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Foreword

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1 Scope

The present document specifies the MAC protocol. The specification describes

- MAC architecture
- MAC entities
- channel structure
- services provided to upper layers
- MAC functions
- services expected from the physical layer
- elements for layer-to-layer communication including primitives between MAC and RLC
- elements for peer-to-peer communication
- protocol data units, formats and parameters
- elementary procedures.

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.

- [1] 3GPP Homepage: www.3gpp.org
- [2] 3G TS 25.301: "Radio Interface Protocol Architecture"
- [3] 3G TS 25.302: "Services provided by the Physical Layer"
- [4] 3G TS 25.303: "Interlayer Procedures in Connected Mode"
- [5] 3G TS 25.304: "UE Procedures in Idle Mode and Procedures for Cell Reselection in Connected Mode "
- [6] 3G TS 25.322: "RLC Protocol Specification"
- [7] 3G TS 25.331: "RRC Protocol Specification"
- [8] 3G TS 25.921: "Guidelines and Principles for Protocol Description and Error Handling"
- [9] 3G TR 25.990: "Vocabulary for the UTRAN"

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [9] apply.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ARQ	Automatic Repeat Request
ASC	Access Service Class
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
C-	Control-
CC	Call Control
CCCH	Common Control Channel
CCTrCH	Coded Composite Transport Channel
CPCH	Common Packet Channel (UL)
CN	Core Network
CRC	Cyclic Redundancy Check
DC	Dedicated Control (SAP)
DCA	Dynamic Channel Allocation
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DL	Downlink
DRNC	Drift Radio Network Controller
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)
LAI	Location Area Identity
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
RNC	Radio Network Controller
RNS	Radio Network Subsystem

RNTI	Radio Network Temporary Identity
RRC	Radio Resource Control
SAP	Service Access Point
SCCH	Synchronization Control Channel
SCH	Synchronization Channel
SDU	Service Data Unit
SHCCH	Shared Channel Control Channel
SRNC	Serving Radio Network Controller
SRNS	Serving Radio Network Subsystem
TDD	Time Division Duplex
TFCI	Transport Format Combination Indicator
TFI	Transport Format Indicator
TMSI	Temporary Mobile Subscriber Identity
TPC	Transmit Power Control
U-	User-
UE	User Equipment
UE _R	User Equipment with ODMA relay operation enabled
UL	Uplink
UMTS	Universal Mobile Telecommunications System
URA	UTRAN Registration Area
USCH	Uplink Shared Channel
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

4 General

4.1 Objective

The objective is to describe the MAC architecture and the different MAC entities from a functional point of view.

NOTE: FAUSCH is not part of release 99.

4.2 Overview on MAC architecture

The following provides a model 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. The description in this chapter is a model and does not represent implementations.

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-c/sh, which identifies the MAC entity that handles the paging channel (PCH), the forward access channel (FACH), the random access channel (RACH), the Common Packet Channel (UL CPCH) for FDD, downlink shared channels (DSCH) for both FDD and TDD and uplink shared channels (USCH) for TDD. There is one MAC-c/sh 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-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 , and MAC-sy

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

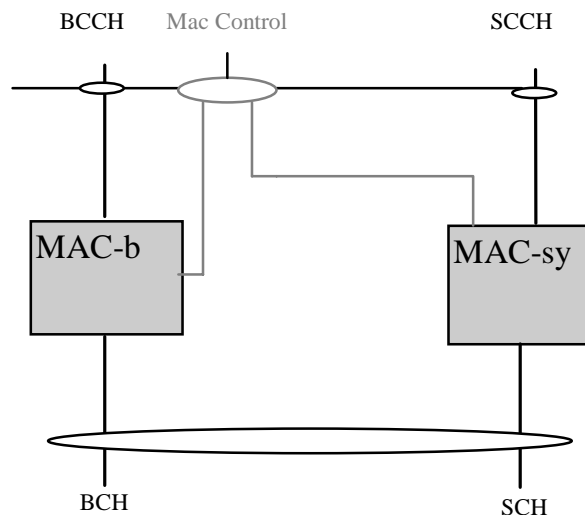


Figure 4.2.2.1: UE side and UTRAN side architecture (BCCH ,PCCH and SCCH)

MAC-b, and MAC-sy represent SCH and BCH control entities, which are cell-specific MAC entities in the UTRAN. In the UE side there is one SCH and BCH control entity per UE. The SCH control entity handles synchronisation channels for the TDD mode. The BCH control entity handles the broadcast channel. 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-c/sh controls access to common transport channels. It is noted that because the MAC-c/sh provides additional capacity then it communicates only with the MAC-d rather than the DTCH directly. The MAC-c/sh, which interfaces with the PCH, FACH, RACH, CPCH, DSCH and USCH common transport channels, is connected with the MAC-d for transfer of DTCH and DCCH data. The MAC Control SAP is used to transfer Control information to each MAC entity. The MAC-c/sh transfers data from the DSCHs to the MAC-d and from the MAC-d to the USCHs (TDD only) under control of the RRC. In the FDD implementation, the MAC-c/sh may transfer data from the MAC-d to the CPCH.

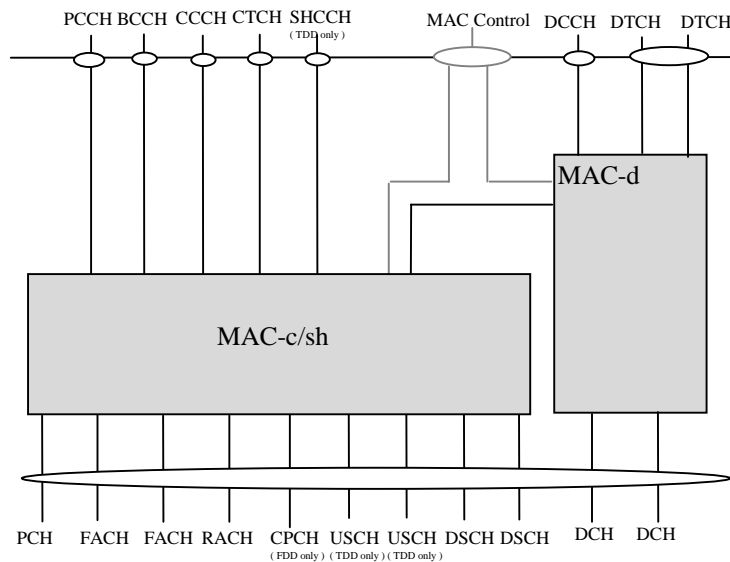


Figure 4.2.3.1: UE side MAC architecture

4.2.3.1 MAC-c/sh entity – UE Side

Figure 4.2.3.1.1 shows the UE side MAC-c/sh entity. The following functionality is covered:

- The TCTF MUX box represents the handling (insertion or detection and deletion) of the TCTF field in the MAC header, and the respective mapping between logical and transport channels. The TCTF field indicates the common logical channel type, or if a dedicated logical channel is used.
- The UE Id field in the MAC header is used to distinguish between UEs.
- In the uplink, the possibility of transport format selection exists.
- ASC selection: MAC indicates the ASC associated with the PDU to the physical layer (this is to ensure that RACH messages associated with a given Access Service Class (ASC) are sent on the appropriate signature(s) and time slot(s)). MAC also applies the appropriate back-off parameter(s) associated with the given ASC.
- Scheduling /priority handling is used to transmit the information received from MAC-d on RACH and CPCH.
- Channel selection is used to select an appropriately sized and available CPCH for transmission.
- Transport format combination selection (out of the RRC assigned transport format combination set) is performed to prioritise transport channels.
- Multiplexing is used to transmit the received information on DSCH to the MAC-d, for TDD the multiplexing is used to transfer data from MAC-d to USCH.

The RLC has to provide RLC-PDUs to the MAC, which fit into the available transport blocks on the transport channels respectively.

