels (DSCH). There is one MAC-sh entity in each UE that is using a DSCH and one MAC-sh entity in the UTRAN for each cell that contains a DSCH.
- MAC-sy, identifies the MAC entity used in TDD operation to handle the information received on the synchronisation channel SCH

According to the RRC functions the RRC is generally in control of the internal configuration of the MAC.

4.2.2 MAC-b , MAC-p and MAC-sy

The following diagram illustrates the connectivity of the MAC-b , MAC-p and MAC-sy entities in a UE and in each cell of the UTRAN:

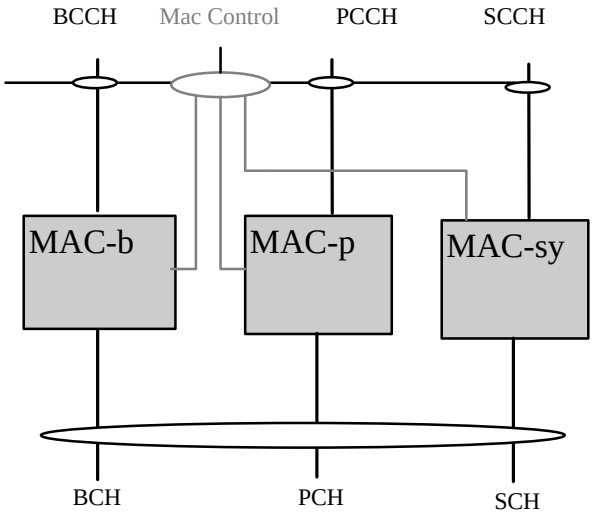


Figure 4.2.2.1 UE side and UTRAN side architecture (BCCH ,PCCH and SCCH)

MAC-b, MAC-p and MAC-sy represents SCH, BCH and PCH control entities, which are cell-specific MAC entities in the UTRAN. In the UE side there is one SCH, BCH and PCH control entity per UE. The SCH control entity handles synchronisation channels for the TDD mode. The details of this entity are left for further study. The MAC Control SAP is used to transfer Control information to each MAC entity.

4.2.3 Traffic Related Architecture - UE Side

Figure 4.2.3.1 illustrates the connectivity of MAC entities. The figure shows a MAC-d servicing the needs of several DTCH mapping them to a number of DCH. A MAC-sh controls access to a common transport channel. It is noted that because the MAC-sh provides additional capacity then it communicates only with the MAC-d rather than the DTCH directly. The MAC-c, which interfaces with the FACH and RACH common signalling channels, is connected with the MAC-d for transfer of data and RNTI. The MAC Control SAP is used to transfer Control information to each MAC entity.

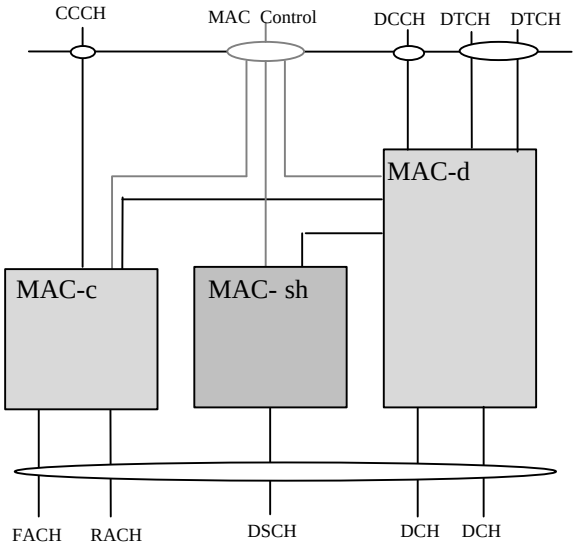
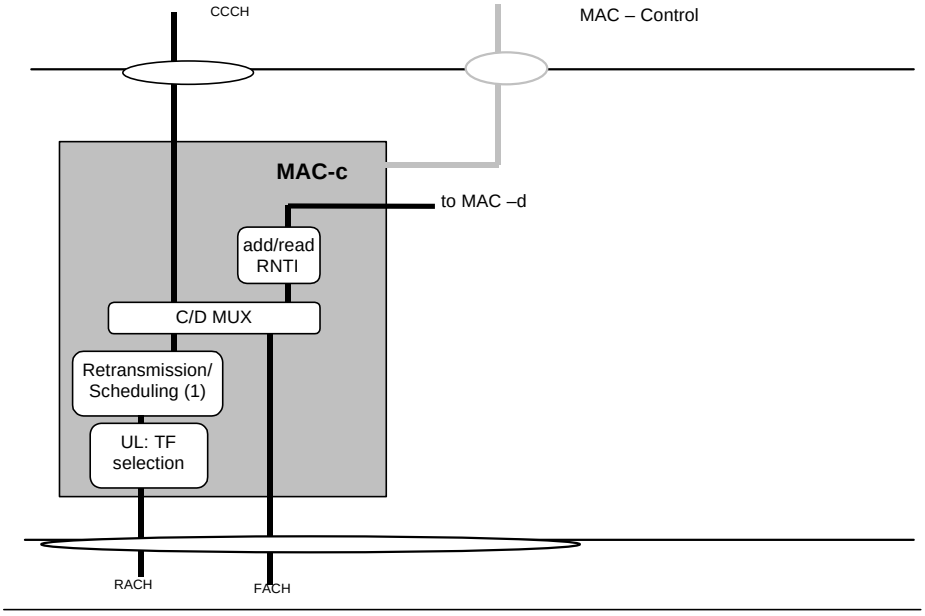


