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Radio Interface Protocol Architecture for 3G Mobile System

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Telecommunication Technology Committee (TTC)
Association of Radio Industries and Businesses (ARIB)

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3.1 Definitions

3.2 Abbreviations

L1	Layer 1 (physical layer)
LAC	Link Access Control
MAC	Medium Access Control
MS	Mobile Station
RRC	Radio Resource Control
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network

4 Assumed UMTS Architecture

5 Radio Interface Protocol Architecture

5.1 Overall Protocol Structure

The radio interface is layered into three protocol layers:

- the physical layer (L1),
- the data link layer (L2),
- network layer (L3).

Layer 2 is split into two sublayers, Link Access Control (LAC) and Medium Access Control (MAC).

Layer 3 and LAC are divided into Control (C-) and User (U-) planes.

In the C-plane, Layer 3 is partitioned into sublayers where the lowest sublayer, denoted as Radio Resource Control (RRC), interfaces with layer 2. The higher layer signalling in Layer 3 are Mobility Management (MM) and Call Control (CC). Note that the protocol architecture is similar to the current ITU-R protocol architecture, ITU-R M.1035.

Figure 1 shows the radio interface protocol architecture. Each block in Figure 1 represents an instance of the respective protocol. Service Access Points (SAP) for peer-to-peer communication are marked with circles at the interface between sublayers. The SAP to the physical layer provides the transport channels. In the C-plane, the interface between RRC and higher L3 sublayers (CC, MM) is defined by the General Control (GC), Notification (Nt) and Dedicated Control (DC) SAPs.

The SAPs to the MAC sublayer provide the logical channels (cf.). The SAP to the physical layer provides the transport channels (cf.).

Also shown in the figure are connections between RRC and MAC as well as RRC and L1 providing inter-layer services. It is for further study whether or not separate service access points need to be defined for these services (it may be merged with other SAP(s), or regarded as services provided through Layer Management).

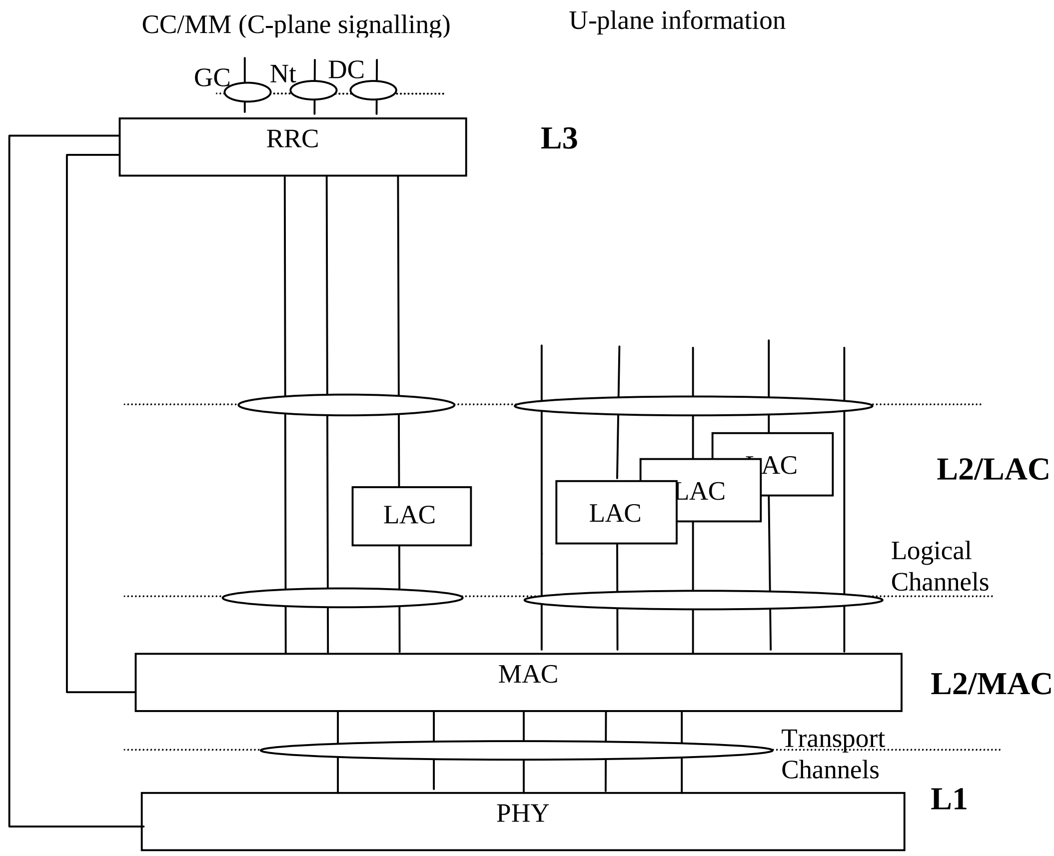


Figure 1. Radio Interface protocol architecture (Service Access Points marked by circles)

5.2 Layer 1 Services and Functions

5.2.1 L1 Services

Transport channels are the services offered by Layer 1 to the MAC layer. A transport channel is defined by how and with what characteristics data are transferred over the air interface.

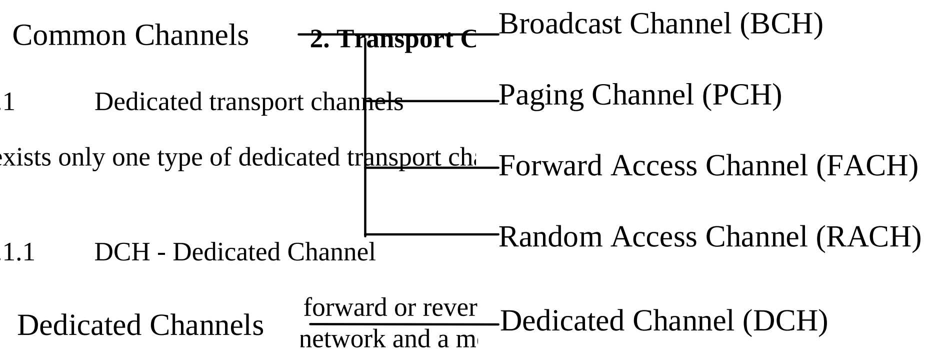
5.2.1.1 Transport Channels

Transport channels are the services offered by Layer 1 to the MAC layer. A transport channel is defined by how and with what characteristics data are transferred over the air interface.

A general classification of transport channels is into two groups:

- Common Channels (where there is a need for in-band identification of the MSs when particular MSs are addressed) and
- Dedicated Channels (where the MSs are identified by the physical channel, i.e. code and frequency)

The transport channel configuration is shown in Figure 2.



2. Transport C

5.2.1.1.1 Dedicated transport channels

There exists only one type of dedicated transport ch

5.2.1.1.1.1 DCH - Dedicated Channel

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The Dedicated Channel (DCH) is characterized by:

- possibility to use beam-forming,
- possibility to change rate fast (each 10ms),
- fast power control and
- inherent addressing of MSs.

5.2.1.1.2 Common transport channels

5.2.1.1.2.1 BCH - Broadcast Channel

The Broadcast Channel (BCH) is a forward link transport channel that is used to broadcast system- and cell-specific information, such as SFN.

The Broadcast Channel (BCH) is characterized by:

- existence in forward link only,
- low fixed bit rate and
- requirement to be broadcast in the entire coverage area of the cell.

5.2.1.1.2.2 PCH - Paging Channel

The Paging Channel (PCH) is a forward link transport channel that is used to carry control information to a mobile station when the system does not know the location cell of the mobile station.

The Paging Channel (PCH) is characterized by:

- existence in forward link only,
- possibility for sleep mode procedures and
- requirement to be broadcast in the entire coverage area of the cell.

5.2.1.1.2.3 FACH - Forward Access Channel

The Forward Access Channel (FACH) is a forward link transport channel that is used to carry control information to a mobile station when the system knows the location cell of the mobile station. The FACH may also carry short user packets.

The Forward Access Channel(s) (FACH) is characterized by**:**

- existence in forward link only,

- possibility to use beam-forming,
- possibility to use slow power control,
- lack of fast power control and
- requirement for in-band identification of MSs.

5.2.1.1.2.4 RACH - Random Access Channel

The Random Access Channel (RACH) is a reverse link transport channel that is used to carry control information from mobile station. The RACH may also carry short user packets.