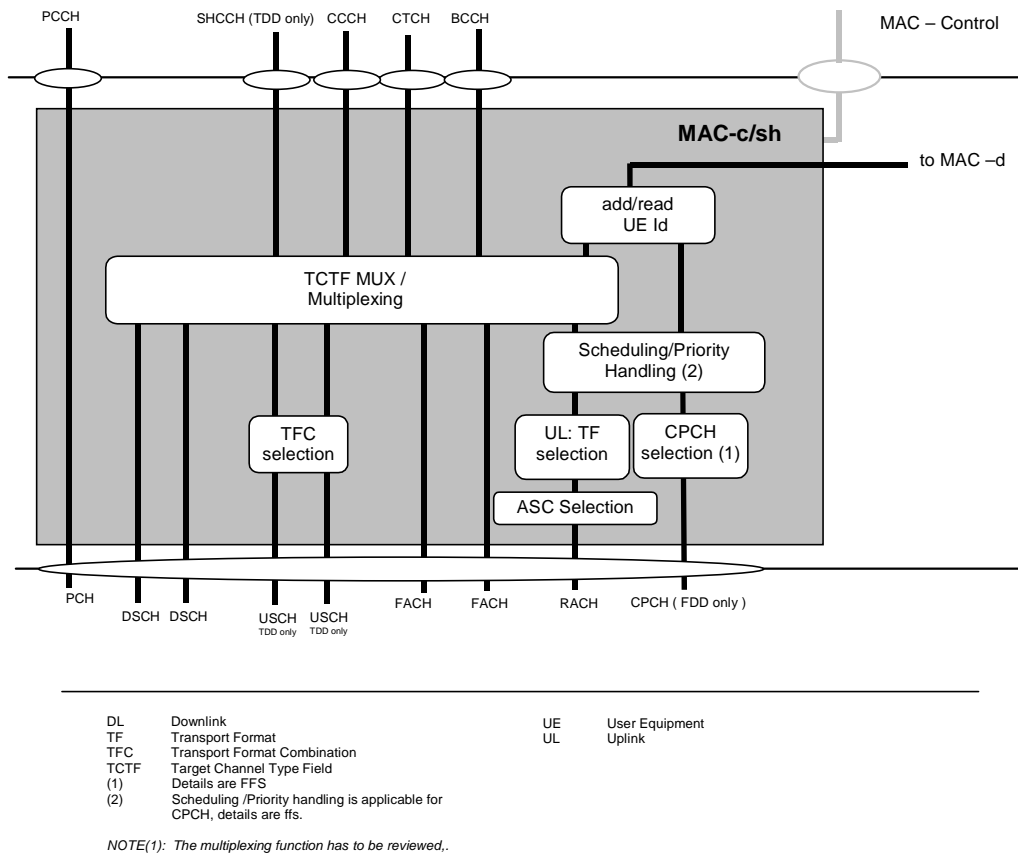


Figure 4.2.3.1.1: UE side MAC architecture / MAC-c/sh details

4.2.3.2 MAC-d entity – UE Side

Figure 4.2.3.2.1 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/sh 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-c/sh entity that handles the reception of data received on the shared channels to which the UE is assigned.
- The MAC-d entity is responsible for mapping dedicated logical channels for the downlink onto the common and dedicated transport channels. One dedicated logical channel can be mapped simultaneously onto DCH and DSCH.
- In the uplink, transport format combination selection (out of the RRC assigned transport format combination set) is performed to prioritise transport channels.
- FAUSCH Handling indicates the function in the MAC-d supports the FAUSCH, details are ffs
- Support of Ciphering / Deciphering for transparent RLC operation in MAC, see [2] for details on the concept.

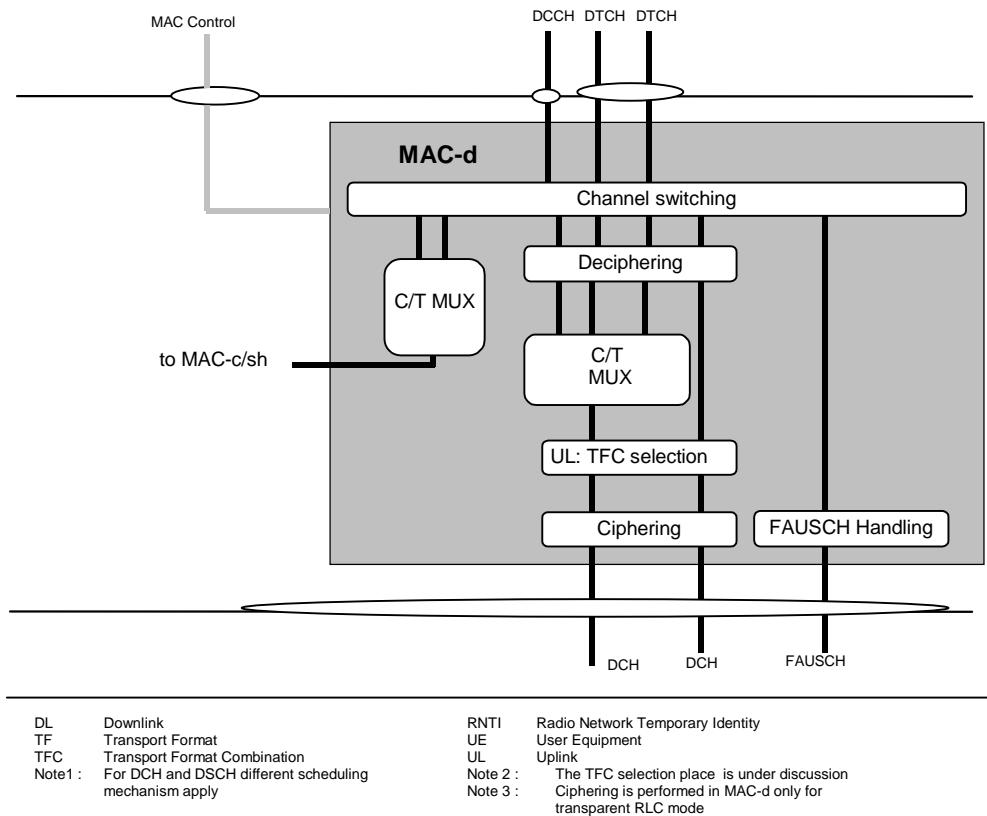


Figure 4.2.3.2.1: UE side MAC architecture / MAC-d details

4.2.4 Traffic Related Architecture - UTRAN Side

Figure 4.2.4.1 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 cell's MAC-c/sh. MAC-c/sh receives the CPCH transport blocks. MAC-c/sh is 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.

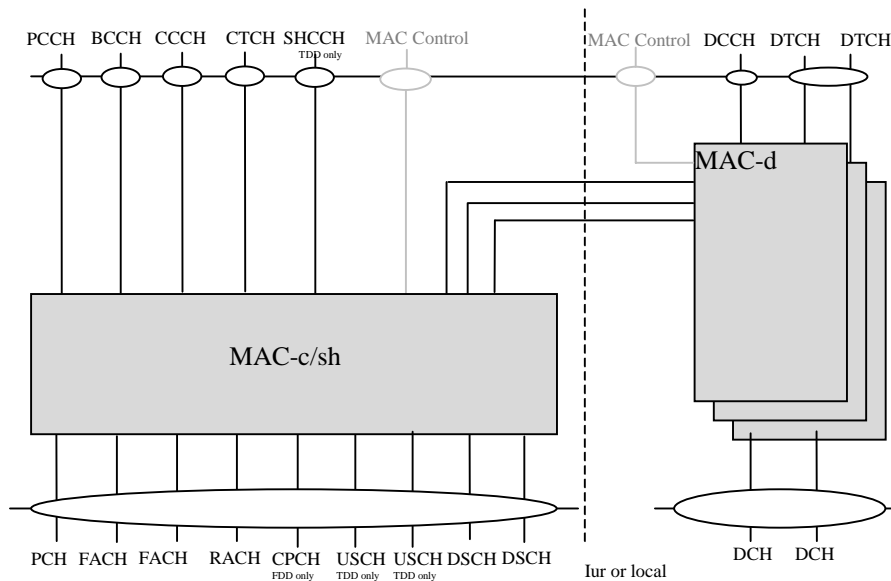


Figure 4.2.4.1: UTRAN side MAC architecture

4.2.4.1 MAC-c/sh entity – UTRAN Side

Figure 4.2.4.1.1 shows the UTRAN side MAC-c/sh entity. The following functionality is covered:

- The Scheduling – Priority Handling box manages FACH resources between the UE's and between data flows according to their priority. DL flow control is also provided to MAC-d.
- The TCTF MUX box represents the handling (insertion or detection and deletion) of the TCTF field in the MAC header, and the respective mapping between logical and transport channels. The TCTF field indicates the common logical channel type, or if a dedicated logical channel is used.
- For dedicated type logical channels, the UE Id field in the MAC header is used to distinguish between UEs.
- In the downlink, transport format combination selection is done for FACH and PCH
- The scheduling /priority handling function in MAC-c/sh shares the DSCH resources between the UEs and between data flows according to their priority.
- For TDD operation the demultiplex function is used to separate USCH data from different UEs, i.e. to be transferred to different MAC-d entities.
- DL code allocation is used to indicate the code used on the DSCH and the appropriate Transport format on the DSCH.
- Flow control is provided to MAC-d.

The RLC has to provide RLC-PDUs to the MAC, which fit into the available transport blocks on the transport channels respectively.

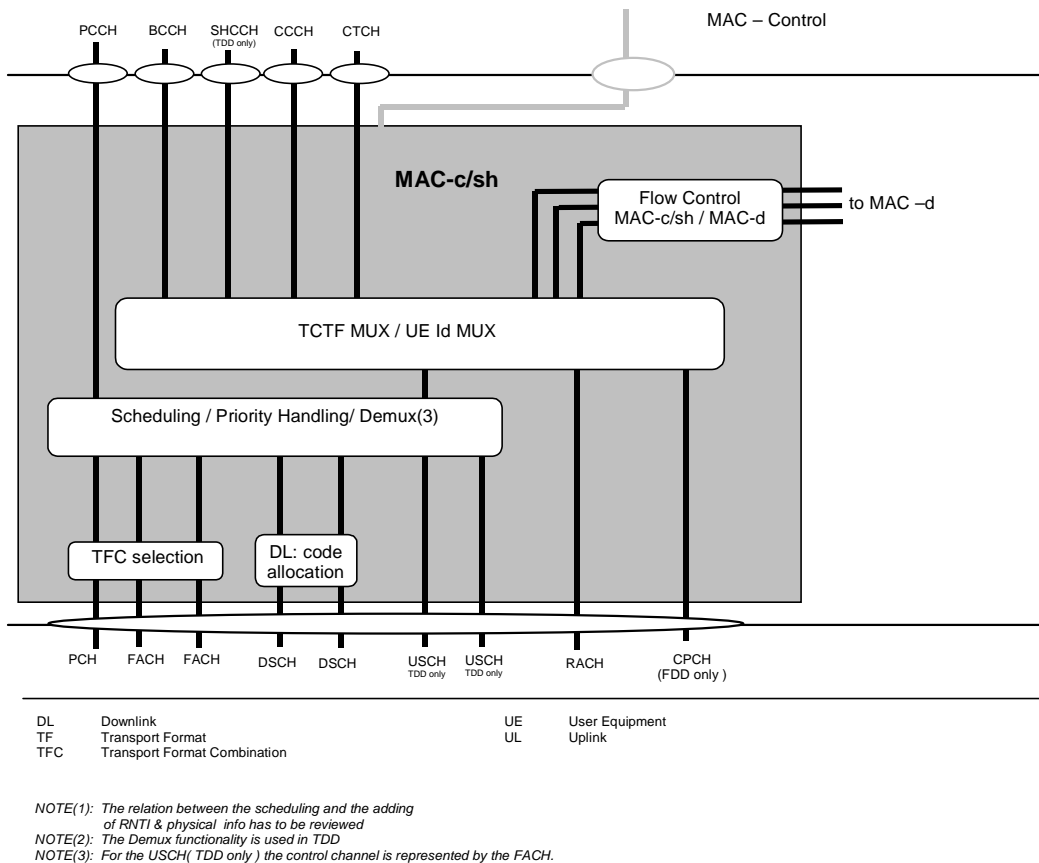


Figure 4.2.4.1.1: UTRAN side MAC architecture / MAC-c/sh details

4.2.4.2 MAC-d entity – UTRAN Side

Figure 4.2.4.2.1 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. C/T Mux is also responsible for priority setting on data received from DCCH / DTCH.
- Each MAC-d entity using common channels is connected to a MAC-c/sh entity that handles the scheduling of the common channels to which the UE is assigned and DL (FACH) priority identification to MAC-c/sh.
- Each MAC-d entity using downlink shared channel is connected to a MAC-c/sh entity that handles the shared channels to which the UE is assigned and indicates the level of priority of each PDU to MAC-c/sh.
- Each MAC-d entity is responsible for mapping dedicated logical channels onto the available common and dedicated transport channels. One dedicated logical channel can be mapped simultaneously on DCH and DSCH.
- In the downlink, scheduling and priority handling of transport channels is performed within the allowed transport format combinations of the TFCS assigned by the RRC. This function supports the TFCI insertion in Node B.
- FAUSCH Handling indicates the function in the MAC-d supports the FAUSCH, details are ffs.
- Support of Ciphering / Deciphering for transparent RLC operation in MAC, see [2] for details on the concept.
- A flow control function exists toward MAC-c/sh to limit buffering between MAC-d and MAC-c/sh entities. This function is intended to limit layer 2 signalling latency and reduce discarded and retransmitted data as a result of FACH or DSCH congestion. It also allows to handle quality of service if MAC-d requires it.

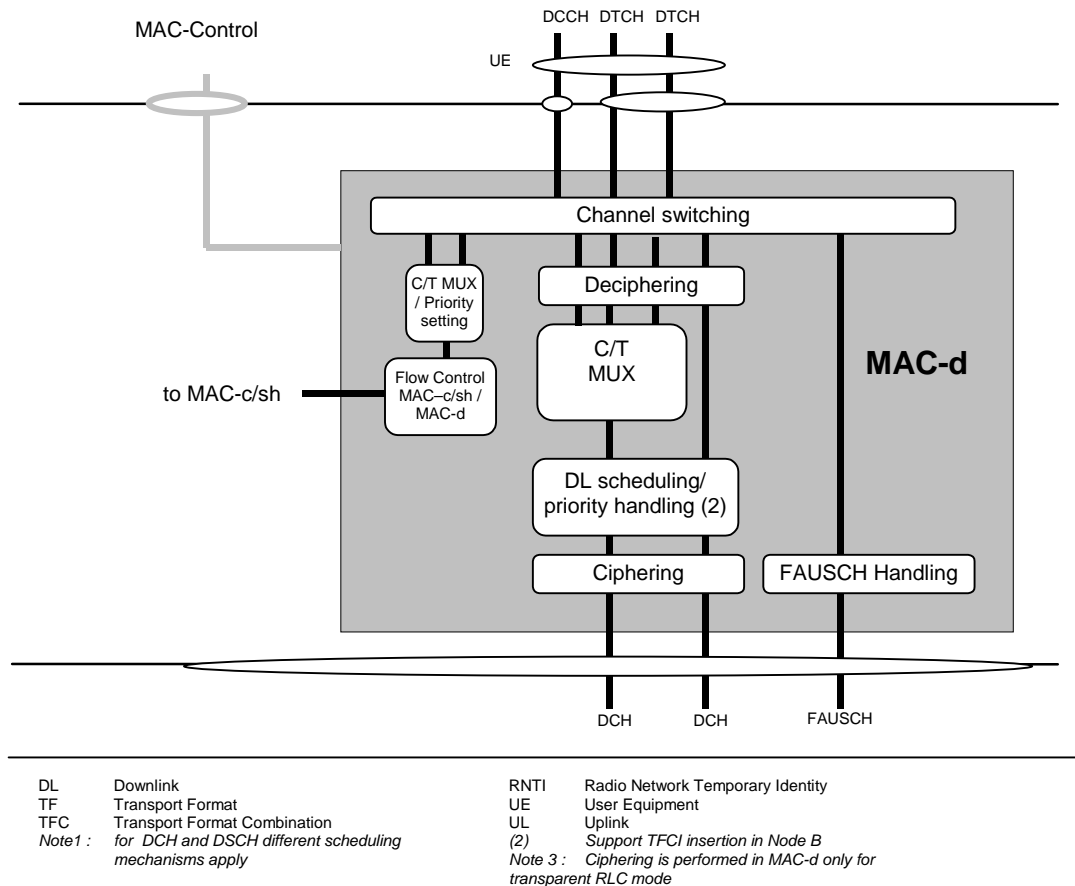


Figure 4.2.4.2.1: UTRAN side MAC architecture / MAC-d details

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 [2] and [3] respectively.