Figure 4.2.3.1 UE side MAC architecture

Figure 4.2.3.2 shows the UE side MAC-c entity. The following functionality is covered:

- The C/D box represents the insertion and detection of the field in the MAC header, indicating whether a common or dedicated logical channel is used.
- The RNTI field in the MAC header is used to distinguish between UEs.
- In the uplink, the possibility of transport format selection exists.
- For RACH termination according YY.01 Case C retransmission/scheduling my apply.



DL	Downlink	RNTI	Radio Network Temporary Identity
TF	Transport Format	UE	User Equipment
TFC	Transport Format Combination	UL	Uplink
(1)	Applies only for Case C termination, see YY.01 [3]		

Figure 4.2.3.2. UE side MAC architecture / MAC-c details

Figure 4.2.3.3 shows the UE side MAC-d entity. The following functionality is covered:

- Dynamic transport channel type switching is performed by this entity, based on decision taken by RRC.
- The C/T MUX box is used when multiplexing of several dedicated logical channels onto one transport channel is used.
- The MAC-d entity using common channels is connected to a MAC-c entity that handles the scheduling of the common channels to which the UE is assigned.
- The MAC-d entity using downlink shared channel is connected to a MAC-sh entity that handles the reception of data received on the shared channels to which the UE is assigned.
- In the uplink, transport format combination selection (out of the RRC assigned transport format combination set) is performed to prioritise transport channels.

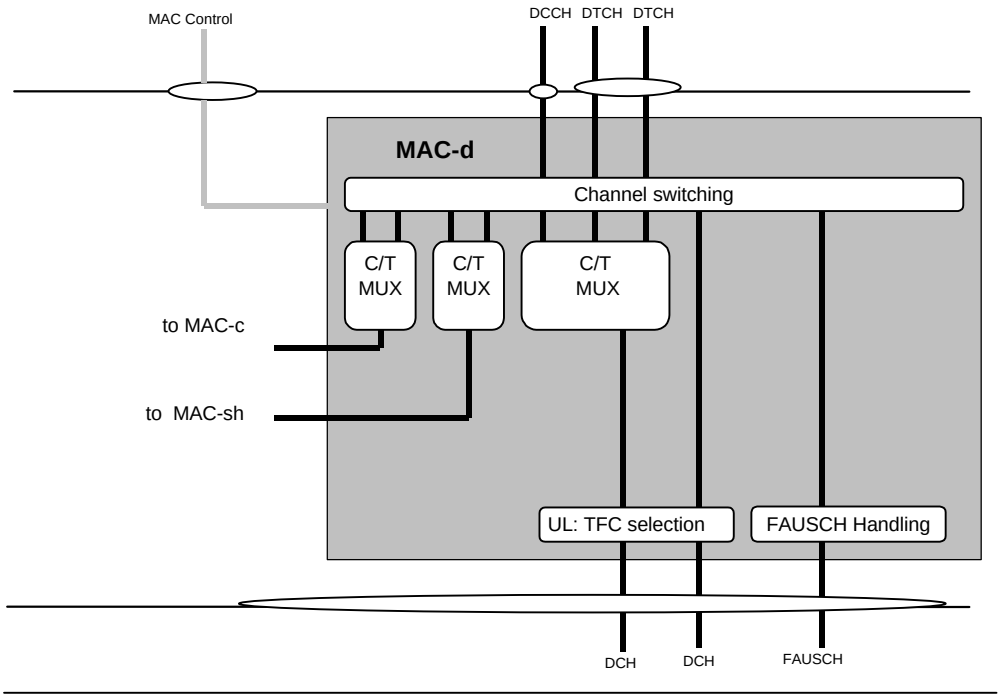


Figure 4.2.3.3. UE side MAC architecture / MAC-d details

Figure 4.2.3.4 shows the UE side MAC-sh entity. The following functionality is covered:

- RNTI is used on the DSCH Control Channel to identify the UE. Additionally, some timing / physical information is needed to tell the UE when to listen to DSCH.
- Multiplexing is used to transmit the received information on DSCH and DCH to the Mac-d
- FAUSCH Handling indicates the function in the MAC-d supports the FAUSCH, details are ffs.