The Random Access Channel(s) (RACH) is characterized by:

- existence in reverse link only,
- collision risk,
- open loop power control,
- limited data field, and
- requirement for in-band identification of the MSs

5.2.1.2 Model of Physical Layer of the MS

5.2.2 L1 Functions

The physical layer offers data transport services to higher layers. The access to these services is through the use of transport channels via the MAC sub-layer.
The physical layer is expected to perform the following functions in order to provide the data transport service.

- FEC encoding/decoding of transport channels
- Macrodiversity distribution/combining and soft handover execution
- Multiplexing/demultiplexing of transport channels and of coded composite transport channels
- Mapping of coded composite transport channels on physical channels
- Modulation and spreading/demodulation and despreading of physical channels
- Frequency and time (chip, bit, slot, frame) synchronization
- Closed-loop power control
- Power weighting and combining of physical channels
- RF processing
- Error detection
- Rate matching(data multiplexed on DCH)
- Radio characteristics measurements including FER, SIR, Interference Power, etc.

In order to access the transport channels from MAC some definitions are needed to characterize the transport channels:

Definition: Transport *Block* is defined as the basic unit passed down to physical layer from MAC, for physical layer processing. A Transport Block equals to a MAC-PDU. The physical layer adds CRC for each Transport Block.

Definition: Transport *Block Set* is defined as a set of Transport Blocks which is passed to physical layer from MAC at the same time instance using the same transport channel.

Definition: Transport *Block Size* is defined as the size (number of bits) of a Transport Block.

Definition: *Transport Block Set Size* is defined as the number of Transport Blocks in a Transport Block Sets.

Definition: *Transmission Time Interval* is defined as the inter-arrival time of Transport Block Sets, i.e. the time it should take to transmit a Transport Block Set. It is always a multiple of 10ms (the length of one Radio Frame).

Definition: *Transport Format* is defined as a format offered by physical layer to MAC for the delivery of a Transport Block Set during a Transmission Time Interval on a Transport Channel. The Transport Format constitutes of two parts – one *dynamic* part and one *semi-static* part.
Attributes of the dynamic part are:

- Transport Block Size
- Transport Block Set Size

Attributes of the semi-static part are:

- Transmission Time Interval
- Type of channel coding
- Transport channel specific rate matching [1]

Definition: A *Transport Format Set* is defined as the set of Transport Formats associated to a Transport Channel. The semi-static parts of all Transport Formats are the same within a Transport Format Set. Effectively the two attributes of the dynamic part form the instantaneous bit rate on the Transport Channel. Variable bit rate on a Transport Channel maybe achieved by varying one or both of the dynamic attributes between each Transmission Time Interval.

Definition: *Transport Format Combination* is defined as the combination of currently valid Transport Formats on all Transport Channels of an MS, i.e. containing one Transport Format from each Transport Channel.

Definition: *Transport Format Combination Set* is defined as a set of Transport Format Combinations to be used by an MS.

The Transport Format Combination Set is what is given to MAC for control. However, the assignment of the Transport Format Combination Set is done by L3. When mapping data onto physical layer, MAC chooses between the different Transport Format Combinations given in the Transport Format Combination Set. Since it is only the dynamic part that differ between the Transport Format Combinations, it is in fact only the dynamic part that MAC can control.
Note that a Transport Format Combination Set does not necessarily contain all possible Transport Format Combinations that can be formed by Transport Format Sets of the corresponding Transport Channels. Only the allowed combinations are included. Thereby a maximum total bit rate of all transport channels of an MS can be set appropriately. That can be achieved by only allowing Transport Format Combinations for which the included Transport Formats (one for each Transport Channel) do not correspond to high bit rates simultaneously.The selection of Transport Format Combinations can be seen as a fast part of the radio resource control. The dedication of these fast parts of the radio resource control to MAC, close to physical layer, means that the flexible variable rate scheme provided by physical layer can be fully utilised. These parts of the radio resource control should be distinguished from the slower parts, which are handled by L3. Thereby the bit rate can be changed very fast, without any need for L3 signalling.

Definition: *Transport Format Indicator (TFI)* is a label for a specific Transport Format within a Transport Format Set. It is used in the inter-layer communication between MAC and physical layer each time a Transport Block Set is exchanged between the two layers on a transport channel.

Definition: *Transport Format Combination Indicator (TFCI)* is a representation of the current Transport Format Combination.

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[1] The rate matching mentioned refers to the Eb/N0 matching of Transport Channels.

There is a one-to-one correspondence between a certain value of the TFCI and a certain Transport Format Combination. The TFCI is used in order to inform the receiving side of the currently valid Transport Format Combination, and hence how to decode, de-multiplex and deliver the received data on the appropriate Transport Channels.
MAC indicates the TFI to Physical layer at each delivery of Transport Block Sets on each transport channel. Physical layer builds the TFCI from the TFIs of all parallel transport channels of the UE. Physical layer processes the Transport Blocks appropriately and appends the TFCI to the physical control signalling (accompanied by TPC and pilot). Through the detection of the TFCI the receiving side is able to identify the Transport Format Combination. For limited Transport Format Combination Sets the TFCI signalling may be omitted, instead relying on blind detection. Nevertheless, from the assigned Transport Format Combinations, the receiving side has all information it needs in order to decode the information and transfer it to MAC on the appropriate Transport Channels.
The multiplexing and exact rate matching patterns follow predefined rules and may therefore be derived (given the Transport Format Combinations) by transmitter and receiver without signalling over the radio interface.

5.3 Layer 2 Services and Functions

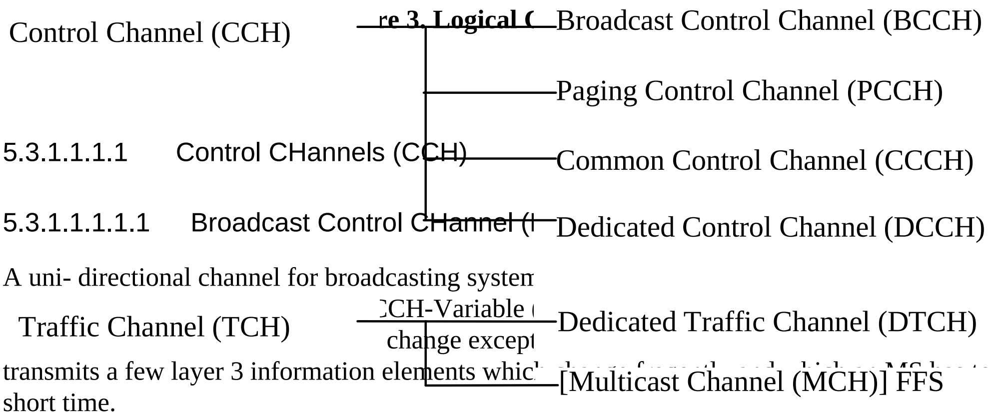
5.3.1 MAC Sub-layer

5.3.1.1 MAC Services to Upper Layers

- **Data transfer**
  This service provides peer-to-peer transportation of LAC-PDUs. The access to this service is provided through the Service Access Point(SAP). There are two SAPs, one is for user data, and the other is for control data.
  This service does not provide any data segmentation. Therefore, Segmentation/Assembly functions should be achieved by upper layer.
- **Reallocation of radio resources and MAC parameters**
  This service performs on request of RRC execution of radio resource reallocation and change of MAC parameters, i.e. reconfiguration of MAC functions such as change of identity of MS, change of transport format (combination) sets, change of transport channel type.
- **Reporting of measurements**
  Traffic volume is reported to RRC.

5.3.1.1.1 Logical Channels

A logical channel is defined by what type of information is transferred. The logical channel structure of ARIB’s W-CDMA system basically follows ITU recommendation ITU-R M.1035. The logical channel types shown in Figure 3 are defined for W-CDMA.



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5.3.1.1.1.1 Control CHannels (CCH)

5.3.1.1.1.1.1 Broadcast Control CHannel (I

A uni- directional channel for broadcasting systen

CH-Variable

change except

transmits a few layer 3 information elements whic

short time.

5.3.1.1.1.1.2 Paging Control CHannel (PCCH)

A uni- directional channel that transfers paging information. This channel is used when the network does not know the location cell of the MS.

5.3.1.1.1.1.3 Common Control CHannel (CCCH)

Bi-directional channel for transmitting control information from network to MS.

5.3.1.1.1.1.4 Dedicated Control CHannel (DCCH)

A point-to-point bi-directional channel that transmits dedicated control information between the MS and the network.

5.3.1.1.1.2 Traffic CHannels (TCH)

5.3.1.1.1.2.1 Dedicated Traffic CHannel (DTCH)

A point-to-point bi-directional channel that transmits user information in both circuit and packet switched mode.