4.3.1 Transport channels

Common transport channel types are:

- Random Access Channel(s) (RACH)
- Forward Access Channel(s) (FACH)
- Downlink Shared Channel(s) (DSCH)
- DSCH Control Channel
- Common Packet Channel(s) (CPCH) for UL FDD operation only
- Uplink Shared Channel(s) (USCH), for TDD operation only
- ODMA Random Access Channel(s) (ORACH)
- Broadcast Channel (BCH)

- Synchronisation Channel (SCH), for TDD operation only
- Paging Channel (PCH)

Dedicated transport channel types are:

- Dedicated Channel (DCH)
- Fast Uplink Signalling Channel (FAUSCH)
- 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:

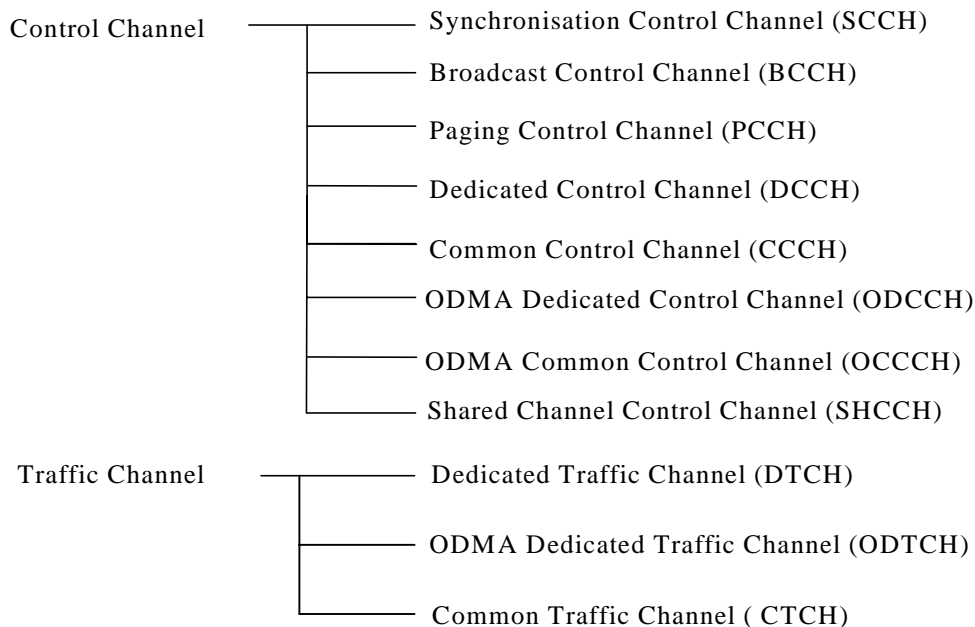


Figure 4.3.2.1: Logical channel structure

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)

- Shared Channel Control Channel (SHCCH)

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)
- Common Traffic Channel (CTCH)

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 and may also be connected to FACH
- PCCH is connected to PCH
- CCCH is connected to RACH and FACH
- DCCH and DTCH can be connected to either RACH and FACH, to CPCH 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.
- CTCH is connected to FACH.
- DCCH and DTCH can be mapped to the USCH (TDD only).
- SHCCH is connected to RACH and USCH/FACH and DSCH.

5 Services provided to upper layers

This section describes the different services provided by the MAC to higher layers. For a detailed description of the following functions see [2].

5.1 Description of Services provided to upper layers

- Data transfer: This service provides unacknowledged transfer of MAC SDUs between peer MAC entities without data segmentation.
- Reallocation of radio resources and MAC parameters: This service performs on request of RRC execution of radio resource reallocation and change of MAC parameters.
- Reporting of measurements: Local measurements are reported to RRC.

6 Functions

6.1 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
- Priority handling between data flows of several users on the DSCH and FACH
- 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
- Dynamic Transport Channel type switching
- Ciphering for transparent RLC
- Access Service Class selection for RACH transmission

6.2 Relation between MAC Functions / Transport Channels and UE

6.2.1 Relation between MAC Functions and Transport Channels

Table 6.2.1.1: UTRAN MAC functions corresponding to the transport channel

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	CPCH					X	X		X
	DCCH	DCH							X	
	DTCH	RACH					X	X		
	DTCH	CPCH					X	X		X
	DTCH	DCH							X	
	SHCCH	RACH					X	X		
	SHCCH	USCH						X		X
	DTCH	USCH	X					X		X
DCCH	USCH	X					X		X	
Downlink (Tx)	SCCH	SCH								
	BCCH	BCH				X				
	BCCH	FACH	X			X		X		
	PCCH	PCH	X			X				
	CCCH	FACH	X	X		X		X		
	CTCH	FACH	X			X		X		
	DCCH	FACH	X	X		X	X	X		
	DCCH	DSCH	X	X				X		
	DCCH	DCH	X		X				X	
	DTCH	FACH	X	X		X	X	X		X
	DTCH	DSCH	X	X				X		X
	DTCH	DCH	X		X				X	X
	SHCCH	FACH	X	X		X		X		
SHCCH	DSCH	X	X				X		X	

6.2.2 Relation of UE MAC functions corresponding to the Transport Channel MAC Functions and Transport Channels

Table 6.2.2.1: 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	X	X	X			
	DCCH	CPCH	X	X	X	X		X	
	DCCH	DCH	X	X			X		
	DTCH	RACH	X	X	X	X		X	
	DTCH	CPCH	X	X	X	X		X	
	DTCH	DCH	X	X			X	X	
	SHCCH	RACH				X			
	SHCCH	USCH	X	X		X		X	
	DCCH	USCH	X	X		X		X	
	DTCH	USCH	X	X		X		X	
	Downlink (Rx)	SCCH	SCH						
		BCCH	BCH						
BCCH		FACH				X			
PCCH		PCH							
CCCH		FACH				X			
CTCH		FACH				X			
DCCH		FACH			X	X			
DCCH		DSCH				X			
DCCH		DCH					X		
DTCH		FACH			X	X			
DTCH		DSCH				X			
DTCH		DCH					X		
SHCCH		FACH				X			
SHCCH	DSCH				X				

7 Services expected from physical layer

The physical layer offers information transfer services to MAC. For detailed description, see [3].

8 Elements for layer-to-layer communication

The MAC is connected to layer 1, RLC and RRC. The following sections describe the primitives between these layers.

8.1 Primitives between layers 1 and 2

The primitives are described in [3].

8.2 Primitives between MAC and RLC

8.2.1 Primitives

The primitives between MAC layer and RLC layer are shown in Table 8.2.1.1.

Table 8.2.1.1: Primitives between MAC layer and RLC layer

Generic Name	Type				Parameters
	Request	Indication	Response	Confirm	
MAC-DATA	X	X			Data, Number of transmitted RLC PDUs, BO, TD (NOTE 1)
MAC-STATUS		X	X		No_PDU, PDU_Size

NOTE 1: TDD only

MAC-DATA-Req/Ind

- MAC-DATA-Req primitive is used to request that an upper layer PDU be sent using the procedures for the information transfer service.
- MAC-DATA-Ind primitive indicates the arrival of upper layer PDUs received within one transmission time interval by means of the information transfer service.