The RLC has to provide RLC-PDU's to the MAC which fits into the available transport blocks on the transport channels respectively.

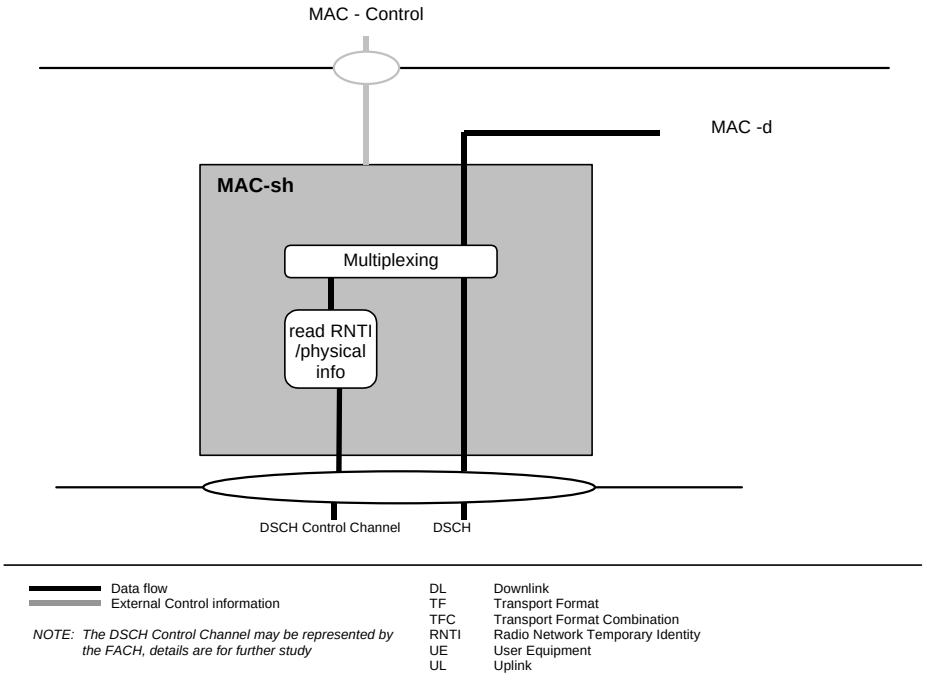


Figure 4.2.3.4. UE side MAC architecture / MAC-sh details

4.2.4 Traffic Related Architecture - UTRAN Side

Figure 4.2.3.1 illustrates the connectivity between the MAC entities from the UTRAN side. It is similar to the UE case with the exception that there will be one MAC-d for each UE and each UE (MAC-d) that is associated with a particular cell may be associated with that cells MAC-sh. MAC-c and Mac-sh are located in the controlling RNC while MAC-d is located in the serving RNC.The MAC Control SAP is used to transfer Control information to each MAC entity belongs to one UE.

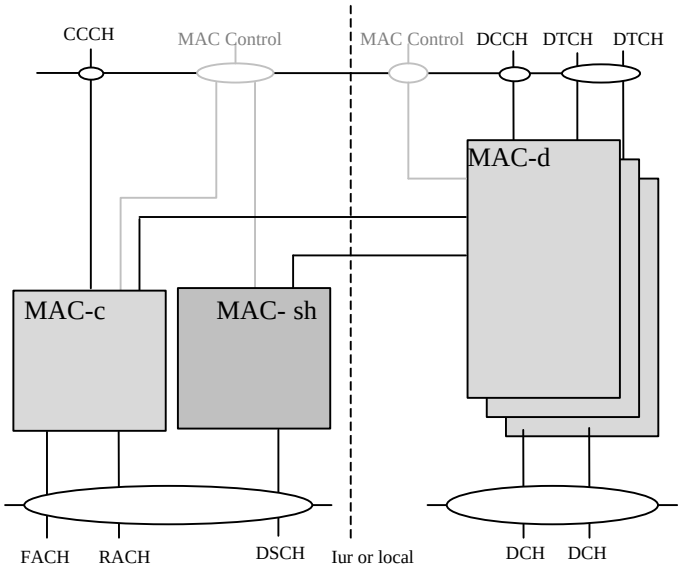


Figure 4.2.4.1: UTRAN side MAC architecture

Figure 4.2.4.2 shows the UTRAN side MAC-c entity. The following functionality is covered:

- The C/D box represents the insertion and detection of the field in the MAC header, indicating whether a common or dedicated logical channel is used.
- For dedicated type logical channels, the RNTI field in the MAC header is used to distinguish between UEs.
- In the downlink, transport format selection might be done if FACH is variable rate.
- For RACH termination according YY.01 Case C retransmission/scheduling my apply.

