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Technical Report

3rd Generation Partnership Project;
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Radio interface protocol aspects
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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

With enhancements such as HSDPA and Enhanced Uplink, the 3GPP radio-access technology will remain highly competitive for several years to come. However, to ensure competitiveness in an even longer time frame, the long-term evolution of the 3GPP radio-access technology is under study. Important parts of such a long-term evolution include reduced latency, higher user data rates, optimised support for packet services, improved system capacity and coverage, and reduced cost for the operator, while also reducing system complexity. In order to achieve this, evolutions of the radio interface as well as the radio network architecture are considered in the study item "Evolved UTRA and UTRAN" [1]. This document covers the Radio Interface Protocol Aspects of the study item.

1 Scope

The purpose of this TR is to help TSG RAN WG2 to define and describe the radio interface protocol evolution under consideration for Evolved UTRA and UTRAN [1]. This activity involves the Radio Access Network work area of the 3GPP studies for evolution and has impacts both on the Mobile Equipment and Access Network of the 3GPP systems. This document is intended to gather the agreements rather than comparing different solutions.

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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] Contribution to RAN26, TD RP-040461: "Proposed Study Item on Evolved UTRA and UTRAN".

[2] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[3] 3GPP TR 25.913: "Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)".

[4] 3GPP TR 25.912; "Feasibility study for evolved Universal Terrestrial Radio Access (UTRA) and Universal Terrestrial Radio Access Network (UTRAN".

[5] 3GPP TR 25.814: "Physical Layer Aspects for Evolved UTRA".

[6] 3GPP TR 23.882, "3GPP System architecture evolution (SAE): Report on technical options and conclusions".

[7] 3GPP TS 25.133, "Requirements for support of radio resource management (FDD)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Carrier frequency: center frequency of the cell.

Frequency layer: set of cells with the same carrier frequency.

3.2 Symbols

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

<symbol> <Explanation>

3.3 Abbreviations

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

aGW	E-UTRAN Access Gateway
ARQ	Automatic Repeat Request
AS	Access Stratum
CP	Control Plane
DL	Downlink
eNB	E-UTRAN NodeB
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
HARQ	Hybrid Automatic Repeat Request
HO	Handover
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
MAC	Medium Access Control
NAS	Non-Access Stratum
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
RLC	Radio Link Control
RRC	Radio Resource Control
SAE	System Architecture Evolution
SDU	Service Data Unit
SFN	Single Frequency Network
TCH	Traffic Channel
UE	User Equipment
UL	Uplink
UP	User Plane
UMTS	Universal Mobile Telecommunications System
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network

Other abbreviations used in the present document are listed in 3GPP TR 21.905 [2].

4 Objectives and requirements

Simplification of the UTRAN protocol architecture and actual protocols is expected. The overall requirements on the E-UTRAN are described in 3GPP TR 25.913 [3].

4.1 Complexity

A key requirement of E-UTRAN is to maintain the complexity at a reasonable level. In this respect the following assumptions apply:

- The number of transport channels is reduced compared to UTRAN, by making use of shared channels and not supporting dedicated transport channels.

- The number of different MAC entities is reduced compared to UTRAN (e.g. MAC-d not needed in the absence of dedicated transport channels).

- The BMC layer and the CTCH of UTRAN are not needed in E-UTRAN i.e. all data broadcast is on MBMS and on e.g. MTCH.

- There is no inter eNB SHO in the downlink and in the uplink (as currently supported for Rel-6 dedicated channels in UTRAN) for the shared channel, in case of unicast transmissions. Note that this does not preclude the potential support of other schemes such as fast cell selection, bi-casting, "softer HO" (L1 combining) for intra eNB cases, etc.

- Compressed mode as defined for UTRAN is not supported. If some transmission/reception gaps for measurement purpose have to be provided to the UE, this will be based on scheduling gaps.
- Only one receiver structure will be assumed for defining the measurements and their requirements.
- RRC is simplified by e.g. reducing the number of RRC states compared to UTRAN (e.g. removal of UTRAN CELL_FACH is agreed).

4.2 Performance

Editor's note: From R2-051759: U-Plane Latency < 5msec; C-Plane Latency < 100msec (from Inactive to Active); optimisation of User Plane for high bit rates; hide breaks from application; shorter transitions (state transitions, handover within UTRA?); support "always-on" efficiently.

5 Protocol architecture

5.1 Overall protocol architecture

The E-UTRAN consists of eNBs, providing the E-UTRA user plane (RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs interface to the aGW via the S1, and are inter-connected via the X2.

Figure 5.1 below gives an overview of the E-UTRAN architecture where:

- It remains FFS whether the aGW is split into U- and C-plane;
- Yellow boxes depict the logical nodes;
- White boxes depict the functional entities of the control plane;
- Blue boxes depict the functional entities of the user plane.
- It is assumed that a logical E-UTRAN node in addition to the eNB is not needed for RRM purposes. Moreover, due to the different usage of inter-cell RRM functionalities, each inter-cell RRM functionality should be considered separately in order to assess whether it should be handled in a centralised manner or in a distributed manner.

The MBMS related functions in E-UTRAN are described in subclause 11.2.

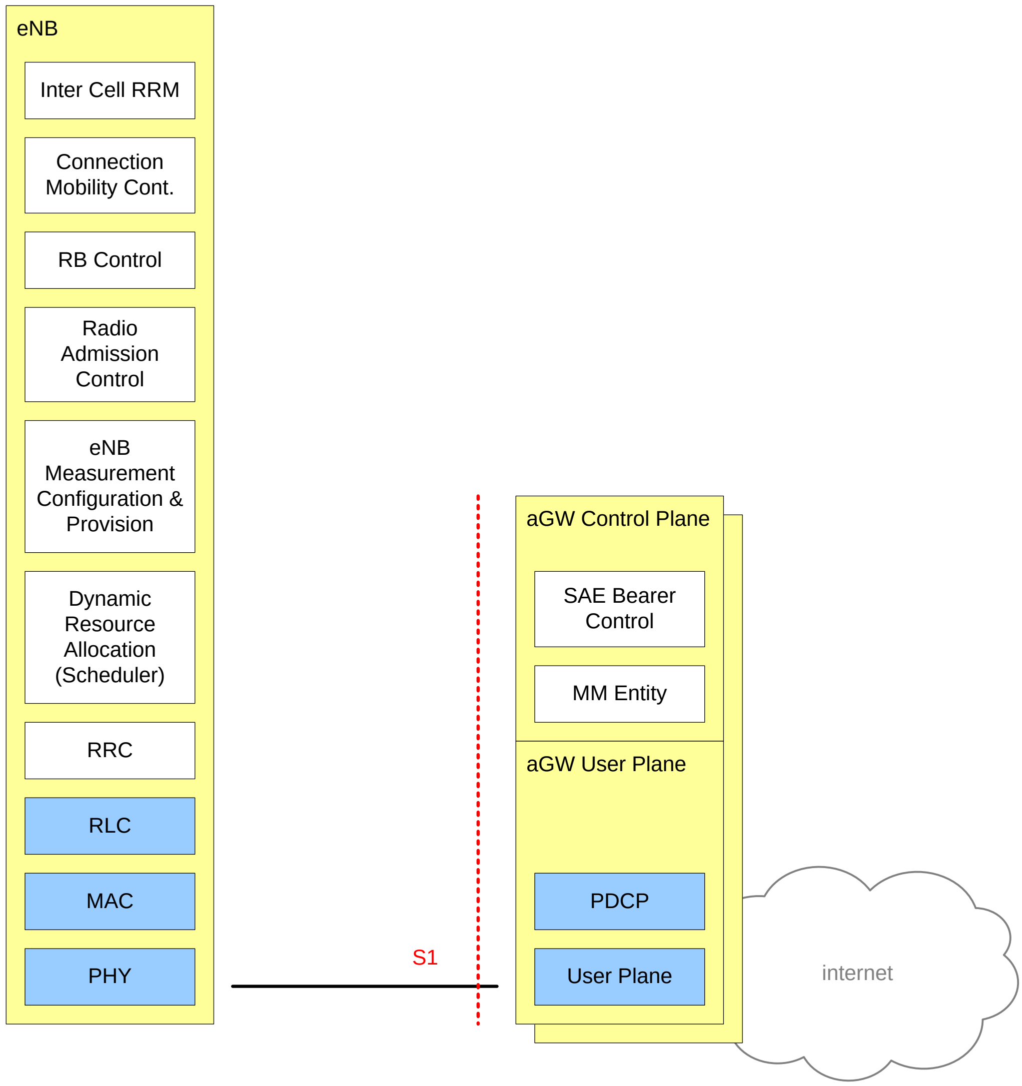

Figure 5.1: E-UTRAN Architecture

The functions agreed to be hosted by the eNB are:

- Selection of aGW at attachment;
- Routing towards aGW at RRC activation;
- Scheduling and transmission of paging messages;
- Scheduling and transmission of BCCH information;
- Dynamic allocation of resources to UEs in both uplink and downlink;
- The configuration and provision of eNB measurements;
- Radio Bearer Control;
- Radio Admission Control;
- Connection Mobility Control in LTE_ACTIVE state.