MAC-STATUS-Ind/Resp

- MAC-STATUS-Ind primitive indicates to RLC the rate at which it may transfer data to MAC. Parameters are the number of PDUs that can be transferred in each transmission time interval and the PDU size.
- MAC-STATUS-Resp primitive enables RLC to acknowledge a MAC-STATUS-Ind. It is possible that RLC would use this primitive to indicate that it has nothing to send or that it is in a suspended state.

8.2.2 Parameters

- a) Data
It contains the RLC layer message (RLC-PDU) to be transmitted, or the RLC layer messages that have been received by the MAC sub-layer.
- b) Number of transmitted RLC PDUs (indication only)
Indicates the number of RLC PDUs transmitted within the transmission time interval, based on the TFI value.
- c) Buffer Occupancy (BO)
The parameter Buffer Occupancy (BO) indicates the amount of data that is currently queued for transmission (or retransmission) in RLC layer
- d) RX Timing Deviation (TD), TDD only
It contains the RX Timing Deviation as measured by the physical layer for the physical resources carrying the data of the Message Unit. This parameter is optional and only for Indication. It is needed for the transfer of the RX Timing Deviation measurement of RACH transmissions carrying CCCH data to RRC.
- e) Number of PDU (No_PDU)
Specifies the number of PDUs that the RLC is permitted to transfer to MAC within a transmission time interval.
- f) PDU Size (PDU_Size)
Specifies the size of PDU that can be transferred to MAC within a transmission time interval.

8.3 Primitives between MAC and RRC

8.3.1 Primitives

The primitives between MAC and RRC are shown in Table 8.3.1.1

Table 8.3.1.1: Primitives between MAC sub-layer and RRC

Generic Name	Type				Parameters
	Request	Indication	Response	Confirm	
CMAC-CONFIG	X				UE information elements RAB information elements TrCH information elements RACH transmission control elements Ciphering elements CPCH transmission control elements
CMAC-MEASUREMENT	X	X			Measurement information elements (for Request), Measurement result (for Indication)
CMAC-STATUS		X			Status info.

CMAC-CONFIG-Req

- CMAC-CONFIG-Req is used to request for setup, release and configuration of a logical channel, e.g. RNTI allocation, switching the connection between logical channels and transport channels, TFCS update or scheduling priority of logical channel.

CMAC-MEASUREMENT-Req/Ind

- CMAC-MEASUREMENT-Req is used by RRC to request MAC to perform measurements, e.g. traffic volume measurements.
- CMAC-MEASUREMENT-Ind is used to notify RRC of the measurement result.

CMAC-STATUS-Ind

- CMAC-STATUS-Ind primitive notifies RRC of status information.

8.3.2 Parameters

See 25.331 for a detailed description of the UE, RB and TrCH information elements.

- UE information elements
 - S-RNTI
 - SRNC identity
 - C-RNTI
 - Activation time
- RB information elements
 - RB multiplexing info (Transport channel identity, Logical channel identity, MAC logical channel priority)
- TrCH information elements
 - Transport Format Combination Set
- Measurement information elements
 - Mode (periodic, event-triggered or both)
 - THU
 - THL (Optional)
 - Measurement quantity identifiers
 - Report Interval
- Measurement result
 - Mode
 - Reporting Quantities
 - Event Type (overflow or underflow)

- f) Status info
Maximum number of preamble ramping cycles reached.
- g) RACH transmission control elements
Persistence value P
Maximum number of preamble ramping cycles M_{\max}
Others (ffs., e.g. minimum and maximum number of time units between two preamble ramping cycles)
- h) Cipherring elements
Cipherring mode
Cipherring key
Cipherring sequence number
- i) CPCH transmission control elements
CPCH persistency value
CPCH channel data rate (implicit in the UL channelisation code)
NFmax (Max packet length in frames)

9 Elements for peer-to-peer communication

The interaction between the MAC layer and other layers are described in terms of primitives where the primitives represent the logical exchange of information and control between the MAC layer and other layers. The primitives shall not specify or constrain implementations.

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 9.1.1.1. 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.

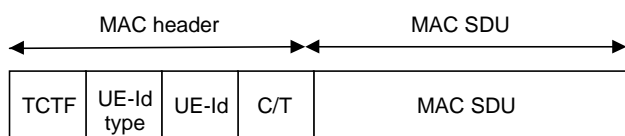


Figure 9.1.1.1: MAC data PDU

9.2 Formats and parameters

NOTE: MAC header field encodings as specified in this section with designation "Reserved" are forbidden to be used by a sender in this version of the protocol.

9.2.1 MAC Data PDU: Parameters of the MAC header

The following fields are defined for the MAC header:

- Target Channel Type Field
The TCTF field is a flag that provides identification of the logical channel class on FACH and RACH transport channels, i.e. whether it carries BCCH, CCCH, CTCH, SHCCH or dedicated logical channel information. The

size and coding of TCTF for FDD and TDD are shown in tables 9.2.1.1, 9.2.1.2 and 9.2.1.3. Note that the size of the TCTF field of FACH for FDD is either 2 or 8 bits depending of the value of the 2 most significant bits.

Table 9.2.1.1: Coding of the Target Channel Type Field on FACH for TDD

TCTF	Designation
000	BCCH
001	CCCH
010	CTCH
011	DCCH or DTCH over FACH
100	SHCCH
101-111	Reserved (PDUs with this coding will be discarded by this version of the protocol)

Table 9.2.1.2: Coding of the Target Channel Type Field on FACH for FDD

TCTF	Designation
00	BCCH
01000000	CCCH
01000001-01111111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
10000000	CTCH
10000001-10111111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
11	DCCH or DTCH over FACH

Table 9.2.1.3: Coding of the Target Channel Type Field on USCH or DSCH (TDD only)

TCTF	Designation
0	SHCCH
1	DCCH or DTCH over USCH or DSCH

Table 9.2.1.4: Coding of the Target Channel Type Field on RACH

TCTF	Designation
00	CCCH
01	DCCH or DTCH over RACH
10	TDD: SHCCH FDD: Reserved (PDUs with this coding will be discarded by this version of the protocol)
11	Reserved (PDUs with this coding will be discarded by this version of the protocol)

- 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. The size of the C/T field is fixed to 4 bits for both common transport channels and dedicated transport channels. Table 9.2.1.5 shows the 4-bit C/T field.

Table 9.2.1.5: Structure of the C/T field

C/T field	Designation
0000	Logical channel 1
0001	Logical channel 2
...	...
1110	Logical channel 15
1111	Reserved (PDUs with this coding will be discarded by this version of the protocol)

- UE-Id

The UE-Id field provides an identifier of the UE on common transport channels. The following types of UE-Id used on MAC are defined:

- UTRAN Radio Network Temporary Identity (U-RNTI) may be used in the MAC header of DCCH when mapped onto common transport channels.
- Cell Radio Network Temporary Identity (C-RNTI) is used on DTCH, DSCH in FDD mode, and may be used on DCCH, when mapped onto common transport channels.
- The UE id to be used by MAC is configured through the MAC control SAP. The lengths of the UE-id field of the MAC header are given in Table 9.2.1.6.

Table 9.2.1.6: Lengths of UE Id field

UE Id type	Length of UE Id field
U-RNTI	32 bits
C-RNTI	16 bits

- UE-Id Type
The UE-Id Type field is needed to ensure correct decoding of the UE-Id field in MAC Headers.