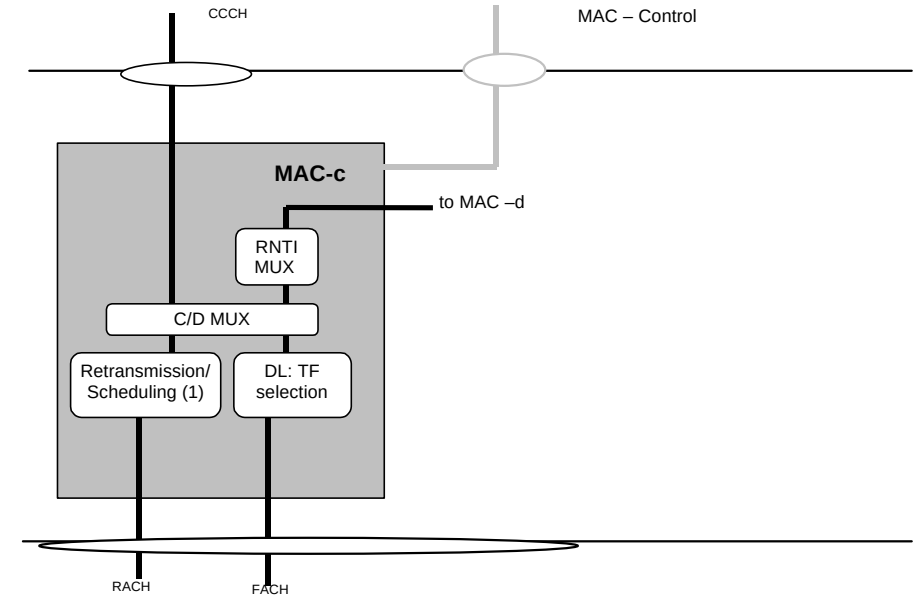
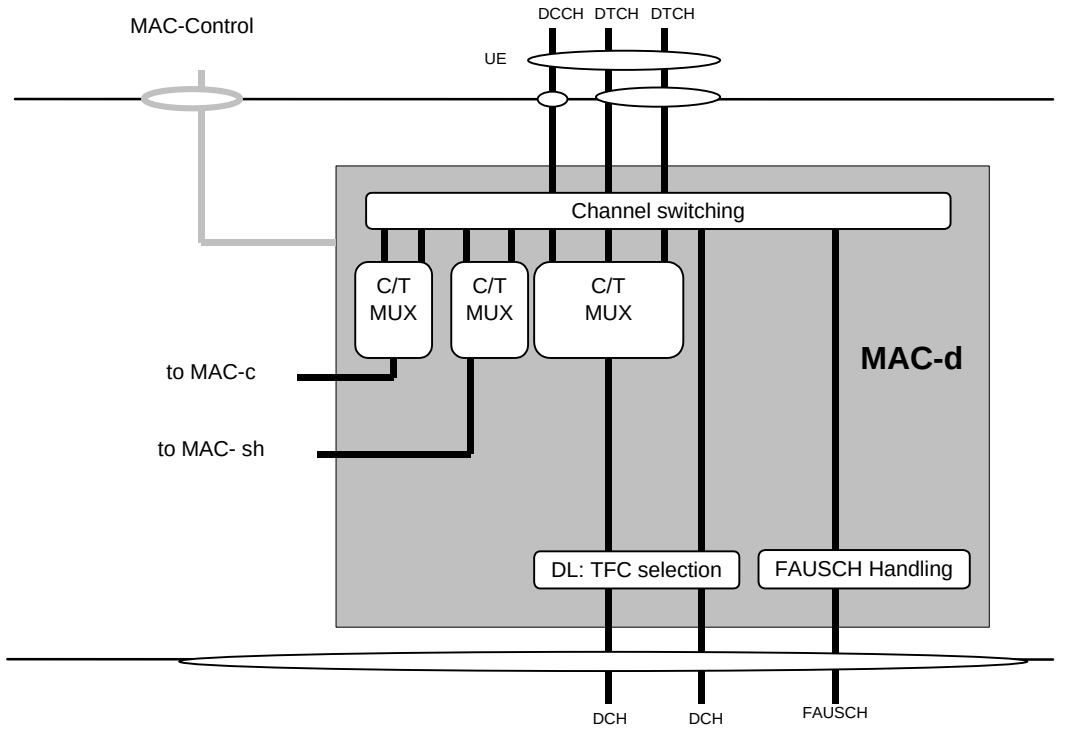