The functions agreed to be hosted by the aGW are:

- Paging origination;
- LTE_IDLE state management;

- Ciphering of the user plane;
- PDCP;
- SAE Bearer Control (see 3GPP TR 23.882 [6]);
- Ciphering and integrity protection of NAS signalling.

5.1.1 User plane

Figure 5.1.1 below shows the user-plane protocol stack for E-UTRAN, where:

- RLC and MAC sublayers (terminated in eNB on the network side) perform the functions listed in subclause 5.3, e.g.:
    - Scheduling;
    - ARQ;
    - HARQ.
- PDCP sublayer (terminated in aGW on the network side) performs for the user plane the functions listed in subclause 5.3, e.g.:
    - Header Compression;
    - Integrity Protection (FFS);
    - Ciphering.

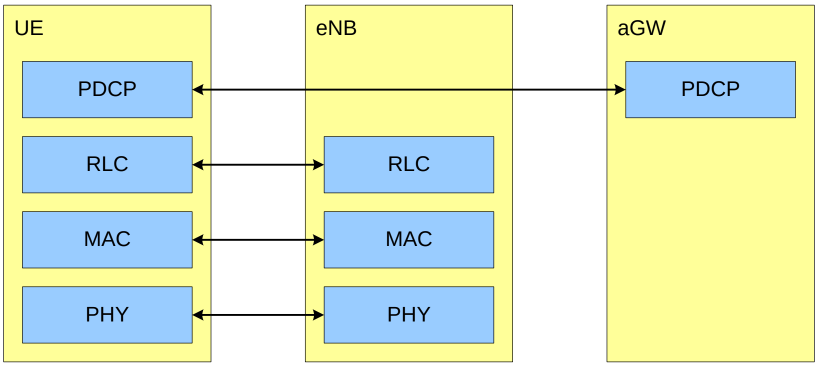

Figure 5.1.1: User-plane protocol stack

5.1.2 Control plane

Figure 5.1.2 below shows the control-plane protocol stack for E-UTRAN. The following working assumptions apply:

- RLC and MAC sublayers (terminated in eNB on the network side) perform the same functions as for the user plane;
- RRC (terminated in eNB on the network side) performs the functions listed in subclause 5.4.2, e.g.:
    - Broadcast;
    - Paging;
    - RRC connection management;
    - RB control;
    - Mobility functions;

- UE measurement reporting and control.

- PDCP sublayer (terminated in aGW on the network side) performs for the control plane the functions listed in subclause 5.3, e.g.:
  - Integrity Protection;
  - Ciphering.
- NAS (terminated in aGW on the network side) performs among other things:
  - SAE bearer management;
  - Authentication;
  - Idle mode mobility handling;
  - Paging origination in LTE_IDLE;
  - Security control for the signalling between aGW and UE, and for the user plane.

NOTE: The NAS control protocol is not covered by the scope of this TR and is only mentioned for information.

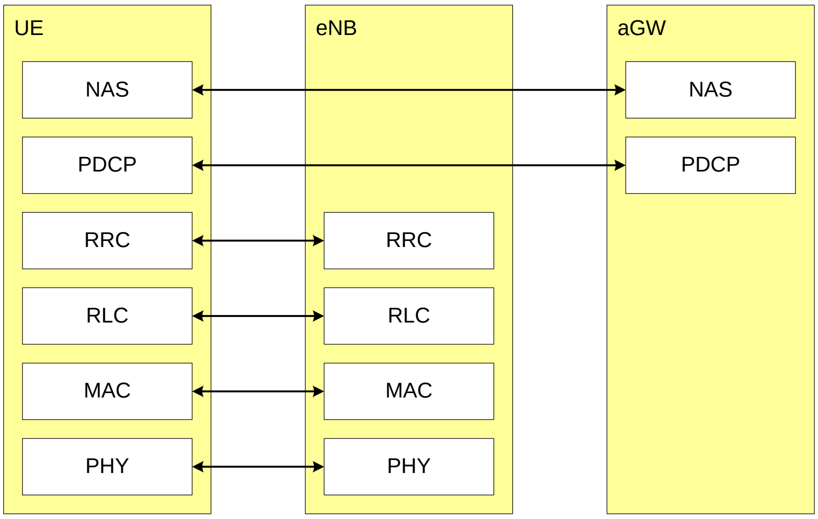

Figure 5.1.2: Control-plane protocol stack

5.2 Layer 1

The physical layer performs the following main functions:

- FEC encoding/decoding;
- Error detection on transport channels;
- Support for Hybrid ARQ with soft combining;
- Power weighting of physical resource;
- Modulation and demodulation of physical channels;
- Frequency and time (symbol, subframe, frame) synchronisation;
- Measurements and indication to higher layers;
- Physical layer mapping;

- Multiplexing of physical channels;
- RF processing;
- Uplink power control (FFS);
- Support for handover;
- Support for timing advance of uplink channels;
- Support for link adaptation;
- Support for diversity;
- Support for multi-stream transmission and reception (MIMO).

NOTE: Some functions require control from upper layers.

5.2.1 Services and functions

The physical layer offers information transfer services to MAC and higher layers. The physical layer transport services are described by *how* and with what characteristics data are transferred over the radio interface. An adequate term for this is "Transport Channel".

NOTE: This should be clearly separated from the classification of *what* is transported, which relates to the concept of logical channels at MAC sublayer.

5.2.2 Transport channels

Downlink transport channel types are:

1. **Broadcast Channel (BCH)** characterised by:
   - fixed, pre-defined transport format;
   - requirement to be broadcast in the entire coverage area of the cell.
2. **Downlink Shared Channel (DL-SCH)** characterised by:
   - support for HARQ;
   - support for dynamic link adaptation by varying the modulation, coding and transmit power;
   - possibility to be broadcast in the entire cell;
   - possibility to use beamforming;
   - support for both dynamic and semi-static resource allocation;
   - support for UE discontinuous reception (DRX) to enable UE power saving;
   - support for MBMS transmission (FFS).

NOTE: the possibility to use slow power control depends on the physical layer.

3. **Paging Channel (PCH)** characterised by:
   - support for UE discontinuous reception (DRX) to enable UE power saving (DRX cycle is indicated by the network to the UE);
   - requirement to be broadcast in the entire coverage area of the cell;
   - mapped to physical resources which can be used dynamically also for traffic/other control channels.
5. **Multicast Channel (MCH)** characterised by:
   - requirement to be broadcast in the entire coverage area of the cell;

- support for combining of MBMS transmission on multiple cells. The exact combining scheme is FFS;
- support for semi-static resource allocation e.g. with a time frame of a long cylic prefix.

Uplink transport channel types are:

1. **Uplink Shared Channel (UL-SCH)** characterised by:
   - possibility to use beamforming; (likely no impact on specifications)
   - support for dynamic link adaptation by varying the transmit power and potentially modulation and coding;
   - support for HARQ;
   - support for both dynamic and semi-static resource allocation; (Note: new attribute, FFS on whether there would be two types of UL-SCH)

NOTE: The possibility to use uplink synchronisation and timing advance depend on the physical layer.

It is FFS, whether a RACH is included. If yes, it would be characterised by the following attributes:

2. **Random Access Channel(s) (RACH)** characterised by:
   - limited data field (FFS);
   - collision risk;

NOTE: The possibility to use open loop power control depends on the physical layer solution.

5.3 Layer 2

Layer 2 is split into the following sublayers: Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP).

This subclause gives a high level description of the Layer 2 sub-layers in terms of services and functions. Figure 5.3a and Figure 5.3b below depicts the PDCP/RLC/MAC architecture for downlink and uplink respectively, where:

- Service Access Points (SAP) for peer-to-peer communication are marked with circles at the interface between sublayers. The SAP between the physical layer and the MAC sublayer provides the transport channels. The SAPs between the MAC sublayer and the RLC sublayer provide the logical channels. The SAPs between the RLC sublayer and the PDCP sublayer provide the radio bearers.
- The multiplexing of several logical channels on the same transport channel is possible;
- The multiplexing of radio bearers with the same QoS onto the same priority queue is FFS. If there is no multiplexing of radio bearers onto priority queues, there is only one level of multiplexing in the RLC and MAC sublayers;
- In the uplink, only one transport block is generated per TTI in the non-MIMO case;
- In the downlink, the number of transport block is FFS.