Table 9.2.1.7: UE-Id Type field definition

UE-Id Type field 2 bits	UE-Id Type
00	U-RNTI
01	C-RNTI
10	Reserved (PDUs with this coding will be discarded by this version of the protocol)
11	Reserved (PDUs with this coding will be discarded by this version of the protocol)

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:
TCTF field, C/T field, UE-Id type field and UE-Id are included in the MAC header.
- d) DTCH or DCCH mapped to DSCH or USCH:
The TCTF field is included in the MAC header for TDD only. The UE-Id type and UE-Id are included in the MAC header for FDD only. The C/T field is included if multiplexing on MAC is applied.
- e) DTCH or DCCH mapped to DSCH or USCH where DTCH or DCCH are the only logical channels:
The UE-Id type and UE-Id are included in the MAC header for FDD only. The C/T field is included in the MAC header if multiplexing on MAC is applied.

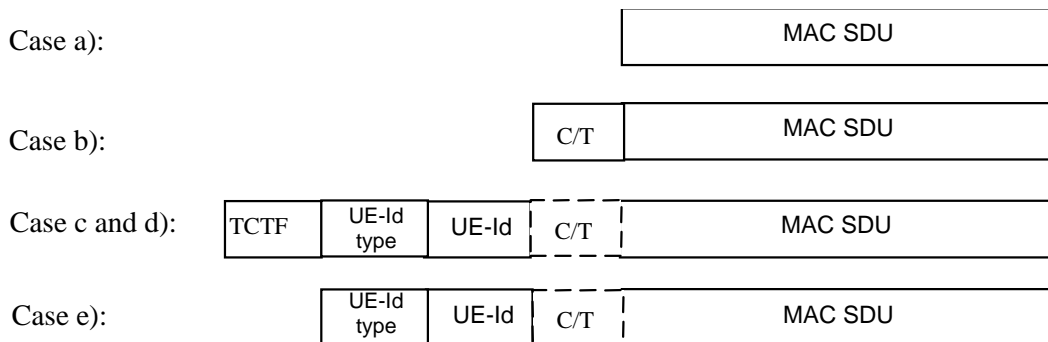


Figure 9.2.1.1.1: MAC Data PDU formats for DTCH and DCCH

9.2.1.2 MAC header for BCCH

- a) BCCH mapped to BCH:
No MAC header is required.
- b) BCCH mapped to FACH:
The TCTF field is included in MAC header.

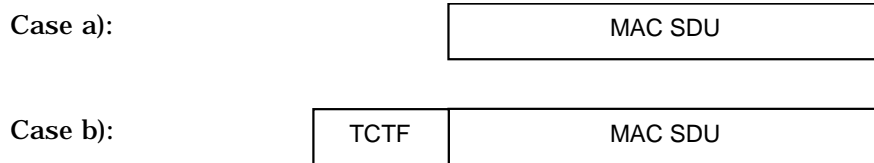


Figure 9.2.1.2.1: MAC Data PDU formats for BCCH

9.2.1.3 MAC header for PCCH

There is no MAC header for PCCH

9.2.1.4 MAC header for CCCH

- a) CCCH mapped to RACH/FACH:
TCTF field is included in MAC header.

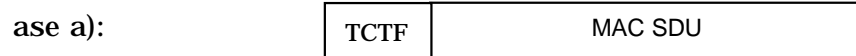


Figure 9.2.1.4.1: MAC Data PDU formats for CCCH

9.2.1.5 MAC Header for CTCH

The TCTF field is included as MAC header for CTCH as shown in Figure 9.2.1.5.1

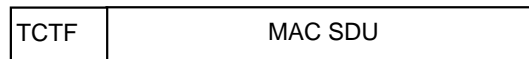


Figure 9.2.1.5.1: MAC Data PDU format for CTCH

9.2.1.6 MAC Header for SHCCH

The MAC header for SHCCH is as shown in Figure 9.2.1.6.1

- a) SHCCH mapped to RACH and USCH/FACH and DSCH:
TCTF has to be included.
- b) SHCCH mapped to RACH and USCH/FACH and DSCH, where SHCCH is the only channel:

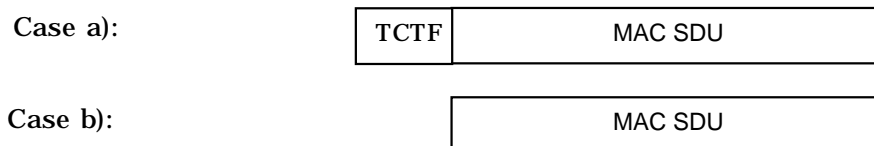


Figure 9.2.1.6.1: MAC Data PDU format for SHCCH

10 Handling of unknown, unforeseen and erroneous protocol data

Basic requirements for handling unknown, unforeseen and erroneous protocol data are described in [8].

11 Elementary procedures

11.1 Traffic volume measurement for dynamic radio access bearer control

Dynamic radio access bearer control is performed in RRC, based on the traffic volume measurement reported by MAC. Traffic volume information is gathered and measured in MAC layer and the result is reported from MAC layer to RRC layer.

Traffic volume monitoring procedure in MAC is shown in Figure 11.1.1. MAC receives RLC PDUs together with information of RLC transmission buffer. Every TTI, MAC compares the amount of data corresponding to a Transport Channel with the thresholds set by RRC. If the value is out of range, MAC indicates the measurement reports on traffic volume status to RRC. Thereby, RRC can be informed the traffic volume status of each transport channel, and therefore can take proper action for new radio access bearer configuration accordingly.

RRC requests MAC measurement report with the primitive CMAC-Measure-REQ including following parameters.

Measurement information elements

- Mode
Indicates whether the report should be periodical or by event-triggered
- THU
Upper threshold value for every transport channel, applicable when mode is event-triggered
- THL (Optional)
Lower threshold value for every transport channel, applicable when mode is event-triggered
- Measurement quantity identifiers
Indicates what should be reported to RRC layer
For each RAB, Buffer amount (mandatory), Variance (optional), or Average (optional)
- Report Interval
Indicates the report interval, applicable when report mode is periodic

MAC receives RLC PDUs with the primitive MAC-Data-REQ including following parameters:

- Data (RLC PDU)
- Buffer Occupancy (BO)
The parameter Buffer Occupancy (BO) indicates the amount of data that is currently queued for transmission (or retransmission)

MAC receives measurement information elements with the primitive CMAC-Measure-REQ that includes parameters such as Mode, report interval, and THL and THU for each transport channel. Whenever MAC receives RLC PDUs from different RLC entities, it is notified by RLC amount of data queued in RLC transmission buffer. If the mode is event-triggered, MAC compares the amount of data to be transmitted on a transport channel with threshold values passed by RRC, THL and THU. In case that the measured value is out of range, MAC reports the status of result of comparison and status of each RAB to RRC. On the other hand, if the mode is periodic, MAC reports measurement result to RRC periodically. Measurement result can contain average and variance as well as amount of data for each RAB as follows:

Measurement result

- Mode
Periodic, or event-triggered
- Reporting Quantity
For each RAB, Buffer Occupancy (mandatory), Variance (optional), and Average (optional)
- Event type
Indicates overflow or underflow for each transport channel, applicable when mode is event-triggered