Figure 4.2.4.2 UTRAN side MAC architecture / MAC-c details

Figure 4.2.4.3 shows the UTRAN side MAC-d entity. The following functionality is covered:

- Dynamic transport channel type switching is performed by this entity, based on decision taken by RRC.
- The C/T MUX box is used when multiplexing of several dedicated logical channels onto one transport channel is used.
- Each MAC-d entity using common channels is connected to a MAC-c entity that handles the scheduling of the common channels to which the UE is assigned.
- Each MAC-d entity using downlink shared channel is connected to a MAC-sh entity that handles the of the shared channels to which the UE is assigned.
- In the downlink, transport format combination selection (out of the RRC assigned transport format combination set) is performed to prioritise transport channels.



DL	Downlink	RNTI	Radio Network Temporary Identity
TF	Transport Format	UE	User Equipment
TFC	Transport Format Combination	UL	Uplink
Note1 :	*for DCH and DSCH different scheduling mechanisms apply*	*Note 2:*	*The TFC selection place is under discussion*

Figure 4.2.4.3 UTRAN side MAC architecture / MAC-d details

Figure 4.2.4.4 shows the UTRAN side MAC-sh entity. The following functionality is covered:

- RNTI is used on the DSCH Control Channel to identify the UE. Additionally, some timing information is needed to tell the UE when to listen to DSCH.
- The scheduling box in MAC-sh shares the DSCH resources between the UEs.
- DL TF selection is used to indicate a appropriated Transport format on the DSCH.
- FAUSCH Handling indicates the function in the MAC-d supports the FAUSCH, details are ffs.

The RLC has to provide RLC-PDU's to the MAC which fits into the available transport blocks on the transport channels respectively.

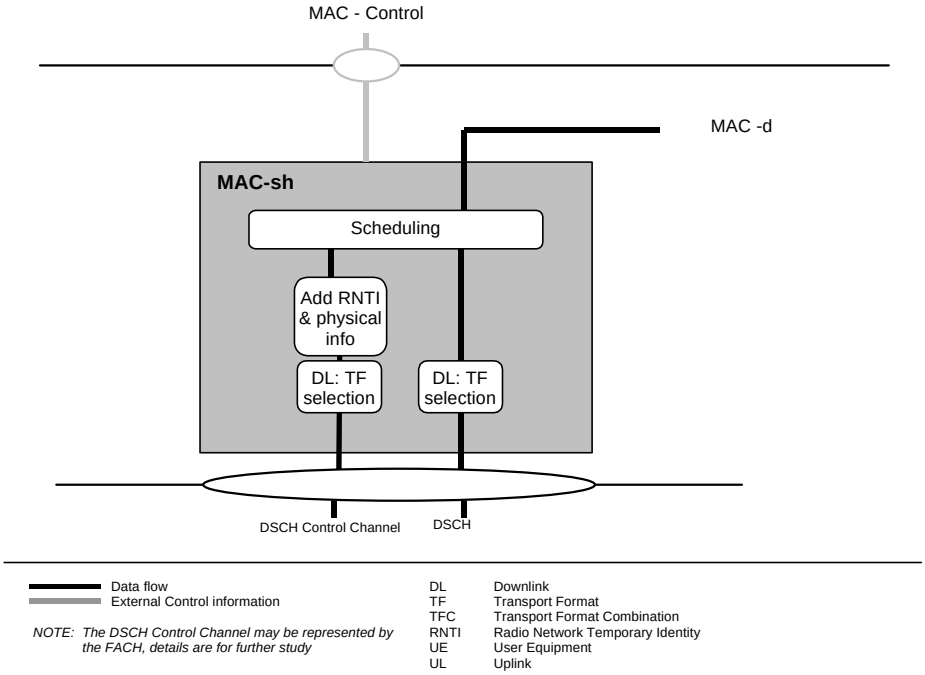


Figure 4.2.4.4 UTRAN side MAC architecture / MAC-sh details

4.2.5 Relation between MAC Functions and Transport Channels

Table 1 UTRAN MAC functions corresponding to the transport channel (note3)

Associated MAC Functions	Logical Ch	Transport Ch	TF Selection	Priority handling between users	Priority handling (one user)	Scheduling	Identification of UEs	Mux/ Demux on common transport CH	Mux/ Demux on dedicated transport CH	Dynamic transport CH switching
Uplink (Rx)	CCCH	RACH						X		
	DCCH	RACH					X	X		
	DCCH	DCH							X	
	DTCH	RACH					X	X		
	DTCH	DCH							X	
Downlink (Tx)	SCCH	SCH								
	BCCH	BCH				X				
	PCCH	PCH				X				
	CCCH	FACH		X				X		
	DCCH	FACH		X			X	X		
	DCCH	DSCH		X				X		
	DCCH	DCH	X		X				X	
	DTCH	FACH	X(note1)	X			X	X		X
	DTCH	DSCH	X(note2)	X				X		X
	DTCH	DCH	X		X				X	X

(Note1) On FACH channel, the transport format set is limited.
(Note2) Whether DSCH has the transport format set is under discussion.
(Note3) The functions not included in the table are listed below.