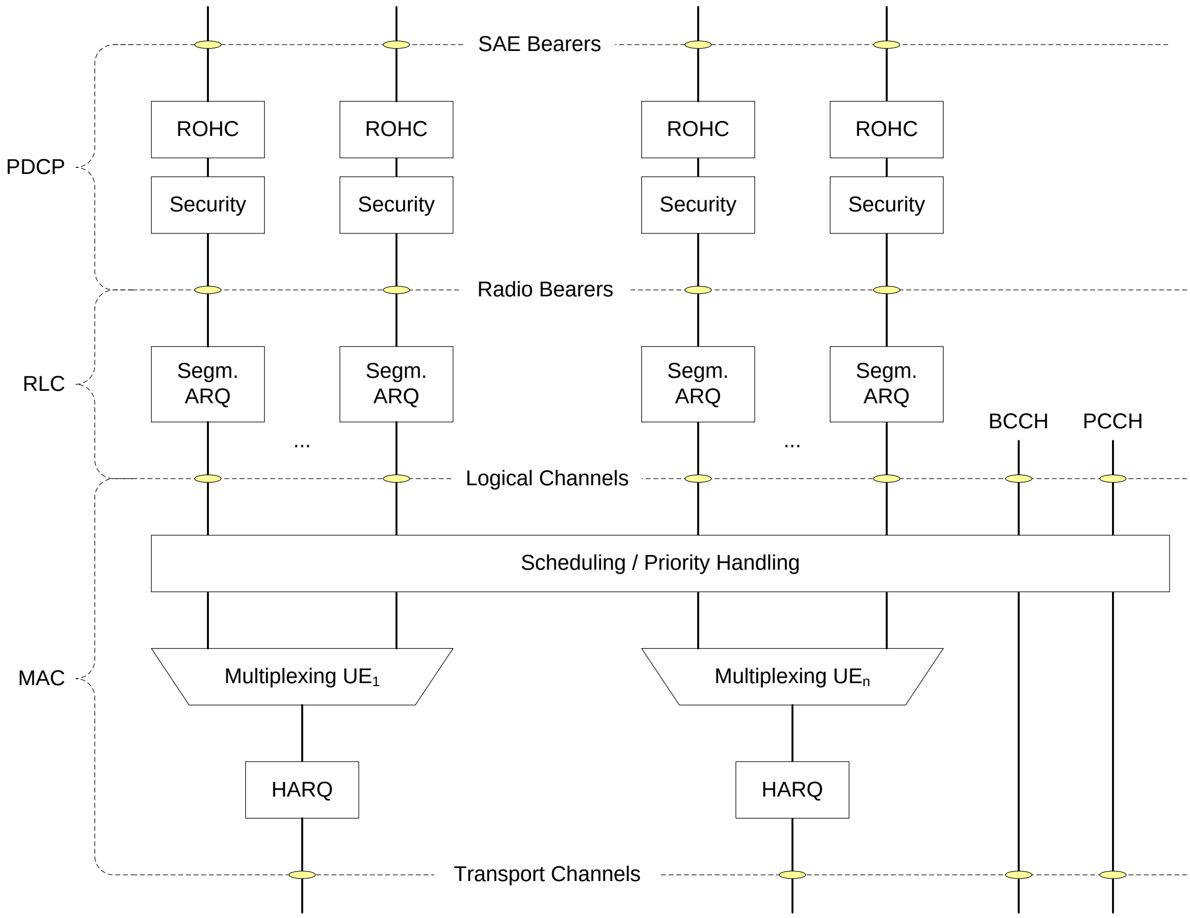

Figure 5.3a: Layer 2 Structure for DL in eNB and aGW

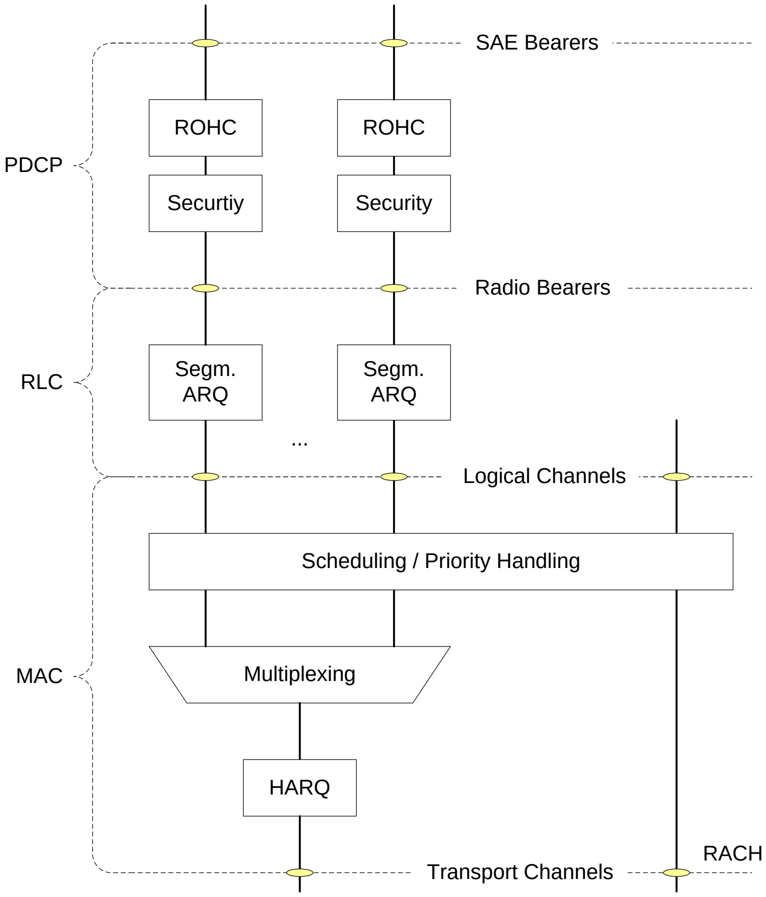

Figure 5.3.b: Layer 2 Structure for UL in UE

5.3.1 MAC Sublayer

This subclause provides an overview on services and functions provided by the MAC sublayer.

5.3.1.1 Services and Functions

The main services and functions of the MAC sublayer include:

- Mapping between logical channels and transport channels;
- Multiplexing/demultiplexing of RLC PDUs belonging to one or different radio bearers into/from transport blocks (TB) delivered to/from the physical layer on transport channels;
- Traffic volume measurement reporting;
- Error correction through HARQ;
- Priority handling between logical channels of one UE;
- Priority handling between UEs by means of dynamic scheduling;
- Transport format selection;
- Mapping of Access Classes to Access Service Classes (FFS for RACH);
- Padding (FFS);
- In-sequence delivery of RLC PDUs if RLC cannot handle the out of sequence delivery caused by HARQ (FFS).

NOTE: How the multiplexing relates to the QoS of the multiplexed logical channels is FFS.

5.3.1.2 Logical Channels

The MAC sublayer 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.

A general classification of logical channels is into two groups:

- Control Channels (for the transfer of control plane information);
- Traffic Channels (for the transfer of user plane information).

There is one MAC entity per cell. MAC generally consists of several function blocks (transmission scheduling functions, per UE functions, MBMS functions, MAC control functions, transport block generation…). Transparent Mode is only applied to BCCH (FFS) and PCCH.

5.3.1.2.1 Control Channels

Control channels are used for transfer of control plane information only. The control channels offered by MAC are:

- **Broadcast Control Channel (BCCH)**

  A downlink channel for broadcasting system control information.

- **Paging Control Channel (PCCH)**

  A downlink channel that transfers paging information. This channel is used when the network does not know the location cell of the UE.

- **Common Control Channel (CCCH)**

  FFS: this channel is used by the UEs having no RRC connection with the network (need is FFS depending on whether the access mechanism is contained in L1. If RACH is visible as a transport channel, CCCH would be used by the UEs when accessing a new cell or after cell reselection).

- **Multicast Control Channel (MCCH)**

  A point-to-multipoint downlink channel used for transmitting MBMS control information from the network to the UE, for one or several MTCHs. This channel is only used by UEs that receive MBMS.

NOTE: It is FFS how MBMS scheduling is transmitted by either L2/3 signalling on MCCH or L1 signalling.

- **Dedicated Control Channel (DCCH)**

  A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. Used by UEs having an RRC connection.

5.3.1.2.2 Traffic Channels

Traffic channels are used for the transfer of user plane information only. The traffic channels offered by MAC are:

- **Dedicated Traffic Channel (DTCH)**

  A Dedicated Traffic Channel (DTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.

- **Multicast Traffic Channel (MTCH)**

  A point-to-multipoint downlink channel for transmitting traffic data from the network to the UE. This channel is only used by UEs that receive MBMS.

5.3.1.3 Mapping between logical channels and transport channels

The figure below depicts the mapping between logical and transport channels (in grey the items for FFS):

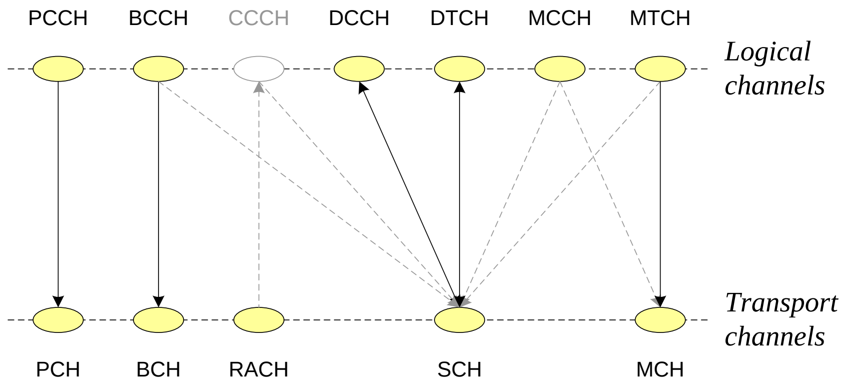

Figure 5.3.1.3: Mapping between logical channels and transport channels

5.3.1.3.1 Mapping in Uplink

In Uplink, the following connections between logical channels and transport channels exist:

- CCCH can be mapped to RACH: FFS if access procedure is not contained within L1;
- CCCH can be mapped to Uplink SCH: FFS if just a transient (random) ID is assigned for the resource request, the actual e.g. RRC Connection Request message has still to contain a UE identifier and therefore such message is considered to be a CCCH message, even if it's transported on the UL-SCH, since the UE is not in RRC_CONNECTED state at this stage;
- DCCH can be mapped to UL- SCH;
- DTCH can be mapped to UL-SCH.