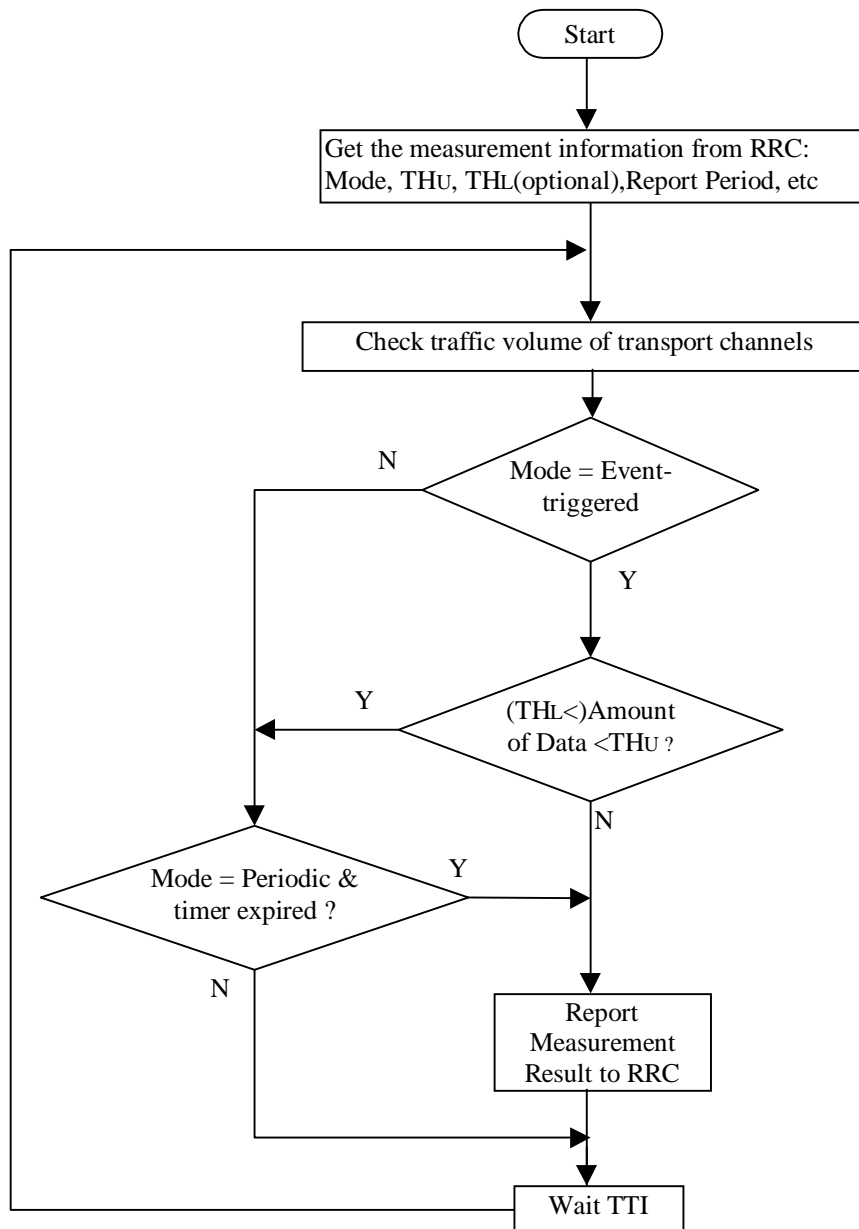


Figure 11.1.1: Traffic volume measurement/report procedure in MAC

11.2 Control of RACH transmissions

The MAC sublayer is in charge of controlling the timing of RACH transmissions on transmission time interval level (i.e. on 10 ms-radio frame level; the timing on access slot level is controlled by L1). Note that retransmissions in case of erroneously received RACH message part are under control of higher layers, i.e. RLC, or RRC for CCCH (and SHCCH for TDD).

11.2.1 Control of RACH transmissions for FDD mode

The RACH transmissions are controlled by the UE MAC sublayer as outlined in Figure 11.2.1.1. Note that the figure shall illustrate the operation of the transmission control procedure as specified below. It shall not impose restrictions on implementation. MAC controls the timing of each initial preamble ramping cycle as well as successive preamble ramping cycles in case that none or a negative acknowledgement is received on AICH.

MAC receives the following RACH transmission control parameters from RRC with the CMAC-Config-REQ primitive:

- persistence value P (transmission probability),

- maximum number of preamble ramping cycles M_{\max} ,
- range of backoff interval for timer T_{BO1} , given in terms of numbers of transmission time intervals N_{BO1max} and N_{BO1min} , applicable when negative acknowledgement on AICH is received,
- Access Service Class (ASC) parameters.

Based on the persistence value P , the UE decides whether to start the L1 PRACH transmission procedure (see TS 25.214) in the present transmission time interval or not. If transmission is allowed, the PRACH transmission procedure (starting with a preamble power ramping cycle) is initiated by sending of a PHY-Data-REQ primitive. MAC then waits for status indication from L1 via PHY-Status-IND primitive. If transmission is not allowed, a new persistency check is performed in the next transmission time interval. The persistency check is repeated until transmission is permitted.

When the preamble has been acknowledged on AICH, respective L1 status information is indicated to MAC with PHY-Status-IND primitive, and the PRACH transmission procedure shall be completed with transmission of the PRACH message part according to L1 specifications.

When PHY indicates that no acknowledgement on AICH is received while the maximum number of preamble retransmissions is reached (defined by parameter `Preamble_Retrans_Max` on L1), a new persistency test is performed in the next transmission time interval. The timer T_2 ensures that two successive persistency tests are separated by at least one transmission time interval.

In case that a negative acknowledgement has been received on AICH a backoff timer T_{BO1} is started. After expiry of the timer, persistence check is performed again. Backoff timer T_{BO1} is set to an integer number N_{BO1} of transmission time intervals, randomly drawn within an interval $0 \leq N_{\text{BO1min}} \leq N_{\text{BO1}} \leq N_{\text{BO1max}}$ (with uniform distribution). N_{BO1min} and N_{BO1max} may be set equal when a fixed delay is desired, and even to zero when no delay other than the one due to persistency is desired.

Before a persistency test is performed it shall be checked whether any new RACH transmission control parameters have been received from RRC with C-MAC-Config-REQ primitive. The latest set of RACH transmission control parameters shall be applied.

NOTE 1: An alternative proposal for determining the backoff additional to persistency drawing and testing in the case of a negative acknowledgement on AICH (L1 status "NACK") has been proposed which is for further study.

NOTE 2: There is a need to study the use of multiple persistence values when there are multiple Access Service Classes and multiple RACH partitions.