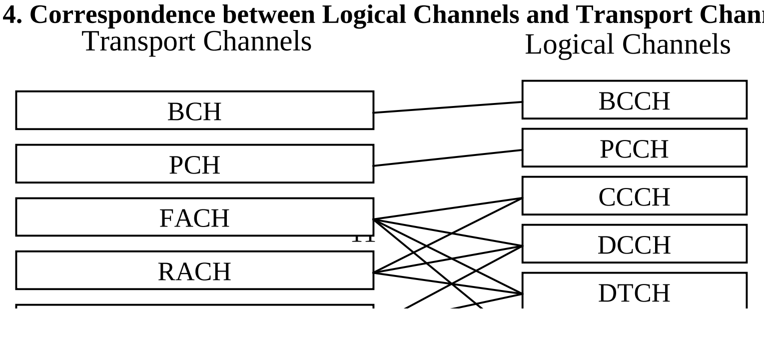
5.3.1.1.1.2.2 Multicast CHannel (MCH) (FFS)

[FFS: A point-to-multipoint uni-directional channel that transmits dedicated user information for a group of specified MSs. (Corresponding control information in reverse link would be transmitted by CCCH.) Handover is applied to this channel.]

5.3.1.1.2 Mapping of Logical Channels onto Transport Channels

Error! Reference source not found. shows the mapping of logical channels to transport channels.

Figure 4. Correspondence between Logical Channels and Transport Channels



5.3.1.2 MAC Functions

5.3.1.2.1 General functions

- Traffic Monitor Function:
  The Traffic monitor function measures traffic amount of the logical channels for controlling the Switching Function by RRC.

- Switching Function:
  The Switching Function houses less time-critical functions that need coordination among different transport channel formats such as the execution of the switch between FACH/RACH andDCH, and vice versa. The Switching Function also communicates with RRC in order to appropriately deal with DCCH and DTCH.

- Multiplexing Function:
  The Multiplexing Function multiplexes/de-multiplexes data between the logical channel (CCCH , DCCH and DTCH) and the transport channels (FACH and RACH) in consideration of the appropriate prioritization. The transport channels are de-multiplexed by using LID (Logical Channel Identifier).
  i) On condition that LID of a MAC-PDU from FACH/RACH indicates “10000” - “11111”, the MAC PDU is transmitted to DTCH.
  ii) On condition that LID of a MAC PDU from FACH/RACH indicates “00100”, the MAC PDU is transmitted to DCCH.
  iii) On condition that LID of a MAC PDU from FACH/RACH or DCH indicates “00010”, the MAC PDU is transmitted to CCCH.

Furthermore, the Multiplexing function can multiplex data from several instances of the logical channels DTCH and BCCH onto their respective transport channels, i.e. DCH and BCH. For DTCH, demultiplexing from one DCH to several DTCHs is also handled
iv) Using LID of a MAC PDU from DCH, the MAC PDU is transmitted to the appropriate DTCH.
v) Using LID of a MAC PDU from BCCH, the MAC PDU is transmitted to the appropriate BCH.

- Retransmission Function:
  The Retransmission Function realizes a stop-and-wait ARQ scheme over FACH and RACH. This function is omitted if RRC sets the maximum number of retransmission (N_{RA}) to 0.

Editors note: Retransmission Function in MAC sublayer is FFS.

- MAC Header Handling Function
  This function is applied to RACH, FACH, BCH and DCH. This function constructs MAC header and adds the header to LAC-PDU to assemble MAC-PDU. And this function deletes MAC header from MAC-PDU to disassemble LAC-PDU and informs the retransmission function and the multiplexing function of contents included in the header.
  FACH-ACK is returned from BSS to UE as a MAC header when BSS received correctly MAC-PDU through RACH. This function constructs FACH-ACK based on information from the retransmission function that includes RNTI of RACH received correctly.

- Access Control Function:

The Access Control Function makes a schedule for messages into the transport channels and synchronizes with physical layer in building MAC-PDU sets that are transmitted as radio frames by physical layer. If RACH is used for transport channel, slotted ALOHA is adopted as multi-access scheme in Access Control Function.

5.3.1.2.2 Common channel related functions

5.3.1.2.2.1 Control of BCH

5.3.1.2.2.1.1 Overview

The Scheduling Functions are used for control of BCH.

5.3.1.2.2.1.2 Scheduling of BCH

Related MAC function entity: ACFE - Access Control function
Two kinds of BCH are mapped to the perch channel. One of them is for BCCH-C transmission, the other is for BCCH-V transmission. Access Control Function in ACFE makes a schedule for two kinds of BCH messages into the BCH in consideration of SFN (System Frame Number).

5.3.1.2.2.2 Control of PCH

5.3.1.2.2.2.1 Overview

The Scheduling Function is used for control of PCH.
[Editor's note: Retransmission function is not applied to PCH in MAC. Retransmission of paging message is achieved by layer 3 protocol.]

5.3.1.2.2.2.2 Scheduling of PCH

Related MAC function entity: ACFE - Access Control function
Access Control Function in ACFE makes a schedule for PCCH messages of 288 paging groups based on the group identifier indicated by the upper layer.

5.3.1.2.2.3 Control of FACH

5.3.1.2.2.3.1 Overview

The Forward Access Channel (FACH) is used in the forward link to carry control information and user packets to a mobile station. The functions associated with the FACH are

- Scheduling
- Multiplexing/demultiplexing
- Inband identification of UEs
- Selection of appropriate transport format (see 5.3.1.2.2.7 Selection of appropriate transport format)

Procedures associated with the FACH are

- Random access procedure

5.3.1.2.2.3.2 Scheduling of ACK, control and user data transmission

Related MAC function entity: ACFE - Access Control Function
This function provides mechanisms for efficient transfer of FACH-ACK, control and user data by means of appropriate scheduling of the messages. This includes the usage of priority information. The priority is arranged in the following order:

1. FACH-ACK
2. Control
3. User

When the information content is the same, the information that gave transmission request earliest shall be transmitted with the highest priority (FIFO). FACH-ACK shall always be transmitted in the first timeslot set. Further scheduling rules are:

- When the information amount of the higher layer information type transmitted by FACH-ACK radio unit is worth of plural number of FACH radio units, transmission continuous in time is guaranteed. In no case, other higher layer information types can break in and be transmitted. The FACH-ACK is transmitted at the highest priority as aforesaid, but can never break a long FACH radio unit.
- The UE shall be able to simultaneously receive all FACH on one Common Physical Channel. When multiple number of physical channels for common control for transmitting FACH are transmitted from the BSS, the UE shall receive only one Common Physical Channel.

- The FACH-ACK can mount maximal 7RNTIs.
- The FACH-ACK shall be transmitted with the highest priority even if its transmission request timing comes later than other FACHs.
- When there are some cases that ACK was not returned for the RACH that detected CRC OK at the time immediately before the transmission timing of radio frame for FACH, the ACK-FACH shall be transmitted by the first FACH from the ones that have the oldest timing among those that received CRC OK. However, those that already passed $T_{BS\text{-}ACK}$ msec or more after detecting CRC OK shall be removed from the list of transmitting ACK mode FACH.

5.3.1.2.2.3.3 Multiplexing/demultiplexing of higher layer PDUs to/from a FACH

Related MAC function entity: ACFE-Multiplexing Function
MAC should support service multiplexing for common transport channels, since the physical layer does not support multiplexing of these channels. This includes multiplexing of data from the U-plane and from the C-plane. The data blocks are put together according to the scheduling of control and user data before being sent on the FACH.

5.3.1.2.2.3.4 Inband identification of UEs

Related MAC function entity: ACFE - Access Control Function
When a particular UE is addressed on FACH, there is a need for inband identification of the UE. This is because on the FACH there is no user separation by code or frequency like on dedicated channels. Since the MAC layer handles the access to, and multiplexing onto, the transport channels, the identification functionality is naturally also placed in MAC. The UE is identified by the RNTI. This RNTI is notified by RRC messages (see 6.1 UE Identification within UTRAN on Common Radio Channels).

5.3.1.2.2.4 Control of RACH

Editor's note: The random selection of spreading codes is related to the usage of signatures, and is therefore to be discussed in SWG2.