5.3.1.3.2 Mapping in Downlink

In Downlink, the following connections between logical channels and transport channels exist:

- BCCH can be mapped to BCH;
- BCCH can be mapped to DL-SCH: FFS;
- PCCH can be mapped to PCH;
- CCCH can be mapped to DL-SCH: FFS if CCCH exists;
- DCCH can be mapped to DL-SCH;
- DTCH can be mapped to DL-SCH;
- MTCH can be mapped to DL-SCH: FFS;
- MTCH can be mapped to MCH;
- MCCH can be mapped to DL-SCH: FFS;
- MCCH can be mapped to MCH: FFS.

5.3.2 RLC Sublayer

This subclause provides an overview on services and functions provided by the RLC sublayer. Note that the reliability of RLC is configurable: some bearers may tolerate rare losses (e.g. TCP traffic).

5.3.2.1 Services and Functions

The main services and functions of the RLC sublayer include:

- Transfer of upper layer PDUs supporting AM, UM or TM data transfer (FFS);
- Error Correction through ARQ;
- Segmentation according to the size of the TB;
- Resegmentation when necessary (e.g. when the radio quality, i.e. the supported TB size changes) (FFS if it takes place at PDU or SDU level);
- Concatenation of SDUs for the same radio bearer is FFS;
- In-sequence delivery of upper layer PDUs;
- Duplicate Detection;
- Protocol error detection and recovery;
- Flow Control (FFS between aGW and eNB);
- SDU discard (FFS);
- Reset.

5.3.3 PDCP Sublayer

This subclause provides an overview on services and functions provided by the PDCP sublayer. A model of the PDCP sublayer is illustrated in the figure below.

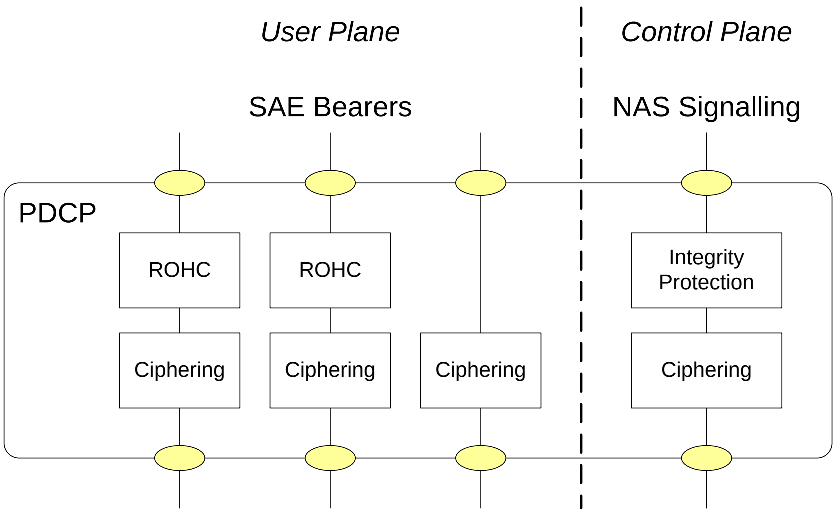

Figure 5.3.3: Model of PDCP sublayer

5.3.3.1 Services and Functions

The main services and functions of the PDCP sublayer include:

- Header compression and decompression: ROHC only;
- Transfer of user data: transmission of user data means that PDCP receives PDCP SDU from the NAS and forwards it to the RLC layer and vice versa;
- Ciphering of user plane data and control plane data (NAS Signalling);
- Integrity protection of control plane data (NAS signalling);

- Integrity protection of user plane data is FFS.

NOTE: The UP and CP PDCP entities are located in the UPE and MME, respectively.

NOTE: When compared to UTRAN, the *lossless DL RLC PDU size change* is not required.

5.3.4 Data flows through Layer 2

Editor's note: Different flows for different transport channels, logical channels and transfer mode.

5.4 RRC

This subclause provides an overview on services and functions provided by the RRC sublayer.

5.4.1 Services and Functions

The main services and functions of the RRC sublayer include:

- Broadcast of System Information related to the non-access stratum (NAS);
- Broadcast of System Information related to the access stratum (AS);
- Paging;
- Establishment, maintenance and release of an RRC connection between the UE and E-UTRAN including:
  - Allocation of temporary identifiers between UE and E-UTRAN;
  - Configuration of radio resources for RRC connection.
- Security functions including:
    - Integrity protection for RRC messages;
    - Ciphering for RRC messages (FFS).
- Establishment, maintenance and release of point to point Radio Bearers including configuration of radio resources for the Radio Bearers;
- Mobility functions including:
  - UE measurement reporting and control of the reporting for inter-cell and inter-RAT mobility;
  - Inter-cell handover;
  - UE cell selection and reselection and control of cell selection and reselection;
  - Context transfer between eNBs.
- Notification for multicast/broadcast services (FFS);
- Establishment, maintenance and release of Radio Bearers for multicast/broadcast services, including configuration of the Radio Bearers (FFS);
- QoS management functions (FFS if spread across multiple layers);
- UE measurement reporting and control of the reporting;
- MBMS control (FFS);
- NAS direct message transfer to/from NAS from/to UE.

5.4.2 RRC protocol states & state transitions

RRC uses the following states:

- **RRC_IDLE**:
  - UE specific DRX configured by NAS;
  - Broadcast of system information;
  - Paging;
  - Cell re-selection mobility;
  - The UE shall have been allocated an id which uniquely identifies the UE in a tracking area;
  - No RRC context stored in the eNB.
- **RRC_CONNECTED**:
  - UE has an E-UTRAN-RRC connection;
  - UE has context in E-UTRAN;
  - E-UTRAN knows the cell which the UE belongs to;
  - Network can transmit and/or receive data to/from UE;
  - Network controlled mobility (handover);
  - Neighbour cell measurements;
  - At RLC/MAC level:
    - UE can transmit and/or receive data to/from network;
    - UE monitors control signalling channel for shared data channel to see if any transmission over the shared data channel has been allocated to the UE;
    - UE also reports channel quality information and feedback information to eNB;
    - DRX/DTX period can be configured according to UE activity level for UE power saving and efficient resource utilization. This is under control of the eNB.

5.5 NAS control protocol

This subclause provides an overview on services and functions provided by the NAS control protocol.

NOTE: the NAS control protocol is not covered by the scope of this TR and is only mentioned for information.

5.5.1 Services and Functions

The main services and functions of the NAS sublayer include:

- SAE Bearer control (see 3GPP TR 23.882 [6]);
- LTE_IDLE mobility handling;
- Paging origination;
- Configuration and control of PDCP;
- Configuration and control of Security.

5.5.2 NAS protocol states & state transitions

The NAS control protocol uses the following states:

- **LTE_DETACHED**:
  - No RRC entity.
- **LTE_IDLE**:
  - RRC_IDLE State;
  - Some information is stored in the UE and in the network:
    - IP address, etc;
    - Security association (keys, etc);
    - UE capability information (FFS);
    - Radio Bearers (FFS);
  - State transition decided in eNB or aGW (FFS);
- **LTE_ACTIVE**:
  - RRC_CONNECTED State;
  - State transition decided in eNB or aGW (FFS);

The following figure reflects how the NAS states relate to the RRC:

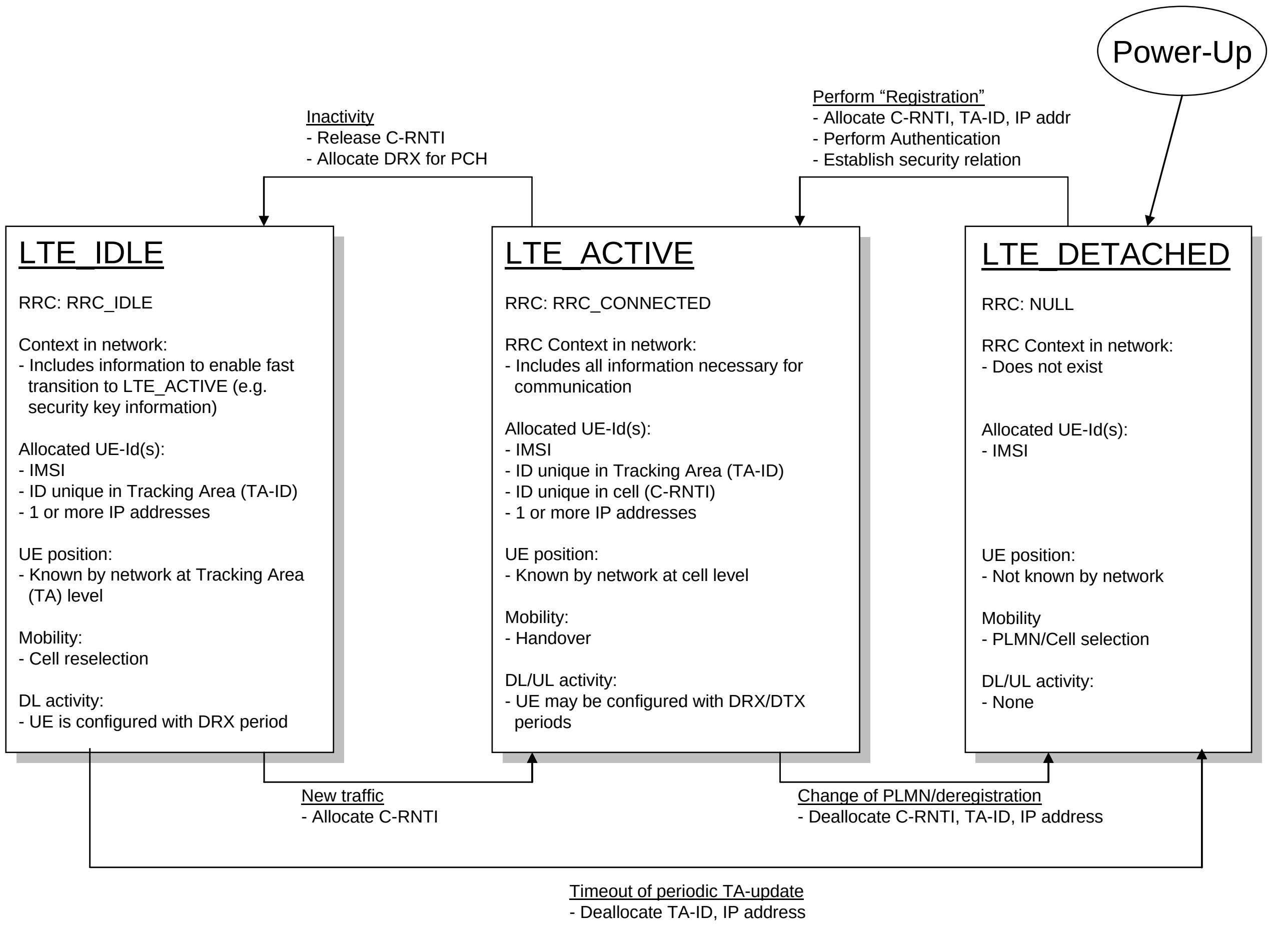

Figure 5.5.2: E-UTRAN RRC protocol states

NOTE: The applicability of the ID unique in Tracking Area (TAID) in LTE_DETACHED is FFS.

The UE context in the aGW will discriminate the 3 states. The UE context in the eNB will only exist in the LTE_ACTIVE state.

5.5.3 Transport of NAS messages

In E-UTRAN, NAS messages are either concatenated with RRC messages or carried in RRC without concatenation:

- Concatenated messages:
    - Initial Direct Transfer is concatenated with RRC connection request;
    - Other NAS messages maybe concatenated with RRC messages i.e. for synchronised NAS/RRC procedure;
    - Integrity protection of the NAS messages from RRC is FFS as integrity protection is already applied in the aGW.
- Non-concatenated messages:
    - No integrity protection from RRC;
- Whether the same logical channel can be used for both NAS/RRC messages and RRC only messages is FFS.

5.6 Identities used over the E-UTRAN radio interface

5.6.1 NAS related UE identities

NAS related UE identities used in E-UTRAN are assumed to be similar to the NAS identities used in 2G or 3G:

a) IMSI/IMEI;

b) TMSI for MME:

- Temporary identity allocated by the MME. The scope of the TMSI for MME is FFS.

c) TMSI for UPE (FFS):

- Temporary identity allocated by the UPE.

5.6.2 E-UTRAN related UE identities

The following E-UTRAN related UE identities are used:

a) C-RNTI:

- The C-RNTI provides a unique UE identification at the cell level;
- It is assumed that this identity is used for scheduling unless the cost would turn out to be too high and the introduction of a separate MAC identity would be required.

b) Random value for contention resolution:

- During some transient states, the UE is temporarily identified with a random value for contention resolution purposes.

5.6.3 Network entity related Identities

The following identities are used in E-UTRAN for identifying a specific network entity:

a) MME identity:

- It is agreed that a UE in LTE_IDLE establishing an RRC connection has to provide a unique identification of its current MME to the eNB when the connection establishment is initially related to NAS signalling;
- It is FFS whether this MME identity is also provided when the RRC connection is initially intended for user plane traffic;
- It is FFS whether this MME identity is provided by the UE to the eNB as a separate identity, or whether this MME identity is included in the TMSI for MME.

b) eNB identity or cell identity (FFS):

- The signalling sequence to be followed in case a UE in LTE_ACTIVE accesses a cell in which no UE context has been established yet (kind of "cell update") is currently not agreed. Identified options are:
  1) In order to obtain the UE context/data from the old eNB, the new eNB directly contacts the old eNB without consulting the aGW;
  2) In order to obtain the UE context/data from the old eNB, the new eNB consults the aGW to obtain the identity of the old eNB;
  3) In order to obtain a UE context, the new eNB contacts the aGW.
- If it is required for the new eNB to be able to contact the old eNB without involving the aGW (case 1 above), the UE has to provide a network entity related identification that enables the new eNB to contact the old eNB, and that enables the old eNB to uniquely identify the UE for retrieving the correct UE context. For this purpose either an eNB identity or cell identity could be used.

c) UPE identity (FFS):

- The signalling sequence to be followed when a UE in LTE_IDLE wants to establish an RRC connection initially intended for user plane traffic is not agreed yet. If it is required to support user plane data transport before the UE context is retrieved from the aGW, the UE might have to provide a UPE identity to the eNB thus enabling the new eNB to contact the UPE directly.

d) Tracking Area identity (FFS):

- Unique identification of a Tracking Area in a PLMN.

The following identities are broadcast in every E-UTRAN cell:

a) Cell identity:

- Uniquely identifying the cell in the area (size of area is FFS).

b) One or more Tracking Area identities (FFS):

- Tracking Area (s) this cell belongs to.

c) One or more PLMNs:

- PLMN (s) for which this cell is providing radio access.

6 ARQ and HARQ

E-UTRAN provides ARQ and HARQ functionalities. The ARQ functionality provides error correction by retransmissions in acknowledged mode at Layer 2. The HARQ functionality ensures delivery between peer entities at Layer 1.

6.1 HARQ principles

The HARQ within the MAC sublayer has the following characteristics:

- N-process Stop-And-Wait HARQ is used;

- The HARQ is based on ACK/NACKs;
- In the downlink:
  - Asynchronous retransmissions with adaptive transmission parameters are supported;
  - Additional optimisations (e.g. less adaptive/synchronous) are FFS.
- In the uplink:
  - HARQ is based on synchronous retransmissions;
  - Whether resource allocation and modulation and coding scheme can be adapted for retransmissions is FFS.
- The HARQ transmits and retransmits TBs;

6.2 ARQ principles

The ARQ within the RLC sublayer has the following characteristics:

- It is FFS whether the ARQ retransmits RLC SDUs or RLC PDUs (segments);
- ARQ retransmissions are based on:
  - RLC status reports (FFS);
  - HARQ/ARQ interactions (see subclause 6.3).
- The RLC transmitter can invoke a discard procedure (FFS);
- The RLC can invoke a reset procedure (FFS).

6.3 HARQ/ARQ interactions

In HARQ assisted ARQ operation, ARQ uses knowledge obtained from the HARQ about the transmission/reception status of a TB e.g.:

- If the HARQ transmitter detects a failed delivery of a TB due to e.g. maximum retransmission limit it is FFS if the relevant transmitting ARQ entities are notified;
- If the HARQ receiver is able to detect a NACK to ACK error it is FFS if the relevant transmitting ARQ entities are notified via explicit signalling;
- If the HARQ receiver is able to detect TB transmission failure it is FFS if the receiving ARQ entities are notified.

7 Scheduling

In order to utilise the SCH resources efficiently, a scheduling function is used in MAC. In this subclause, an overview of the scheduler is given in terms of scheduler operation, signalling of scheduler decisions, and measurements to support scheduler operation.

Scheduler Operation:

- MAC in eNB includes dynamic resource schedulers that allocate physical layer resources for the DL-SCH and UL-SCH transport channels. Different schedulers operate for the DL-SCH and UL-SCH.
- Taking account the traffic volume and the QoS requirements of each UE and associated radio bearers, schedulers assign resources between UEs and potentially also between different radio bearers associated with a single UE (FFS).