- Mapping between logical channels and transport channels.
- Traffic volume monitoring
- Constrained execution of open loop power control algorithms

Further, the following additional functions are not included yet in the table :

- Routing of higher layer signalling
- Maintenance of a MAC signalling connection between peer MAC entities
- Monitoring the links of the assigned resources

- Processing of messages received at common control channels

4.2.6 Relation of UE MAC functions corresponding to the transport channel MAC Functions and Transport Channels

Table 2 UE MAC functions corresponding to the transport channel

Functions	Logical Ch	Transport Ch	TF Selection	Priority handling data of one user	Identification	Mux/Demux on common transport channels	Mux/Demux on dedicated transport channels	Dynamic transport channel type switching
Uplink (Tx)	CCCH	RACH				X		
	DCCH	RACH	X(note1)		X	X		
	DCCH	DCH	X	X			X	
	DTCH	RACH	X(note1)		X	X		X
	DTCH	DCH	X	X			X	X
Downlink (Rx)	SCCH	SCH						
	BCCH	BCH						
	PCCH	PCH						
	CCCH	FACH				X		
	DCCH	FACH			X	X		
	DCCH	DSCH				X		
	DCCH	DCH					X	
	DTCH	FACH			X	X		
	DTCH	DSCH				X		
	DTCH	DCH					X	

(Note1) The RACH channel has the limited transport format set.

4.3 Channel structure

The MAC operates on the channels defined below; the transport channels are described between MAC and Layer1, the logical channels are described between MAC and RLC. The following sections provide an overview, the normative description can be found in [3] and [4] respectively.

4.3.1 Transport channels

Common transport channel types are:

1 Random Access Channel(s) (RACH)
2 Forward Access Channel(s) (FACH)
3 Downlink Shared Channel(s) (DSCH)
4 ODMA Random Access Channel(s) (ORACH)
5 Broadcast Channel (BCH)
6 Synchronisation Channel (SCH), for TDD operation only
7 Paging Channel (PCH)

Dedicated transport channel types are:

1 Dedicated Channel (DCH)
2 Fast Uplink Signalling Channel (FAUSCH)
3 ODMA Dedicated Channel (ODCH)

4.3.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC. Each logical channel type is defined by what type of information is transferred.

4.3.2.1 Logical channel structure

The configuration of logical channel types is depicted in Figure 4.3.2.1:

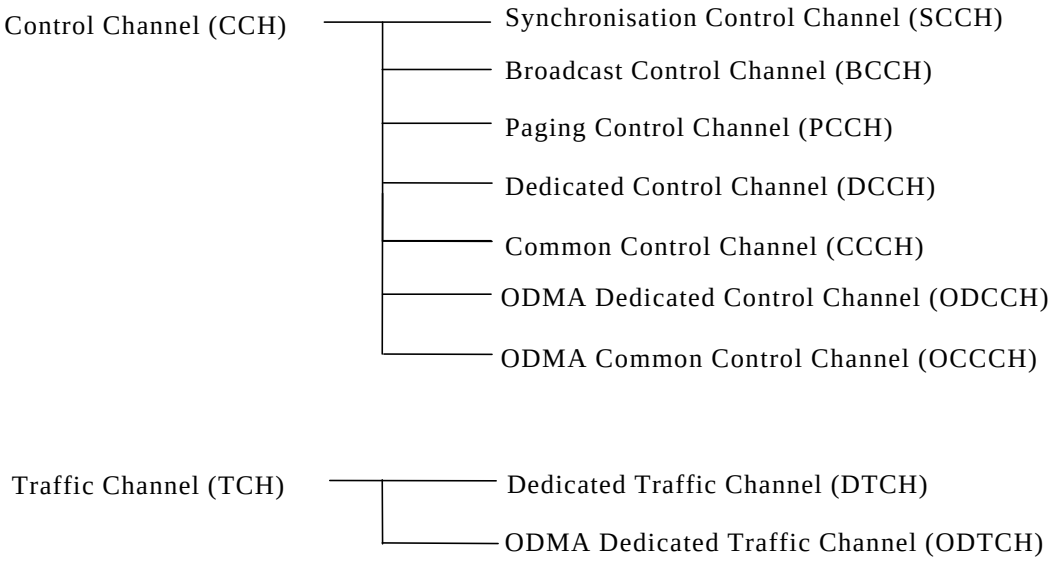


Figure 4.3.2.1 : Logical channel structure

4.3.2.2 Control Channels

Following control channels are used for transfer of control plane information only:

- Synchronisation Control Channel (SCCH)
- Broadcast Control Channel (BCCH)
- Paging Control Channel (PCCH)
- Common Control Channel (CCCH)
- Dedicated Control Channel (DCCH)
- ODMA Common Control Channel (OCCCH)
- ODMA Dedicated Control Channel (ODCCH)

4.3.2.3 Traffic Channels

Following traffic channels are used for the transfer of user plane information only:

- Dedicated Traffic Channel (DTCH)
- ODMA Dedicated Traffic Channel (ODTCH)

4.3.3 Mapping between logical channels and transport channels

The following connections between logical channels and transport channels exist:

- SCCH is connected to SCH
- BCCH is connected to BCH
- PCCH is connected to PCH
- CCCH is connected to RACH and FACH
- DCCH and DTCH can be connected to either RACH and FACH, to RACH and DSCH, to DCH and DSCH, or to a DCH, the DCCH can be connected to FAUSCH.
- ODCCH, OCCCH and ODTCH can be connected to ORACH, ODCCH and ODTCH can be connected to ODCH.

5. Functions

5.1 Description of the MAC functions

The functions of MAC include:

- Mapping between logical channels and transport channels.

- Selection of appropriate Transport Format for each Transport Channel depending on instantaneous source rate
- Priority handling between data flows of one UE
- Priority handling between UEs by means of dynamic scheduling
- Scheduling of broadcast, paging and notification messages
- Identification of UEs on common transport channels
- Multiplexing/demultiplexing of higher layer PDUs into/from transport blocks delivered to/from the physical layer on common transport channels
- Multiplexing/demultiplexing of higher layer PDUs into/from transport block sets delivered to/from the physical layer on dedicated transport channels
- Traffic volume monitoring
- Monitoring the links of the assigned resources
- Constrained execution of open loop power control algorithms
- Routing of higher layer signalling
- Maintenance of a MAC signalling connection between peer MAC entities
- Dynamic Transport Channel type switching

The following potential functions is regarded as further study items:

- Processing of messages received at common control channels

6 Services provided to upper layers

6.1 Description of the Services provided to the upper layers

- Data transfer
- Reallocation of radio resources and MAC parameters
- Reporting of measurements

The following potential service is regarded as a further study item:

- Allocation/de-allocation of radio resources

7 Services expected from physical layer

see YY.02

8 Elements for layer-to-layer communication

8.1 Primitives between layers 1 and 2

see YY.02

8.2 Primitives between MAC and RLC

8.3 Primitives between MAC and RRC

see YY.02

9 Elements for peer-to-peer communication

9.1 Protocol data units

9.1.1 MAC Data PDU

MAC PDU consists of an optional MAC header and a MAC Service Data Unit (MAC SDU), see figure 9.1.1. Both the MAC header and the MAC SDU are of variable size.
The content and the size of the MAC header depends on the type of the logical channel, and in some cases none of the parameters in the MAC header are needed.
The size of the MAC-SDU depends on the size of the RLC-PDU, which is defined during the setup procedure.

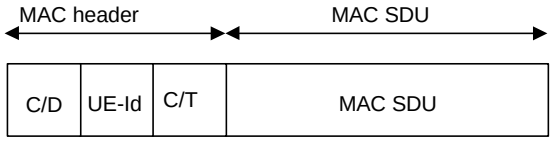


Figure 9.1.1.1 MAC data PDU

9.2 Formats and parameters

9.2.1 MAC Data PDU: Parameters of the MAC header

The following fields are defined for the MAC header:
C/D field
The C/D field is a single-bit flag that provides identification of the logical channel class on FACH and RACH transport channels, i.e. whether it carries CCCH or dedicated logical channel information.

Table 9.2.1.1: Coding of the C/D Field

C/D field	Designation
1	CCCH
0	DCCH or DTCH

C/T field
The C/T field provides identification of the logical channel instance when multiple logical channels are carried on the same transport channel. The C/T field is used also to provide identification of the logical channel type on dedicated transport channels and on FACH and RACH when used for user data transmission.

Table 9.2.1.2: Structure of the C/T field

C/T field	Designation
ffs	ffs

Editors note: In table 9.2.1.2 the general structure of the C/T field should contain information elements, which describes indicators for DCCH/DTCH and the number of logical channels. One possible solution is a seperation into two parts, details are ffs.
UE-Id
The UE-Id field provides an identifier of the UE .
Editors note: It may includes a ID type field to distinguish between different types of UE Id's but has to include in any case the appropriated UE Identification. The type and the length of the UE-Id field may be different depending on the C/D field value. If available the Id type indicates the type of UE identifier that is actually in use. The RNTI is one of the possible UE-Id's, further UE-id formats are ffs.