5.3.1.2.2.4.1 Overview

The Random Access Channel (RACH) is used in the reverse link to carry control information and user packets from a mobile station. The functions associated with the RACH are

- Scheduling
- Multiplexing/demultiplexing
- Inband identification of UEs
- Selection of appropriate transport format (see 5.3.1.2.2.7 Selection of appropriate transport format)

Procedures associated with the RACH are

- Random access procedure

5.3.1.2.2.4.2 Scheduling of control and user data transmission

Related MAC function entity: ACFE – Access Control Function
This function provides mechanisms for efficient transfer of control and user data by means of appropriate scheduling and repetition of the messages. The control data has higher priority than user data.
Random Access/Packet mode:
Initial Transmission:

- When the mobile station begins to transmit the first radio frame of random access messages, the transmission timing offset, the RACH spreading code and the signature shall be determined as follows:
  The transmission timing offset (frame and/or slot), the RACH spreading code and the signature of the first radio frame on a RACH are determined pseudo-randomly. Possible timing offsets, spreading codes and signatures are determined by a set broadcasted via BCCH. The MAC header generation is described in the section on the PDU format (8.2).

Succeeding Transmission:

- When the mobile station continues to transmit the succeeding (second or more) radio frames because the message length is longer than a radio frame, the transmission timing offset, the RACH spreading code and signature shall be determined as follows:
  The transmission timing offset (frame and/or slot) shall be determined pseudo-randomly. The RACH spreading code and the signature of the succeeding radio frame can be determined pseudo-randomly. The same RNTI shall be used as in the previous radio frame (for the radio frames belonging to the same CPS).

Retransmission:

- If the mobile station fails to receive an ACK within $T_{MS\text{-}ACK}$ msec it retransmits the radio frame after a pseudo-random delay. This implies automatically the use of the same RNTI for retransmission. The maximum number of allowed retransmissions shall be set to N_{RA}.
  Transmission timing offset, RACH spreading code and signature may be adapted in order to decrease collision probability.

5.3.1.2.2.4.3 Multiplexing/demultiplexing of higher layer PDUs to/from a RACH

Related MAC function entity: ACFE - Multiplexing Function

MAC should support service multiplexing for common transport channels, since the physical layer does not support multiplexing of these channels.

5.3.1.2.2.4.4 Inband Identification of UEs

Related MAC function entity: ACFE - Access Control Function
The unambiguous separation of different UEs using the contention based RACH channel is handled by MAC. When a particular UE is using the RACH, there is a need for inband identification of the UE. Since the MAC layer handles the access to, and multiplexing onto, the transport channels, the identification functionality is naturally also placed in MAC. When several random access packets are received at the BS the physical layer detects them and delivers them to the MAC. The MAC distinguishes the valid random access packets by different RNTIs. Thus the UE is identified by the RNTI.

5.3.1.2.2.5 Control of DCH

5.3.1.2.2.5.1 Overview

Functions associated with dedicated channels are:

- Selection of appropriate transport format (described in other functions)
- Priority handling between data flows of one UE
- Traffic volume monitoring (described in other functions)

5.3.1.2.2.5.2 Priority handling between data flows of one UE

Related MAC function entity: ACFE – Access Control Function
When selecting between the allowed transport formats for a given user, priorities of data flows to be mapped onto the corresponding Transport Channels can be taken into account. Priorities are e.g. given by attributes of radio bearer services and transmitter buffer status. Priority handling is achieved by selecting a “high bit rate” transport format for high-priority data, at the same time letting lower priority data be mapped with a “low bit rate” (could be zero bit rate) transport format.
In this case the load control facilities within RRC control only the aggregate capacity of the user. With this approach, fast re-scheduling with the resolution of MAC-PDUs is possible. Scheduling on MAC can be the primary approach also when multiplexing is done on the physical layer.
If different NRT (non-real-time) radio bearers require different channel coding (or service-specific rate matching), i.e. scheduling is done among multiple dedicated channels, there may be no simple rule for performing the scheduling function between these services. This matter may require further study. Also, MAC cannot re-schedule traffic that has been scheduled by a higher layer.

5.3.1.2.2.6 Other functions

This section contains functions that are not directly associated with any specific type of transport channels or which should be seen as operations, where MAC shares the responsibility for the function with RRC. Where RRC participation is assumed, a more detailed description of the MAC operation is given below.
Other functions currently consist of:

- Selection of appropriate transport format (applicable to DCH, RACH, FACH)
- Traffic volume measurement (reporting to RRC)
- Channel type switching execution (decision by RRC)
- Priority handling between different users by means of scheduling (Resource division between users controlled by RRC, thus may later be moved to RRC)

5.3.1.2.2.7 Selection of appropriate transport format

Related MAC function entity: ACFE– Access Control Function
MAC chooses the appropriate transport format within the transport format combination set according to the required transmission rate (see 5.3.1.2.2.8 Traffic volume measurement).
For RACH and FACH, the present specification defines two data rates, which can be regarded as transport formats.

5.3.1.2.2.8 Traffic volume measurement

Related MAC function entity: MAFE – Traffic Monitoring Function
Measurement of traffic volume and reporting to RRC.
The information on traffic volume and transmitter buffer status can influence admission control and the allocation of transport formats by RRC. The same information is sent by MAC to RRC that uses the information as a basis for the decision if channel type switching needs to be performed (5.3.1.2.2.9 Channel type switching execution). Indication of needed switching from common to dedicated or from dedicated to common channels is based on the traffic volume measurements. This information is passed to RRC.

5.3.1.2.2.9 Channel type switching execution

Related MAC function entity: MAFE – Switching Function
Execution of the switching between common (RACH and FACH) and dedicated transport channels. It is currently assumed, that based on the traffic volume measurements of MAC (5.4.2) RRC makes the decision on channel type switching and signals the transition to both peer MAC entities, which then execute the switch.
This function means connecting the logical DTCH to either RACH and FACH, or a dedicated transport channel.

5.3.1.2.2.10 Priority handling between data flows of different users by means of scheduling

Related MAC function entity: MAFE – Traffic Monitoring Function
[Editor's note: For dedicated channels, this part may be later moved to RRC.]
In order to utilize the spectrum resources efficiently for bursty traffic (packet), a dynamic scheduling function may be applied. The control of radio resources between users is an RRC function. MAC, being the entry point for user data within BSS, has the function to perform the needed resource negotiation with RRC. This is closely connected to traffic volume monitoring and is thus performed by MAFE.
In the downlink the scheduling function can be realised by coordinating the requests fortransport format combination sets for different users appropriately, taking the maximum allowed interference level and radio access bearer priorities (or corresponding) of different users into account in RRC. In the uplink the same functionality can be achieved, but then requiring messages across the air interface for fast resource requests and allocations of transport format combination sets.

5.3.1.2.2.11 Ciphering

FFS

5.3.1.3 Open Issues

The main open issues are:

- whether there is a retransmission Function in MAC sublayer or not
- whether priority handling between data flows of different users by means of scheduling is in RRC or MAC
- how ciphering is handled in MAC

5.3.2 LAC Services and Functions

5.3.2.1 LAC Services provided to the upper layer

The LAC sub-layer should provide the following services to the upper layer.

- **LAC connection establishment/release**

  This Service performs establishment/release LAC connec tions.

- **Acknowledged delivery mode**

In this mode, LAC provides peer-to-peer delivery of LAC-SDUs utilising error correction by LAC level re-transmission mechanism. If the LAC is configured to provide a reliable link, the user of the transmitting LAC layer is notified if LAC fails in LAC-SDU transmission. The acknowledged delivery mode has the following characteristics:

1) Error-free delivery:

LAC sub-layer should deliver only those SDUs to the receiving Layer 3 entity that are free of transmission errors.

2) Unique delivery:

LAC sub-layer should deliver each SDU to the receiving Layer 3 entity only once. .

3) In-sequence delivery (if so configured in setup, also out of sequence delivery possible, but it is FFS):

LAC sub-layer should provide support for in-order delivery of SDUs, i.e., LAC sub-layer should deliver SDUs to the receiving Layer 3 entity in the same order as the transmitting Layer 3 entity submits them to LAC sub-layer.

- **Unacknowledged delivery mode**

In this mode, layer2 provides peer-to-peer delivery of LAC SDUs without re-transmission mechanism. The unacknowledged delivery mode has the following characteristics:

1) Error-free delivery:

LAC sub-layer should deliver only those SDUs to the receiving Layer 3 entity that are free of transmission errors.

2) Unique delivery:

LAC sub-layer should deliver each SDU to the receiving Layer 3 entity only once

3) Immediate delivery:

LAC sub-layer should deliver a SDU to the Layer 3 receiving entity as soon as it arrives at the receiver

4) Enhanced probability of delivery: (Necessity is FFS.)