- Schedulers may assign resources taking account the radio conditions at the UE identified through measurements made at the eNB and/or reported by the UE.

- Radio resource allocations can be valid for one or multiple TTIs.

- Resource assignment consists of radio resources (resource blocks). Allocations for time periods longer than one TTI might also require additional information (allocation time, allocation repetition factor…).

Signalling of Scheduler Decisions:

- UEs identify whether resources are assigned to them by receiving a scheduling (resource assignment) channel. There may be separate scheduling channels for uplink and downlink resource assignment.

- Scheduling decisions are signalled via MAC messages. It is FFS whether resources can be assigned by other means e.g. MAC headers or RRC signalling.

Measurements to Support Scheduler Operation:

- Measurement reports are required to enable the scheduler to operate in both uplink and downlink. These include transport volume and measurements of a UEs radio environment. The time and frequency granularity of the UE radio environment measurement reports is FFS.

- Uplink buffer status reports are needed to provide support for QoS-aware packet scheduling. Uplink buffer status reports refer to the data that is buffered in the logical channel queues in the UE MAC. The uplink packet scheduler in the eNB is located at MAC level. Uplink buffer status reports may be transmitted using MAC signalling (e.g. as a specific type of MAC control PDU). A way to separately signal buffer status reports for different QoS classes may be used. To define the exact content of buffer status reports and the possible use of physical layer signalling are FFS.

- The buffer reporting scheme used in uplink should be flexible in order to support different types of data services. The buffer reporting criteria are setup and reconfigured on a per user basis or per radio bearer basis (FFS) using RRC or MAC signalling (FFS). The use of System Information should also be considered for the initial setup of default buffer reporting criteria (on a per cell basis). Constraints on how often uplink buffer reports are signalled from the UEs can be specified by the network to limit the overhead from sending the reports in the uplink.

- It is FFS whether additional measurement information is required to support the classification of UEs between localised and distributed resource allocation.

- It is FFS whether additional measurement information is required to support cell center / cell-edge resource subdivision.

8 QoS Control

Editor's note: This clause will describe how QoS is managed.

9 Mobility

9.1 Intra E-UTRAN

In E-UTRAN RRC_CONNECTED state, network controlled UE assisted handovers are performed and various DRX/DTX cycles are supported:

- UE performs neighbour cell measurements based on measurement control and neighbour cell information from the network;

- Network signals reporting criteria for event-triggered and possibly periodical (FFS) reporting.

Following defines the handover support within E-UTRAN:

- The intra E-UTRAN HO in RRC_CONNECTED state is UE assisted NW controlled HO with HO preparation signalling in E-UTRAN.

- In E-UTRAN RRC_IDLE state, cell reselections are performed and DRX is supported.

9.1.1 Variable bandwidth scenarios

The Figure below shows a number of scenarios for adjacent cells with different transmission bandwidths and UEs with different receiver bandwidths. Measurements, reselection and handover need to be considered for these different scenarios.

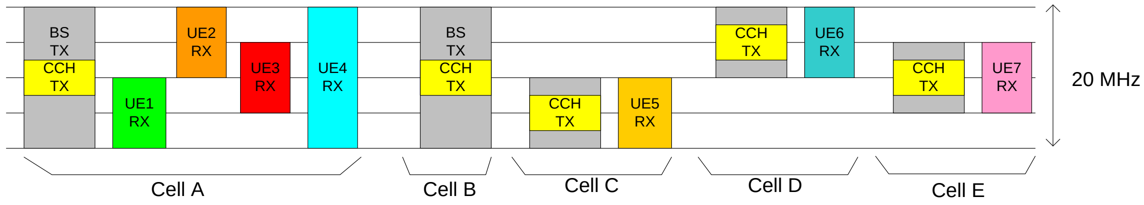

Figure 9.1.1: Variable bandwidth scenarios

1) A cell transmits one set of common channel information. This information must be contained in a bandwidth equal than or less than the UE minimum bandwidth capability (assumed to be 10MHz). This ensures all UEs in RRC_IDLE are capable of receiving the common channels irrespective of UE capability. The need to replicate some control information is FFS.

2) The term handover is used for the procedure that changes the serving cell of a UE in RRC_CONNECTED. A frequency reconfiguration within the same serving cell is not a handover. A frequency reconfiguration is used to move the UE reception bandwidth within the cell transmission bandwidth.

3) Neighbour cell lists on which the network requests the UEs to perform measurements for handover and cell reselection do not classify cells as intra-frequency or inter-frequency (i.e. there are no intra-frequency cells and inter-frequency cells)

9.1.2 Cell selection

The principles of PLMN selection in E-UTRA are based on the 3GPP PLMN selection principles. Cell selection is required on transition from LTE_DETACHED to LTE_IDLE or LTE_ACTIVE, on transition from RRC_CONNECTED to RRC_IDLE and on recovery from out of coverage.

Cell selection:

- The UE NAS identifies a selected PLMN and equivalent PLMNs;

- The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s):

  - Details for the cell search are FFS;

  - The UE may search each carrier in turn ("initial cell selection") or make use of stored information to shorten the search ("stored information cell selection").

- The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure:

  - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a forbidden location area;
  - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred;
  - The measurements made and the cell selection criteria to be applied are FFS.

Transition to RRC_IDLE:

On transition from RRC_CONNECTED to RRC_IDLE, a UE should camp on the last cell for which it was in RRC_CONNECTED or a cell/any cell of set of cells or frequency be assigned by RRC in the state transition message.

Recovery from out of coverage:

The UE should attempt to find a suitable cell in the manner described for stored information or initial cell selection above. If no suitable cell is found on any frequency or RAT the UE should attempt to find an acceptable cell.

9.1.3 Cell reselection

UE in RRC_IDLE performs cell reselection. The principles of the procedure are the following:

- Cell reselection takes place in a hierarchical or non hierarchical cell topology. The type of topology will be indicated in system information;
- The UE makes measurements of attributes of the serving and neighbour cells to enable the reselection process:
  - Cells listed in the serving cell system information broadcast are searched and measured by the UE; it is FFS whether the UE can search and measure cells that are not listed in system information;
  - The attributes to be measured for E-UTRAN cells are FFS;
- Measurements may be omitted if the serving cell attribute fulfils particular search or measurement criteria. The criteria and rules relating to which measurements may be omitted are FFS;
- Cell reselection identifies the cell that the UE should camp on. It is based on cell reselection criteria which involves measurements of the serving and neighbour cells. Details for cell reselection criteria are FFS (e.g. whether a cell specific offset is applied to measurements);
- Cell reselection parameters are applicable for all UEs in a cell, but it is possible to configure specific reselection parameters per UE group or per UE.

Cell access restrictions apply as for UTRAN, which consist of access class (AC) barring and cell reservation (e.g. for cells "reserved for operator use", other purpose are FFS) applicable for mobiles in RRC_IDLE mode.

9.1.4 Paging

Editor's note: From R2-051759: Several proposals 1) paging channel; 2) DRX on shared channel instead of paging channel. URA concept retained. Common with UTRA or specific to E-UTRA always? No need for NAS paging if some NAS/AS functionality merge (PMM with RRC) take place (e.g. if Idle mode is removed).

9.1.5 Handover

The intra E-UTRAN HO in RRC_CONNECTED state is UE assisted NW controlled HO, with HO preparation signalling in E-UTRAN. The Figure below depicts the basic handover scenario where neither MME nor UPE changes:

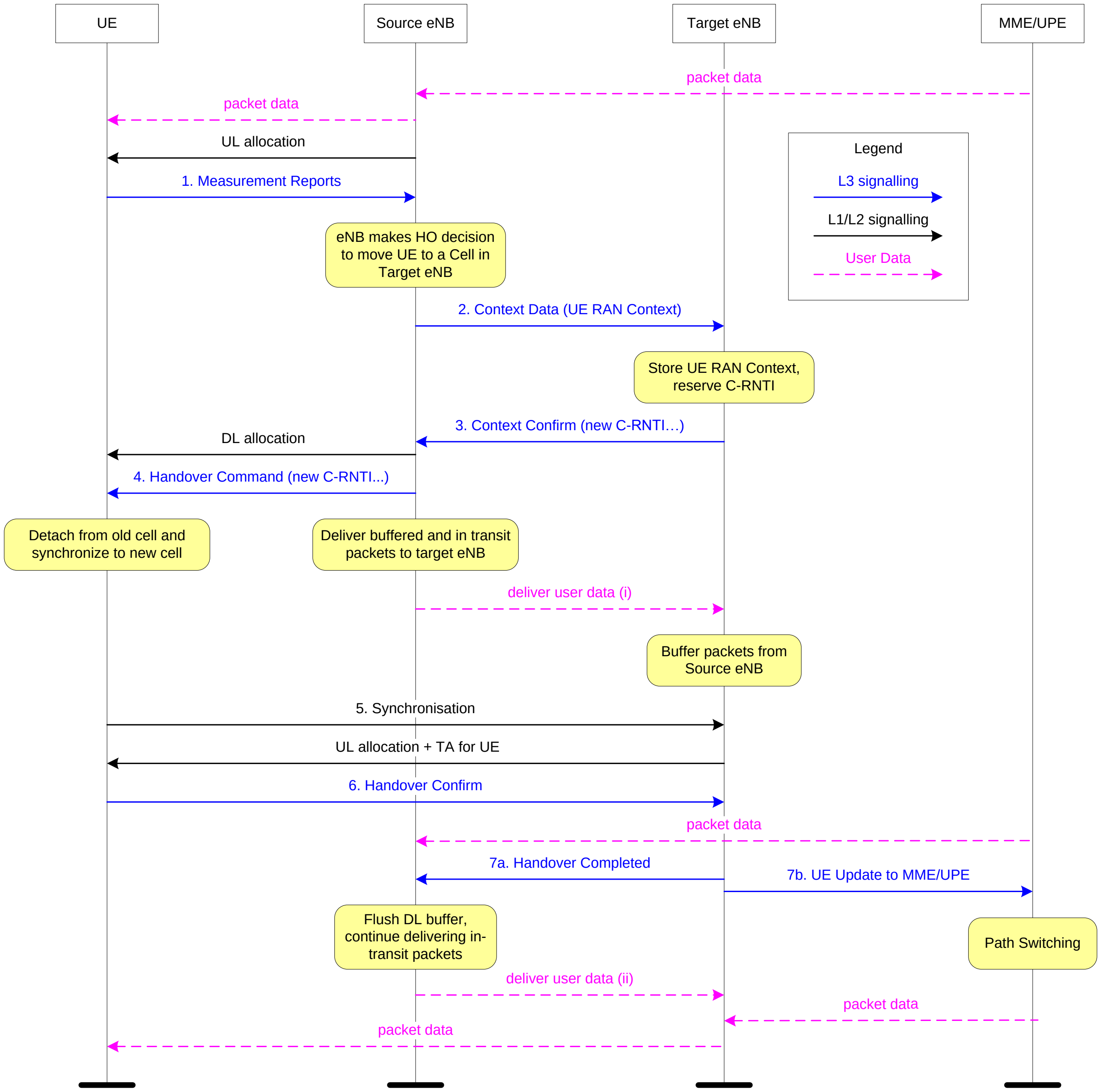

Figure 9.1.5: Intra-MME/UPE HO

Below is more detailed description of the intra-MME/UPE HO procedure:

1 UE is triggered to send MEASUREMENT REPORT by the rules set by i.e. system information, specification etc.

2 Source eNB makes decision based on MEASUREMENT REPORT and RRM information to hand off UE. The eNB prepares target eNB for handover and passes relevant information in the Handover Request.

3 Target eNB prepares HO with L1/L2 and responds to source eNB by providing new C-RNTI and possibly some other parameters i.e. access parameters, SIBs, etc. After reception of accepted preparation of HO, source eNB starts forwarding data packets to target eNB.

4 UE receives HANDOVER COMMAND with necessary parameters i.e. new C-RNTI, possible starting time, target eNB SIBs etc. It is probable that UE needs to acknowledge reception of the HO COMMAND with RLC acknowledgment procedure.

5 After expiry of starting time in HO COMMAND, UE performs synchronisation to target eNB and then starts acquiring UL timing advance.

6 Network responds with UL allocation and timing advance. These are used by UE to send HANDOVER CONFIRM to the target eNB, which completes handover procedure for the UE. It is probable that NW needs to acknowledge reception of the HO CONFIRM with RLC acknowledgment procedure.

7a Target eNB informs success of HO to source eNB, which can then clear already forwarded data from its buffers. Source eNB still continues forwarding UE data if it has some in its buffers or if UPE still forwards data to it.

7b UE location information is updated to MME/UPE in order to enable UPE to forward packets directly to target eNB

The handling of outstanding uplink and downlink data upon inter-eNB handover is described in subclause 9.1.7.

9.1.6 Measurements

Measurements to be performed by a UE for intra/inter-frequency mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control for RRC_IDLE state is FFS. In RRC_CONNECTED state, a UE shall follow the measurement configurations specified by RRC directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

Depending on whether the UE needs transmission/reception gaps to perform the relevant measurements, measurements are classified as gap assisted or non gap assisted. A non gap assisted measurement is a measurement on a cell that does not require transmission/reception gaps to allow the measurement to be performed. A gap assisted measurement is a measurement on a cell that does require transmission/reception gaps to allow the measurement to be performed.

Whether a measurement is non gap assisted or gap assisted depends on the UE's capability and current operating frequency. The UE determines whether a particular cell measurement needs to be performed in a transmission/reception gap and the scheduler needs to know whether gaps are needed. The exact scenarios that require gap assisted measurements are FFS (see subclause 9.1.1).

9.1.6.1 Neighbour cell measurements within the serving frequency layer

In a system with frequency reuse = 1, mobility within the same frequency layer (i.e. between cells with the same carrier frequency) is predominant. Good neighbour cell measurements are needed for cells that have the same carrier frequency as the serving cell in order to ensure good mobility support and easy network deployment. Search for neighbour cells with the same carrier frequency as the serving cell, and measurements of the relevant quantities for identified cells are needed.

NOTE: To avoid UE activity outside the DRX/DTX cycle, the reporting criteria for neighbour cell measurements should match the used DRX/DTX cycle.

9.1.6.2 Neighbour cell measurements of other frequency layers

Regarding mobility between different frequency layers (i.e. between cells with a different carrier frequency), UE may need to perform neighbour cell measurements during DL/UL idle periods that are provided by DRX/DTX or packet scheduling (i.e. gap assisted measurements).

NOTE: How the gaps are controlled, as well as how the scheduler knows the gaps required by the UE, is FFS.

9.1.7 Network aspects

Upon handover, the source eNB forwards all downlink RLC SDUs, starting from the first SDU that has not been successfully received by the UE, to the target eNB. The source eNB discards any remaining downlink RLC PDUs. The target eNB re-transmits all downlink RLC SDUs forwarded by the source eNB. Correspondingly, the source eNB does not forward the downlink RLC context to the target eNB. Support of re-ordering of downlink RLC SDUs during handover, which either the target eNB or the UE could provide (e.g. based on PDCP sequence numbers), is FFS. The optimisation, to only re-transmit the downlink RLC SDUs not successfully received by the UE, is FFS.

Upon handover, the source eNB forwards all successfully received uplink RLC SDUs to the aGW and discards any remaining uplink RLC PDUs. The UE re-transmits the uplink RLC SDUs that have not been successfully received by the source eNB. Correspondingly, the source eNB neither forwards uplink RLC SDUs nor the uplink RLC context to the target eNB. If needed, the PDCP within aGW may support re-ordering of uplink RLC SDUs during handover (operator control).

9.2 Inter RAT

The following list defines the mobility support between E-UTRAN and UTRAN (see Figure 9.2), with mobility support between E-UTRAN and GERAN being FFS.

1) The HO from E-UTRAN RRC_CONNECTED state to UTRAN CELL_DCH state is supported with UE assisted NW controlled manner including HO preparation signalling. From UTRAN CELL_DCH state to E-UTRAN RRC_CONNECTED state mobility is supported. The utilisation of the HO with preparation signalling or relying on Network Assistant Cell Change (NACC) is FFS.

2) When a UE in CELL_FACH state in the UTRAN goes out-of-service it may reselect to E-UTRAN. If the UE camps on E-UTRAN coverage the UE completes the Tracking Area update procedure to the MME. In this case the UE stores the UTRAN MM configuration.

3) The transition between UTRAN CELL/URA_PCH and E-UTRAN RRC_IDLE is completed by UE controlled cell reselection. The support of signalling-free transition between UTRAN CELL/URA_PCH and E-UTRAN RRC_IDLE states requires the UTRAN RRC Connection configuration to be stored by the UE whilst in E-UTRAN RRC_IDLE state (including the Last RRC State). The storage of the UTRAN context is indicated in the figure by the "UTRAN RRC Connected Configuration Stored".

   If, when reselecting from E-UTRAN to UTRAN the UE has a valid UTRAN RRC Connection Configuration Stored, it shall automatically enter the Last RRC State indicated in the UTRAN Stored Configuration.

   If, when changing between E-UTRAN and UTRAN the UE has moved out of its mobility area (e.g. Cell, URA, TA) then the UE initiates the normal mobility update procedure (e.g. Cell Update, URA update or Tracking Area Update procedures), but the completion of a Tracking Area Update in the E-UTRAN does not affect the stored UTRAN configurations, and the UTRAN RRC connection for the UE is maintained.

   If the timer relating to the periodic CELL/URA Update of UTRAN has expired when the UE is in E-UTRAN coverage, then the UE can delete the stored UTRAN RRC Connected configuration.

4) The transition between UTRAN IDLE and E-UTRAN RRC_IDLE is completed by UE controlled cell reselection. The UTRAN MM configuration is stored after completing the state transition to LTE_IDLE state, and the LTE_IDLE configuration is stored when reselecting from E-UTRAN RRC_IDLE to UTRAN IDLE.

NOTE: The handling in the E-UTRAN RRC_IDLE state is independent of the stored UTRAN configuration.