9.2.1.1 MAC header for DTCH and DCCH

a) DTCH or DCCH mapped to DCH, no multiplexing of dedicated channels on MAC:
No MAC header is required.
b) DTCH or DCCH mapped to DCH, with multiplexing of dedicated channels on MAC:
C/T field is included in MAC header.

c) DTCH or DCCH mapped to RACH/FACH:
C/D field and UE-Id are included in the MAC header. C/T field is included if multiplexing on MAC is applied.
d) DTCH or DCCH mapped to RACH/FACH, where DTCH or DCCH are the only channels (ffs).
UE-Id field is included in MAC header. C/T field is included if multiplexing on MAC is applied.
e) DTCH or DCCH mapped to DSCH:
The MAC-PDU format for DSCH is left for further study.

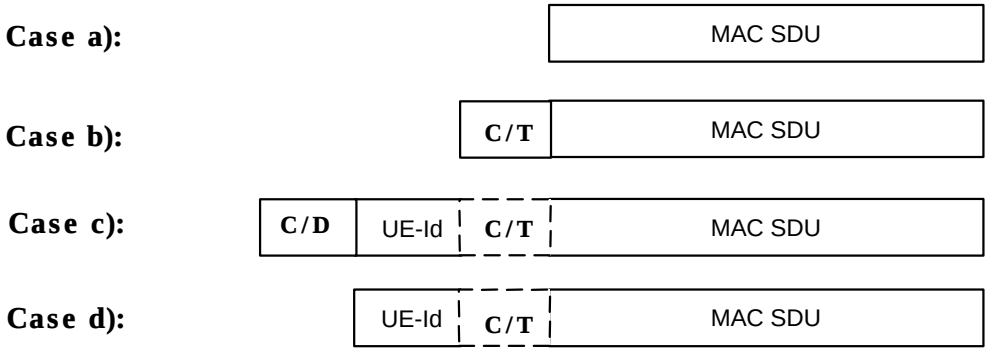


Figure 9.2.2.1: MAC Data PDU formats for DTCH and DCCH

9.2.1.2 MAC header for CCCH

a) CCCH mapped to RACH/FACH:
C/D has to be included and UE-id field may be included in MAC header. Details of usage the UE-id field is ffs.
b) CCCH mapped to RACH/FACH, where CCCH is the only channel (ffs):
UE-id field may be included in the MAC header.

Editors note: The usage of the MAC header for BCCH and PCCH is ffs.

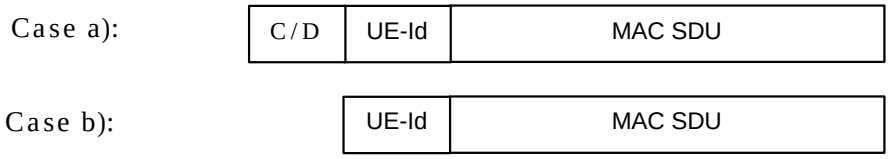


Figure 9.2.1.2.1 : MAC Data PDU formats for CCCH

9.3 Protocol states

(Description of states, provision of state transition diagram(s))

9.4 State variables

9.5 Timers

9.6 Protocol Parameters

(e.g. max, min values of state variables to be initialized)

9.7 Specific functions

(description of specific protocol functions, if applicable)

10 Handling of unknown, unforeseen and erroneous protocol data

11 Elementary procedures

Examples: data transfer, random access procedure, transport channel type switching (dedicated/common channel)

11.1 Dynamic radio bearer control in packet data services

- This procedure is applicable only in case of optimisation of established radio bearers
- The algorithm exist in the UE and is controlled by the network. The algorithm requests to RRC for a reconfiguring of radio resources, details are ffs.

History

Document history		
Date	Version	Comment
August 1998	0.0.0	Created
September 1998	0.0.1	Rapporteur inserted
October 1998	0.0.2	editorial changes, reflecting current working assumptions from YY.01 V0.3.0 and YY.02 V0.2.0
November 1998-1	0.0.3	editorial changes
November 1998-2	0.0.4	changes after L23 EG #7
December 1998	0.0.5	changes after L23 EG #8: Mac architecture updated
January 1999-1	0.0.6	changes after L23 EG #8: Mac architecture updated, additional changes based on e-mail discussion
January 1999-2	0.0.7	changes: Mac architecture updated, Incorporation of MAC PDU formats
January 1999-3	0.1.0	Version approved by L23 EG at L23 Meeting #9, January 18-19, Helsinki, Finland
January 1999	1.0.0	Re-formatted for SMG#28 Clause renumbered
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