When requested by the transmitting Layer 3 entity, LAC should be able to invoke special transmission techniques to increase the probability of successful delivery of a SDU. These techniques may include: repeated transmissions.

(Note: This service may be performed by layer 3.)

- **Transparent delivery mode**

In transparent mode, the LAC layerl provides only predefined type of segmentation and reassembly mechanism (without adding any LAC overhead).

- **QoS Setting**
  The retransmission protocol shall be configurable by layer 3 to provide different levels of QoS. This can be controlled e.g. by adjusting the maximum number of retransmissions according to delay requirements

- **Notification of unrecoverable errors**
  LAC notifies the upper layer of errors which cannot be resolved by LAC itself by normal exception handling procedures

  The following potential service is FFS:

- **Multicast delivery of layer 3 messages**
  In this mode, the LAC sub-layerprovides multicast delivery of layer 3 messages without re-transmission mechanism.

5.3.2.2 LAC Functions

The LAC sub-layer performs the following functions in order to deliver the LAC layer services listed in section 5.3.2.1 LAC Services provided to the upper layer.

- **Connection Control**
  This function performs establishment, release, and maintenanceof a LAC connection.

- **LAC-SDU Segmentation and Reassembly**
  This function provides segmentation/ reassembly of a LAC SDU from/to LAC PDUs.

- **Sequence Integrity Delivery**
  This function preserves the order of LAC SDUs that were submitted for transfer by this layer using the acknowledged data transfer services.

- **Transfer of User-Data**
  This function is used for the conveyance of user data between users of the LAC. LAC supports assured, unassured and transparent data transfer.

- **Error Correction by Selective Retransmission**
  Through a sequencing mechanism, the receiving LAC entity can detect missing LAC PDUs. This function corrects sequence errors through selective retransmission.

- **Protocol Error Detection and Recovery**
  This function detects and recovers from errors in the operation of the protocol.

- **Duplicate Detection**
  This functions detects duplicated received LAC PDUs and ensures that the resultant LAC SDU is delivered only once to the upper layer.

- **QoS Adaptation**
  The retransmission protocol shall be configurable to provide different levels of QoS. This can be controlled e.g. by adjusting the maximum number retransmissions according to delay requirements.

- **Concatenation of LAC SDUs in LAC PDUs and padding:**

This function is used to fit as many segments into fixed size LAC PDUs. The concatenation function minimizes the padding.

- **Sequence number check (Unacknowledged delivery mode):**
  This function guarantees the integrity of reassembled PDUs and provides mechanism for the detection of corrupted LAC SDU through checking sequence number in LAC PDUs when they are reassembled into one LAC SDU. A corrupted LAC SDU will be discarded.

- **Flow Control:**

This function allows a LAC receiver to control the rate at which the peer LAC transmitter entity may send information.

- **Quick Repeat (C-plane only)**
  This function provide mechanisms to transmit PDUs corresponding to Unacknowledged Priority Mode several time
  (Editor's note: Whether this function is performed by layer 3 or by LAC sub-layer is FFS.)

5.3.2.3 LAC Open Issues

LAC services:

- Whether Multicast delivery of layer 3 messages is included or not.

LAC functions:

- Whether Quick Repeat is performed by layer 3 or by the LAC sub-layer is FFS.

5.3.3 Data Flows through Layer 2

Data flows through layer 2 are characterized by the applied data transfer modes on RLC (acknowledged, unacknowledged and transparent transmission) in combination with the data transfer type on MAC, i.e. whether or not a MAC header is required.

The resulting different data flow cases are illustrated in FiguresFigure 5 -Figure 8. Acknowledged and unacknowledged LAC transmission is collectively referred to as *non-transparent LAC*.
The case where no MAC header is required is referred to as *transparent MAC transmission*, whereas the case where a MAC header is needed is called *non-transparent MAC transmission*.

Figure 5 and Figure 6 illustrate the data flows for transparent LAC with transparent and non-transparent MAC transmission, respectively.

Figure 7 and Figure 8 illustrate the data flows for non-transparent LAC with transparent and non-transparent MAC transmission, respectively.
Each mapping between a logical channel and a transport channel as defined in **Error! Reference source not found.** in combination with the respective LAC transmission modes imply a certain data flow which is specified below.

5.3.3.1 Data flow for BCCH mapped to BCH

Regarding the mapping of RRC PDUs into LAC PDUs, two alternatives exist:

(i) All RRC PDUs transmitted on BCCH have a fixed length and fit into one (or a fixed number) of LAC PDUs (and, equivalently, MAC PDUs, as defined by the transport format). For this type of segmentation *no* LAC header is needed, i.e. the transparent data transfer mode of LAC is applied.

(ii) The RRC PDUs do not fit into the size of a fixed number of LAC PDUs. In this case, the unacknowledged LAC transfer mode must be applied, since segmentation/reassembly requires a LAC header for segmentation sequence control.

A MAC header is needed only if multiple BCCH logical channels are mapped onto a BCH.
If the transparent LAC transfer mode is applied (above option (i)), depending on whether the MAC header is needed or not, either the data flow in Figure 5 or Figure 6 is applicable. If the unacknowledged LAC transfer mode is applied (above option (ii)), depending on whether the MAC header is needed or not, either the data flow in Figure 7 or Figure 8 is applicable.

5.3.3.2 Data flow for PCCH mapped to PCH

Since transparent mode LAC and transparent mode MAC is used, Figure 5 is applicable for PCCH.

5.3.3.3 Data flow for CCCH mapped to FACH/RACH

For CCCH, unacknowledged[2] transmission mode for LAC is employed. A MAC header is mandatory. It is used for logical channel identification (CCCH, DCCH and DTCH). The data flow shown in Figure 8 is applicable.

5.3.3.4 Data flow for DCCH mapped to FACH/RACH

For DCCH, both unacknowledged and acknowledged transmission mode for LAC is employed. A MAC header is mandatory for FACH/RACH. The data flow shown in Figure 8 is applicable.

5.3.3.5 Data flow for DTCH (non-transparent LAC) mapped to FACH/RACH

Mapping to FACH/RACH implies a DTCH with acknowledged (possibly also unacknowledged) transmission on LAC. A MAC header is mandatory for FACH/RACH transmission. The data flow shown in Figure 8 is applicable.

5.3.3.6 Data flow for DTCH (transparent LAC) mapped to DCH

A continuous DTCH data stream is segmented into transport blocks on LAC and mapped on a DCH transport channel on MAC. The transport block size is naturally implied by the data rate. Both LAC and MAC sub-layers are transparent (i.e. no protocol control information is added) when no multiplexing of DTCH on MAC is applied. The data flow shown in Figure 5 is applicable. If multiplexing on MAC is performed, a MAC header is needed, and Figure 6 applies.

5.3.3.7 Data flow for DTCH (non-transparent LAC) mapped to DCH

In this case acknowledged or unacknowledged transmission on LAC is applied. A MAC header is needed only if multiple DTCH logical channels are multiplexed in MAC before mapping to a DCH, i.e. either the data flow in Figure 7 or Figure 8 is applicable.

5.3.3.8 Data flow for DCCH mapped to DCH

In this case non-transparent transmission mode on LAC is applied. A MAC header is needed only if DCCH and DTCH logical channels are multiplexed in MAC before mapping to a DCH, i.e. either the data flow in Figure 7 or Figure 8 is applicable

[2] The following is FFS: RRC will not utilise LAC at all when there is no UE identity allocated/no RRC connection established. Hence, during initial access when establishing an RRC Connection, RRC will send the “RRC Connection Request” message directly to MAC.