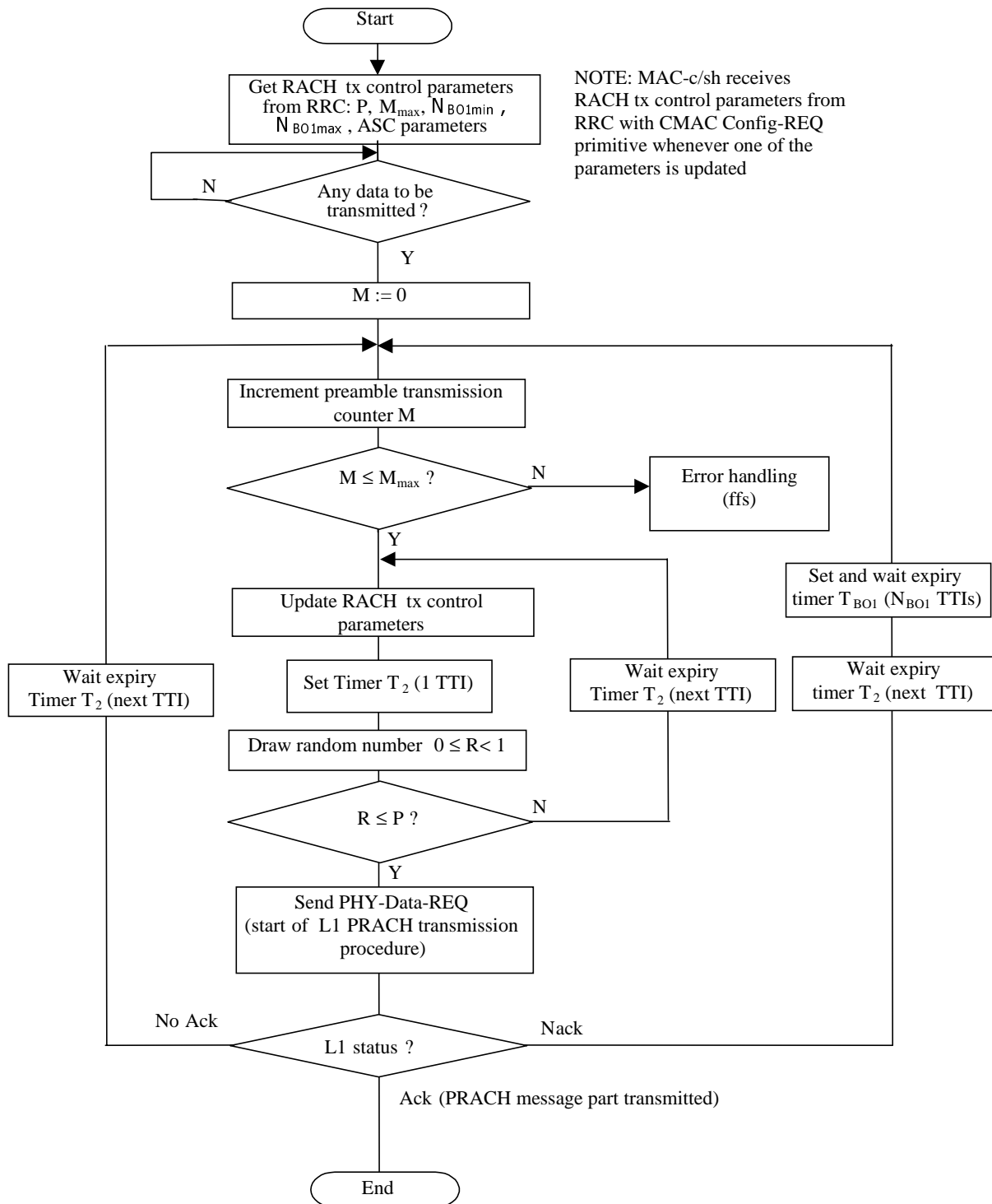


Figure 11.2.1.1: RACH transmission control procedure (UE side, informative)

11.2.2 Control of RACH transmissions for TDD

The RACH transmissions are performed by the UE as shown in Figure 11.2.2.1. Note that the figure shall illustrate the operation of the transmission control procedure as specified below. It shall not impose restrictions on implementation.

MAC receives the following RACH transmission control parameters from RRC with the CMAC-Config-REQ primitive:

- persistence value P (transmission probability),
- Access Service Class parameters

Based on the persistence value P, the UE decides whether to send the message on the RACH. If transmission is allowed, the PRACH transmission procedure is initiated by sending a PHY-Data-REQ primitive. If transmission is not allowed, a new persistency check is performed in the next transmission time interval. The persistency check is repeated until transmission is permitted.

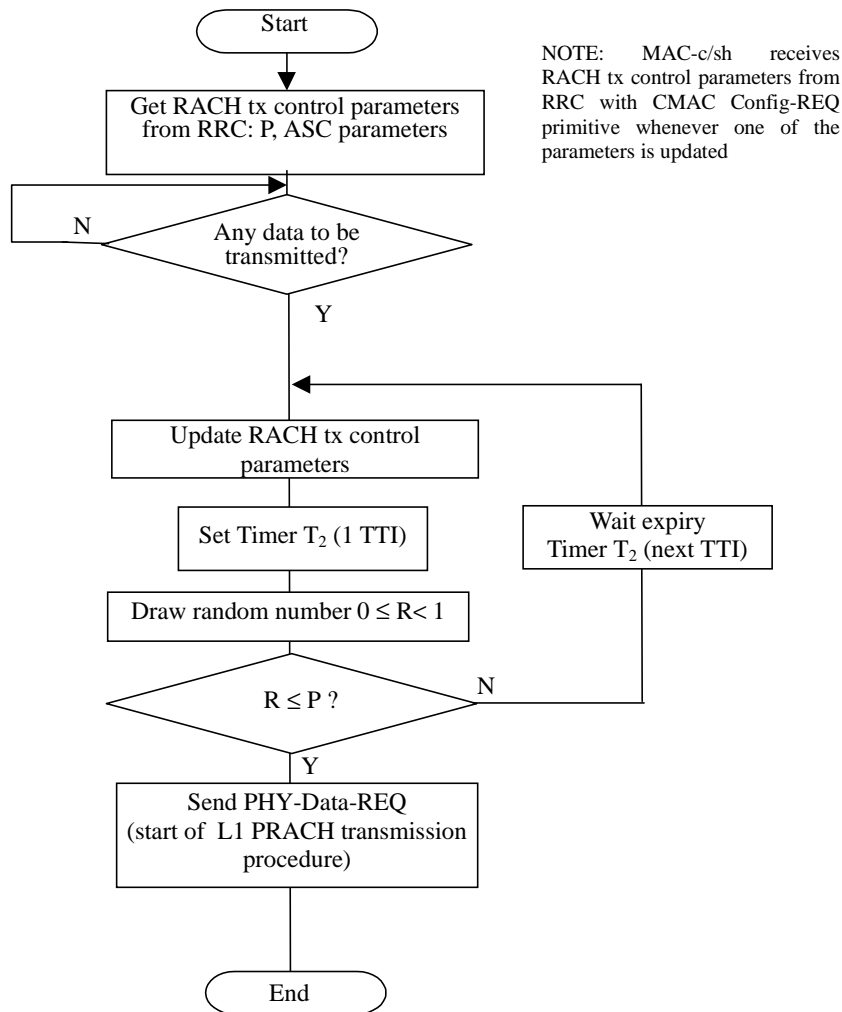


Figure 11.2.2.1: RACH transmission control procedure for TDD (UE side, informative)

Annex A (informative): Change history

Change history					
TSG-RAN#	Version	CR	Tdoc RAN	New Version	Subject/Comment
RAN_04	-	-	RP-99312	3.0.0	Approved at TSG-RAN #4 and placed under Change Control
RAN_05	3.0.0	001	RP-99463	3.1.0	Modified MAC handling of PCH and FACH
RAN_05	3.0.0	002	RP-99463	3.1.0	Modifications of MAC primitives
RAN_05	3.0.0	003	RP-99463	3.1.0	RACH/FACH MAC header – Channel type identification
RAN_05	3.0.0	004	RP-99463	3.1.0	Support for USCH/DSCH signalling in TDD
RAN_05	3.0.0	006	RP-99463	3.1.0	Clarification on RACH partitioning and prioritization via access service class (ASC) and relation to back-off algorithm
RAN_05	3.0.0	010	RP-99463	3.1.0	Modifications on UE-Id formats
RAN_05	3.0.0	011	RP-99463	3.1.0	CPCH primitives
RAN_05	3.0.0	012	RP-99463	3.1.0	Timing advance for TDD
RAN_05	3.0.0	013	RP-99463	3.1.0	Traffic volume measurement report procedure
RAN_05	3.0.0	014	RP-99463	3.1.0	Mapping of BCCH logical channel onto FACH transport channel
RAN_05	3.0.0	015	RP-99463	3.1.0	MAC PDU formats for DCCH/DTCH on DSCH and for PCCH
RAN_05	3.0.0	016	RP-99463	3.1.0	Informative parts that shall not specify or constrain implementations
RAN_05	3.0.0	017	RP-99463	3.1.0	Modification of RACH transmission control procedure
RAN_05	3.0.0	018	RP-99463	3.1.0	Removal of MAC function for system information and paging scheduling
RAN_05	3.0.0	019	RP-99463	3.1.0	RACH transmission control procedure on MAC for TDD mod
RAN_05		020	RP-99463		MAC procedure for control of CPCH transmission postponed
RAN_05	3.0.0	021	RP-99463	3.1.0	Removal of Annex A and B of TS 25.321
RAN_06	3.1.0	022	RP-99638	3.2.0	Modified MAC header field sizes
RAN_06	3.1.0	023	RP-99638	3.2.0	MAC: Multiple shared channels (DSCH/USCH)
RAN_06	3.1.0	024	RP-99638	3.2.0	Parameters for Status Primitive
RAN_06	3.1.0	025	RP-99638	3.2.0	Support of shared channel operation in TDD
RAN_06	3.1.0	028	RP-99638	3.2.0	Modification of Cell Broadcast Service (CBS)
RAN_06	3.1.0	030	RP-99637	3.2.0	Editorial changes
RAN_06	3.1.0	031	RP-99638	3.2.0	Simultaneous mapping of logical channels on

History

Document history		
V3.2.0	January 2000	Publication