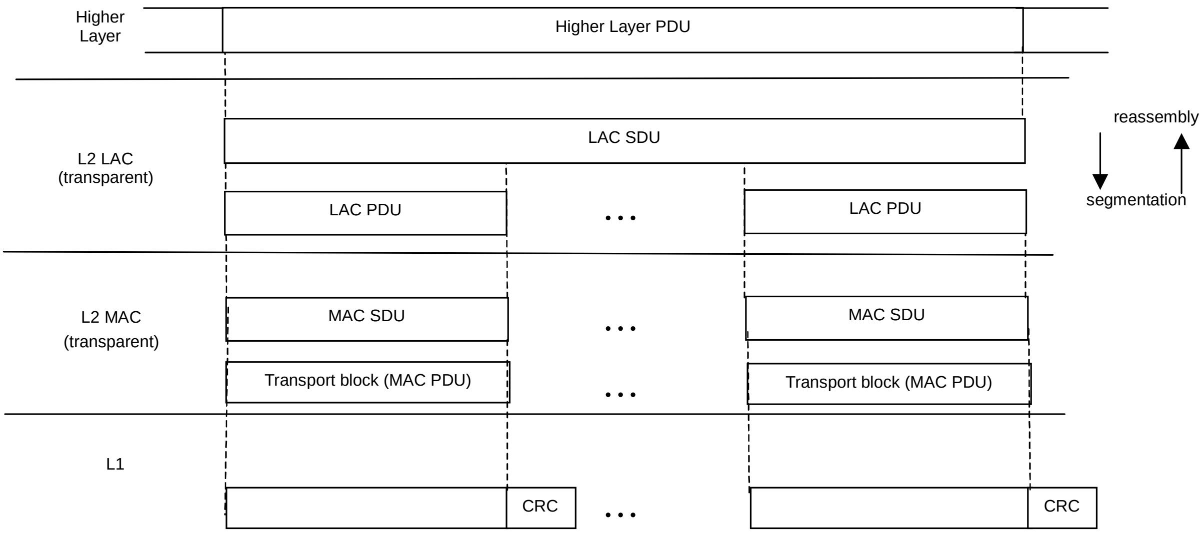


Figure 5. Data flow for transparent LAC and MAC

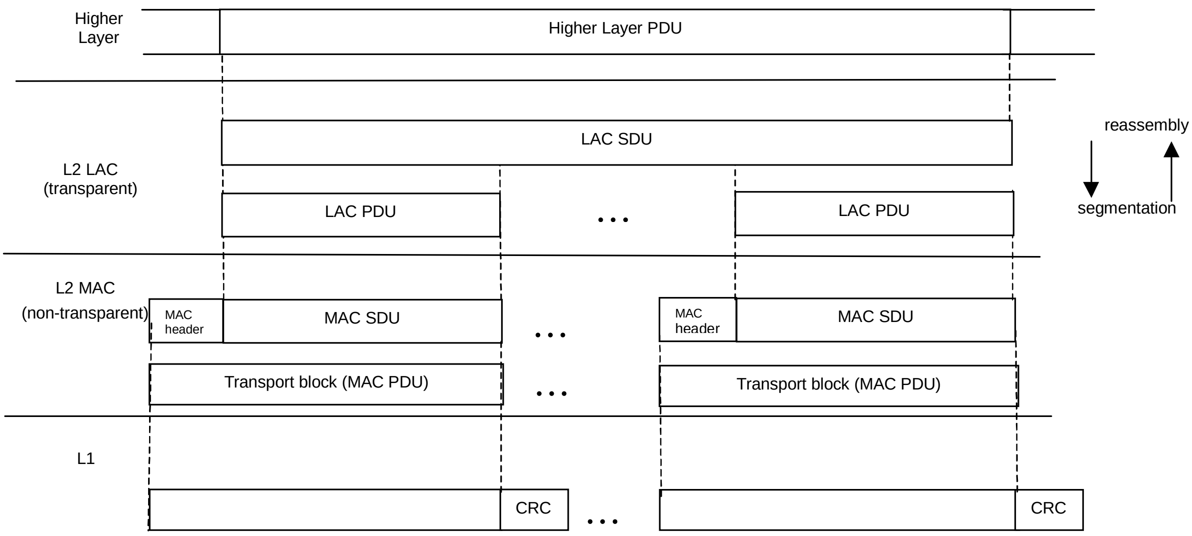


Figure 6. Data flow for transparent LAC and non-transparent MAC

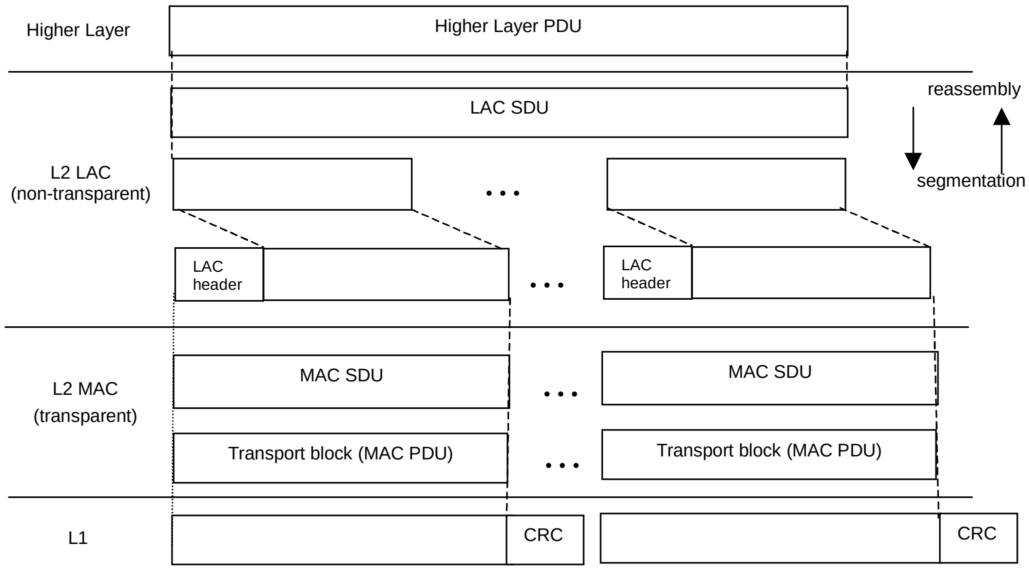


Figure 7. Data flow for non-transparent LAC and transparent MAC,

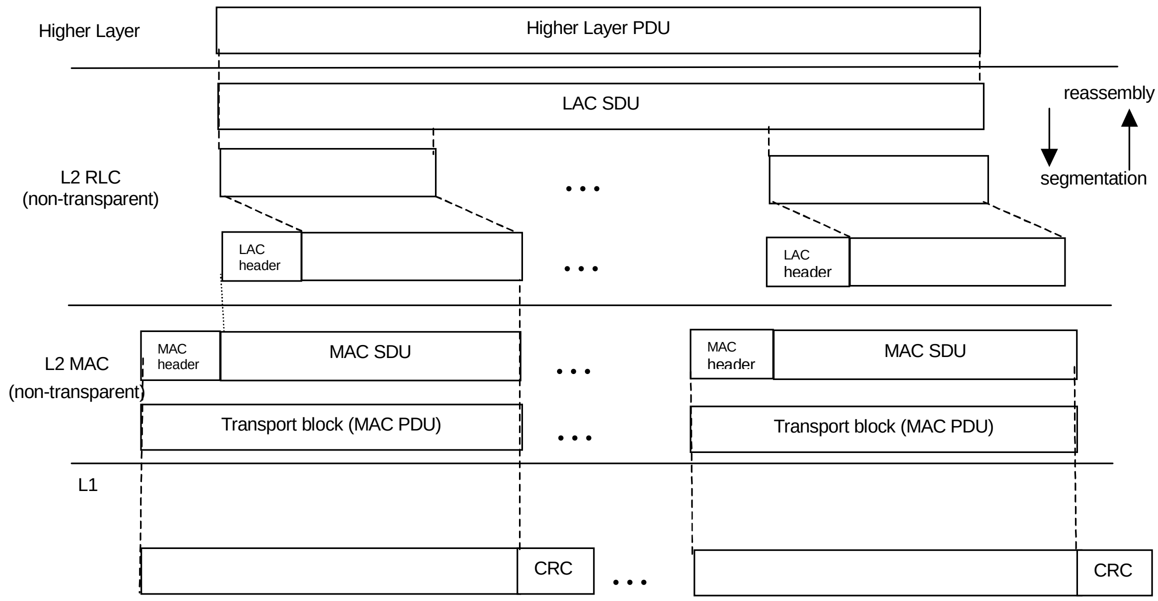


Figure 8. Data flow for non-transparent LAC and MAC

5.4 Layer 3 - RRC Services and Functions

5.4.1 RRC Services

5.4.1.1 General Control

The GC SAP provides an information broadcast service. This service broadcasts information to all UEs in a certain geographical area. The basic requirements from such service are:

- It should be possible to broadcast non-access stratum (Core Network originated) information in a certain geographical area.
- The information is transferred on an unacknowledged mode link. Unacknowledged mode means that the delivery of the broadcast information can not be guaranteed (typically no retransmission scheme is used). It seems reasonable to use an unacknowledged mode link since the information is broadcasted to a lot of UEs and since broadcast information often is repeated periodically.
- It should be possible to do repeated transmissions of the broadcast information (how it is repeated is controlled by the core network).

The point where the UE received the broadcast information should be included, when the access stratum delivers broadcast information to the non-access stratum.

5.4.1.2 Notification

The Nt SAP provides **paging service** and **notification broadcast service**. The paging service sends information to a specific UE(s). The information is broadcasted in a certain geographical area but addressed to a specific UE(s). The basic requirements from such service are:

- It should be possible to broadcast paging information to a number of UEs in a certain geographical area.
- The information is transferred on an unacknowledged mode link. It is assumed that the protocol entities in core network handle any kind of retransmission of paging information.

The notification broadcast service broadcasts information to all UEs in a certain geographical. The basic requirements from this service are typically the same as for the information broadcast service of the GC SAP:

- It should be possible to broadcast notification information in a certain geographical area.
- The information is transferred on an unacknowledged mode link.

5.4.1.3 Dedicated Control

The DC SAP provides services for **establishment/release of a connection** and **transfer of messages** using this connection. It should also be possible to transfer a message during the establishment phase. The basic requirements from the establishment/release services are:

- It should be possible to establish connections (both point and group connections).
- It should be possible to transfer an initial message during the connection establishment phase. This message transfer has the same requirements as the information transfer service.
- It should be possible to release connections.

The information transfer service sends a message using the earlier established connection. The basic requirements from the information transfer services are:

- Acknowledged mode link for transfer of messages
  This acknowledged mode link guarantees that the upper layer (CC and MM) messages are transferred to the corresponding side. Acknowledged mode means that the delivery of the upper layer messages can be guaranteed (some kind of retransmission scheme is used).
- A connection between two DC SAPs using an acknowledged mode link is called *signalling connection*. This link should also guarantee that no messages are lost or duplicated during handover.
- Preserved message order
  The order of the transferred messages is preserved.
- Priority handling
  If SMS messages should be transported through the control plane it should be possible to give higher priority to signalling messages.

5.4.2 RRC Functions

The Radio Resource Control (RRC) layer handles the control plane signaling of Layer 3 between the UEs and UTRAN.

- **Broadcast of information provided by the non-access stratum (Core Network).** The RRC layer performs system information broadcasting from the network to all UEs. The system information is normally repeated on a regular basis. This function supports broadcast of higher layer (above RRC) information. Typically this information is not cell specific.
- **Broadcast of information related to the access stratum (UTRAN).** The RRC layer performs system information broadcasting from the network to all UEs This function supports broadcast of typically cell-specific information.
- **Establishment, maintenance and release of a RRC connection between the UE and UTRAN**. The establishment of an RRC connection is initiated by a request from higher layers at the UE side to establish the first Signalling Connection for the UE. The establishment of an RRC connection includes an optional cell re-selection, an admission control, and a layer 2 signalling link establishment. The release of an RRC connection can be initiated by a request from higher layers to release the last Signalling Connection for the UE or by the RRC layer itself in case of RRC connection failure. The RRC layer detects loss of RRC connection and releases resources assigned for the RRC connection in case of connection failure.
- **Establishment, reconfiguration and release of Radio Access Bearers**. The RRC layer can, on request from higher layers, perform the establishment, reconfiguration and release of radio access bearers in the user plane. A number of radio access bearers can be established to an UE at the same time. At establishment and reconfiguration, the RRC layer performs admission control and selects parameters describing the radio access bearer processing in layer 2 and layer 1, based on information from higher layers.
- **Assignment, release and reconfiguration of radio resources within the RRC connection**. The RRC layer handles the assignment of radio resources (e.g. codes) needed for the RRC connection including needs from both the control and user plane. The RRC layer may reconfigure radio resources during an established RRC connection. This function includes co-ordination of the radio resource allocation between multiple radio bearers related to the same RRC connection.
- **RRC connection mobility functions.** The RRC layer performs evaluation, decision and execution related to RRC connection mobility during an established RRC connection, such as handover, cell re-selection and cell/paging area update procedures, based on e.g. measurements done by the UE**.**
- **UE measurement reporting and control of the reporting**, The measurements performed by the UE are controlled by the RRC layer, in terms of what to measure, when to measure and how to report. The RRC layer also performs the reporting of the measurements from the UE to the network
- **Outer loop power control**. The RRC layer controls setting of the target of the closed loop power control.
- **Control of requested QoS**. This function shall ensure that the QoS requested for the radio access bearers can be met. This includes the allocation of a sufficient number of radio resources.
- **Control of ciphering.** The RRC layer provides procedures for setting of ciphering (on/off) between the UE and UTRAN.
- **Paging/notification.** The RRC layer can broadcast paging information from the network to selected UEs. Paging and notification can be requested by higher layers on the network side. The RRC layer can also initiate paging during an established RRC connection.
- **Routing of higher layer PDUs.** This function performs at the UE side routing of higher layer PDUs to the designated higher layer entity.

The following functions are FFS:

- **Arbitration of the radio resource allocation between the cells**. This function shall ensure optimal performance of the overall UTRAN capacity.

- **Initial cell selection and re-selection in idle mode**
- **Contention resolution**
- **Congestion control**

5.5 Interactions between MAC and RRC in the C Plane

5.6 Protocol Termination

5.6.1 Protocol Termination for DCH

In Figure 9 and Figure 10 below, the protocol termination for DCH is shown for the control and user planes, respectively. The part of physical layer terminating in the RNC for the DCH is the topmost macro-diversity combining and splitting function.

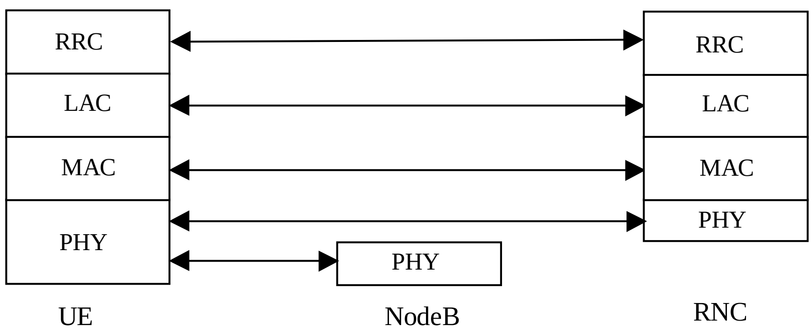


Figure 9. Protocol Termination for DCH, control plane

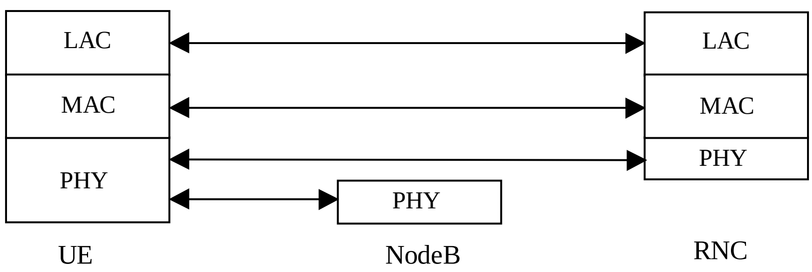


Figure 10. Protocol Termination for DCH, user plane

5.6.2 Protocol Termination for RACH/FACH

FFS

5.6.3 Protocol Termination for Transport Channel of Type BCH

System information on BCCH can include information which is available only in Node B; and need to be updated very frequently (each 10-100 ms), such as uplink interference in the cell. Also, for the system information originating from the RNC, we assume that the updating of system information is at least one magnitude less (minutes) than the repetition frequency on the BCCH (in the order of 1s). Note that the LAC sublayer is transparent for the BCH channel type and therefore not shown in Figure 11 below.

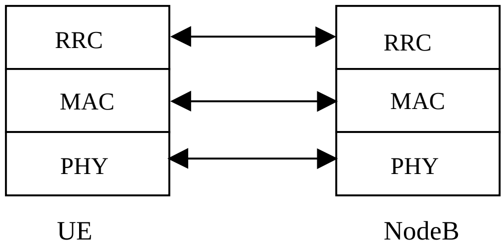


Figure 11. Protocol termination for BCH

5.6.4 Protocol Termination for Transport Channel of Type PCH

Since a Node B possibly can control several cells, the paging distribution signalling can be reduced if the Node B handles the distribution to each cell it controls. Thus results in less paging signalling on the Iub interface and thus lower processor load for distribution of paging. Note that the LAC sublayer is transparent for the PCH channel type and therefore not shown in Figure 12 below.

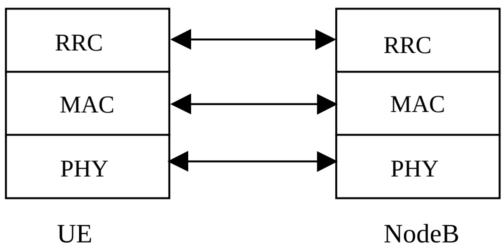


Figure 12. Protocol termination for PCH

6 User Identity and RRC Connection Mobility

6.1 UE Identification within UTRAN on Common Radio Channels

A Radio Network Temporary Identiry (RNTI) is used by the MAC protocol for identifying a mobile station on RACH/FACH/PCH when an RRC connection exists. Hence, it is not used by MAC as an identifier during initial random access because at this time no RRC connection exists.

An RNTI is allocated by the network (RRC) when an RRC connection is established and deallocated by RRC when the RRC connection is released. The RNTI is transferred from the network to a mobile station using layer 3 RRC signalling.

A specific RNTI is valid in several cells, thus decreasing the RNTI reallocation signalling for packet data mobile stations that are inactive and moves between cells.

6.2 Activity Levels on the Radio Interface

6.2.1 Definition of UTRAN Registration Area

UTRAN Registration Area (URA) is a page optimisation. URA allows that a signalling connection and radio access bearers are established, even if the radio channel handling is made on an area level on PCH/RACH. Fast access to the communication channel can be achieved, when packets need to be sent. Typically a URA activity level would be used for inactive packet data radio access bearers.

If the Radio Access bearers are disconnected, and the CN takes care of the mobility, it will take a longer time to re-establish the communication, since more signalling and processing is required to set-up a signalling connection and radio access bearers in UTRAN.

It is also efficient to allocate the common channel identity (RNTI) on URA or RNS basis. The signalling to re-allocate RNTI is thus reduced, compared to PID which needs to be re-allocated at each cell change.

7 History

Document history		
Date	**Version**	**Comment**
June 11, 1998	0.0.0	Initial document (empty).
June 18, 1998	0.0.1	Attachment 1; CC and MM is added.
June 22, 1998	0.0.2	UTRAN changed to RAN. Abbreviations used in version 0.0.1 added.
July 9, 1998	0.0.3	RAN changed back to UTRAN. Abbreviations updated accordingly.
July 22, 1998	0.0.4	Updated to reflect the approved changes proposed in GEL3-9-4
October 9, 1998	0.0.5	The following changes/additions have been made: - Changed title - Changed Table of Contents (added chapters for LAC-U and LAC-C, “Interactions between RRC and MAC in the C plane” and “Protocol Termination”) - Added contents to ch. 5.1 (Overall Protocol Structure) - Added contents to ch. 5.2.1 and 5.2.1.1 (Transport Channels) from ARIB, Vol. 3, Ver. 0.5_12, ch 3.2.1.2 - Added contents to ch. 5.2.2 (L1 Functions) from “MAC Sublayer Specification for 3G Mobile system”, Version 0.6, ch.5 (Services expected from physical layer) - Added contents to ch. 5.3.1.1 (MAC Services to Upper Layers) from “MAC Sublayer Specification for 3G Mobile system”, Version 0.6, ch. 4 (Services provided to upper layer) - Added contents to ch. 5.3.1.1.1 (Logical Channels) from “MAC Sublayer Specification for 3G Mobile system”, Version 0.6, ch. 3.1 (Logical channels) - Added contents to ch. 5.3.1.1.2 (Mapping between Logical

		Channels and Transport Channels) from "MAC Sublayer Specification for 3G Mobile system", Version 0.6, ch. 3.3 (Mapping of Logical channels onto Transport Channels) - Added contents to ch. 5.3.1.2 (MAC Functions) and ch. 5.3.2.3 (Open Issues) from "MAC Sublayer Specification for 3G Mobile system", Version 0.6, ch. 6 (MAC Functions) - Added contents to ch. 5.3.2.1 (LAC-U Services) and ch. 5.3.2.2 (LAC-U Functions) from "LAC sub-layer (User-Plane specification", ch. 2.1 and ch. 2.2. - Added contents to ch. 5.6 (Protocol Termination) based on GEL3-15-4 (Radio Interface Protocol Termination) as agreed according to TTC641-3-1, ch. 5.4 - Added definition of URA in ch. 6.2 based on TTC641-3-8 (Usage of RNTI and definition of URA) as agreed according to TTC641-5-1, ch. 5.3
November 13, 1998	0.0.6	The following changes/additions have been made: - Minor changes in ch. 5.3.1 (MAC Sub-layer) from "MAC Sublayer Specification for 3G Mobile system", Version 0.7, ch. 4 (Services provided to upper layer) and ch. 6 (MAC Functions) - Changes in ch. 5.3.2.1 (LAC-U Services) and ch. 5.3.2.2 (LAC-U Functions) based on "LAC sub-layer (User-Plane) specification", November 6, ch. 2.1 (Services offered by LAC sub-layer (User-Plane) to layer 3) and ch. 2.2 (Functions of LAC sub-layer (User-Plane) to deliver LAC Layer services) and RAP-36-3 (Segmentation/Reassembly in Transparent Mode) - Added contents to ch. 5.3.2.4 (LAC-C Services), ch. 5.3.2.5 (LAC-C Functions) and 5.3.2.6 (LAC-C Open Issues) based on "IMT-2000 Signaling Protocol for Radio Interface - Layer 2 ", Version 0.1.1, ch. 2.1 (Service offered by LAC sub-layer to layer 3) and ch. 2.2 (Functions of LAC sub-layer to deliver layer 2 services) - Added RRC services in ch. 5.4.1 and RRC functions in 5.4.2 based on SWG641-7-8 (Draft MS-UTRAN L3 RRC Signaling Protocol) approved according to SWG641-10-1), ch. 4 - Added definition of RNTI in ch. 6.1 based on SWG641-6-5 (Comments on Identities Handled by RRC) as agreed according to SWG641-7-1, ch. 5.5
November 27, 1998	0.0.7	The following changes/additions have been made (based on MS-UTRAN L3 RRC Signaling Protocol, ver. 0.0.6): - RRC function 'Arbitration of the radio resource allocation between the cells' now FFS - RRC function 'Routing of higher layer PDUs' added as FFS
January 8, 1999	0.0.8	The following changes/additions have been made: - Attachment 1 (CC/MM) removed as agreed according to SWG641-15-1 - Added ch. 5.3.3 (Data Flows through Layer 2) based on TTC-ARIB LAC Adhoc-45-8 ("Data Flows through Layer 2") contributions including comments from TTC-ARIB LAC ad hoc and ARIB SWG2 ST7 (PCCH uses transparent LAC and transparent MAC) - Change of 'MS' to 'UE' based on "UE-UTRAN L3 RRC Signaling Protocol", ver. 0.0.8 as agreed - RRC: Addition of RRC function 'Control of ciphering' in ch. 5.4.2 as FFS based on RRC adhoc 6-x - LAC-C: Removed 'Keep Alive' from ch. 5.3.2.5 (LAC-C Functions) based on "IMT-2000 Signaling Protocol for Radio

		Interface - Layer 2 ", Version 0.1.2, ch. 2.2 (Functions of LAC sub-layer to deliver layer 2 services) - MAC: Added multiplexing/de-multiplexing of BCCH and DTCH to/from BCH and DCH, respectively in ch. 5.3.1.2 (MAC Functions) from "Proposed Changes to MAC Sublayer Specification Version 0.7" as agreed by ARIB SWG2 ST7
January 14, 1999	0.0.9	The following changes/additions have been made: - MAC: Added function Ciphering (as FFS) and logical channel Multicast Channel (MCH) (as FFS) in ch. 5.3.1 (MAC Sub-layer) based on "MAC Sublayer Specification for 3G Mobile system", Ver 1.0 - LAC: merge of LAC-C and LAC-U based on "IMT-2000 Signaling Protocol for Radio Interface - Layer 2 ", Ver. 0.1.3 - RRC: 'Control of ciphering', 'Paging/notification', 'Routing of higher layer PDUs' no longer FFS, but included as RRC functions based on "MS-UTRAN L3 RRC Signaling Protocol", ver. 0.0.8, January 14
January 15, 1999	1.0.0	The following changes/additions have been made: - MAC: editorial changes regarding MCH (FFS) - LAC: changes based on "IMT-2000 Signaling Protocol for Radio Interface - Layer 2 ", Ver. 1.0.0; more detailed description of LAC services 'Acknowledged data transfer' and 'Unacknowledged data transfer', minor changes in LAC function 'Connection Control'

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