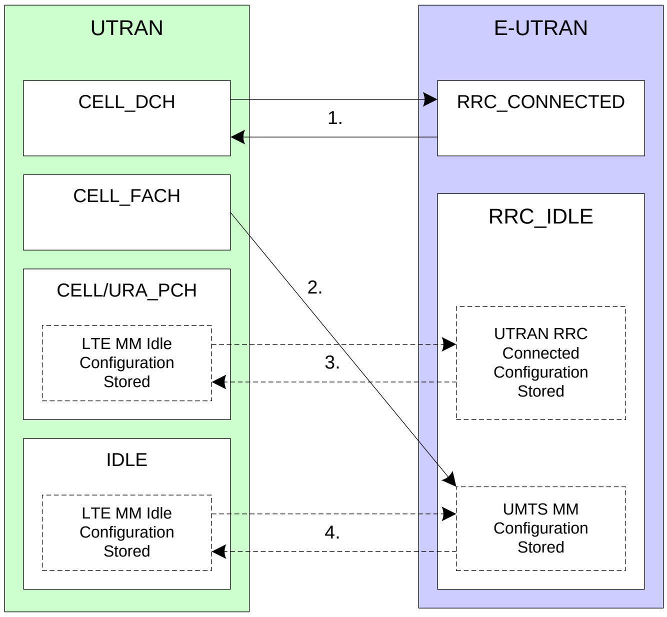

Figure 9.2: Handovers between E-UTRAN and UTRAN

9.2.1 Cell reselection

It is FFS whether inter RAT cell reselection forms part of a single intra and inter RAT cell reselection process.

It is FFS whether, within a single reselection process particular rules and criteria apply to inter RAT reselection.

9.2.2 Handover

9.2.3 Measurements

9.2.3.1 Inter-RAT handovers from E-UTRAN

Measurements to be performed by a UE for inter-RAT mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC_CONNECTED state, a UE shall follow the measurement parameters specified by RRC or MAC commands (FFS) directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

UE performs inter-RAT neighbour cell measurements during DL/UL idle periods that are provided by the network through suitable DRX/DTX period or packet scheduling if necessary.

NOTE: How the gaps are controlled, as well as how the scheduler knows the gaps required by the UE, is FFS.

9.2.3.2 Inter-RAT handovers to E-UTRAN

From UTRAN, UE performs E-UTRAN measurements by using idle periods created by compressed mode (CELL_DCH), FACH measurement occasions (CELL_FACH - FFS), or DRX (other states).

From GERAN, E-UTRAN measurements are performed in the same way as WCDMA measurements for handover to UTRAN: E-UTRAN measurements are performed in GSM idle frames in a time multiplexed manner. However, it should be discussed with GERAN how to ensure that inter-RAT measurements do not take too much measurement time, while the requested 3GPP inter-RAT measurements can be performed well enough.

Design constraints of 3GPP inter-RAT measurements should be considered when L1 details of E-UTRAN concept are defined.

9.2.3.3 Inter-RAT cell reselection from E-UTRAN

In RRC_IDLE state, a UE shall follow the measurement parameters specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control is FFS.

9.2.3.4 Limiting measurement load at UE

Introduction of E-UTRA implies co-existence of various UE capabilities. Each UE may support different combinations of RATs, e.g., E-UTRA, UTRA, GSM, and non-3GPP RATs, and different combinations of frequency bands, e.g., 800 MHz, 1.7 GHz, 2 GHZ, etc. Moreover, some UEs may support the full E-UTRA spectrum bandwidth of 20 MHz, whereas some UEs may support only a part of 20 MHz. Despite such heterogeneous environment, the measurement load at UE should be minimised. To limit the measurement load and the associated control load:

- E-UTRAN can configure the RATs to be measured by UE;
- The number of measurement criteria (event and periodic reporting criteria) should be limited (as in TS 25.133 subclause 8.3.2 [7]);
- E-UTRAN should be aware of the UE capabilities for efficient measurement control, to prevent unnecessary waking up of the measurement entity;
- The UE capabilities should be categorised to prevent diversion of capabilities and conformance test scenarios , FFS;
- Support for blind HO (i.e., HO without measurement reports from UE) is FFS.

9.2.4 Network Aspects

9.3 Timing Advance

The timing advance is a signal derived from the time synchronisation of the UL sequence and sent by the eNB to the UE which the UE uses to advance its timings of transmissions to the eNB so as to compensate for propagation delay and thus time align the transmissions from different UEs with the receiver window of the eNB. By avoiding the overlapping of uplink transmissions, timing advance allows time domain multiplexing in the uplink.

In RRC_CONNECTED, it remains FFS whether the timing advance is permanently maintained or not. If not, MAC knows if the L1 is synchronised and which procedure to use to start transmitting in the uplink (FFS for RRC).

Cases where the UL synchronisation status may move from "synchronised" to "non-synchronised" include:

- Expiration of a timer;
- Non-synchronised handover;
- Explicit request by MAC or RRC in the eNB;

10 Security

10.1 Security Termination Points

The table below describes the security termination points.

Table 10.1 Security Termination Points

	Ciphering	Integrity Protection
NAS Signalling	Required and terminated above eNB (NOTE 1)	Required and terminated above eNB (NOTE 1)
U-Plane Data	Required and terminated in aGW (NOTE 2)	Need is FFS
RRC Signalling (AS)	Need is FFS	Required an terminated in eNB (NOTE 3)
MAC Signalling (AS)	Need is FFS	Need is FFS
NOTE 1: "Above eNB" means that the termination point is in either the aGW or above (FFS) and that the activation/deactivation is not controlled by the eNB. NOTE 2: The protocol stack layer in which the ciphering takes place is FFS. The activation/deactivation of ciphering of the U-Plane is not controlled by the eNB NOTE 3: Key set for RRC protection cannot be used to derive NAS and user-plane keys.		

11 MBMS

This subclause provides an overview on MBMS in E-UTRA/E-UTRAN.

11.1 MBMS principles

The E-UTRA/E-UTRAN supports the following principles for MBMS:

- E-UTRA/E-UTRAN should permit simultaneous, tightly integrated and efficient provisioning of dedicated (unicast) and MBMS services to the user;
- MBMS transmissions from several eNBs may be co-ordinated. Co-ordination of MBMS transmissions with SFNs may be done in several eNBs of an SFN area. SFNs may be differently defined in multiple SFN areas;
- To avoid unnecessary MBMS transmission in a cell where there is no MBMS user, the network may detect at least one MBMS user interested in the MBMS service in the cell e.g. by polling. It is FFS whether or not it is needed to count the precise number of UEs interested in an MBMS service;
- UEs in either RRC_IDLE or RRC_CONNECTED mode are allowed to receive an interested MBMS service;
- The scheduler may take into account UE capability and MBMS transmission to allow for simultaneous reception of unicast and broadcast services;
- TDM multiplexing of all MBMS services in one cell should be supported. This allows as low duty cycle as possible in the UE;
- The PDCP layer performs header compression for MBMS transmission;
- Single-cell services e.g. like CBS and multi-cell services e.g. with SFN may be supported by different transmission mechanisms;
- Link adaptation, on e.g. ack/nack, CQI report, etc, and improvements for single-cell MBMS transmission indicated to be studied further.
- MBMS may be provided on a frequency layer dedicated to MBMS (set of cells dedicated to MBMS transmission i.e. set of "MBMS dedicated cells") as well as on a frequency layer shared with non-MBMS services (set of cells supporting both unicast and MBMS transmissions i.e. set of "mixed cells").
- In order to enable RF combining on air interface three layers synchronization requirements are needed for the MBMS data transmission for SFN operation.

11.2 MBMS functions

The E-UTRAN supporting MBMS comprises eNBs and co-ordinating functions.

The functions hosted by the eNB may be:

- Scheduling and transmission of MBMS control information;
- Scheduling of single-cell MBMS transmissions;
- Transmission of single-cell and multi-cell MBMS services;
- Radio bearer control for MBMS.

The co-ordinating functions may include:

- Distribution of MBMS services;
- Co-ordination of multi-cell MBMS transmissions;
- MBMS SAE bearer control.

It is FFS which node in E-UTRAN performs the co-ordination functions.

11.3 MBMS transmission

A point-to-multipoint radio bearer is used to carry MBMS traffic. It is FFS whether a point-to-point radio bearer is also used to carry MBMS traffic or not. Improvements for single-cell MBMS transmission (e.g. HARQ) and MCS that would enable potential removal of p-t-p transmissions for MBMS are FFS.

A frequency layer can be dedicated to MBMS transmissions:

- When a cell belongs to a frequency layer dedicated to MBMS transmissions (MBMS dedicated cell):
    - The MBMS transmission (MTCH and MCCH) occurs on MCH or DL-SCH;
    - No uplink or counting mechanism supported; Counting may be done (FFS) in another "unicast" cell. Dedicated cell and "unicast" cell may have (partially) different coverage;
    - No support for unicast data transfer in the cell;
    - The MBMS transmission is self-sufficient and can be received by UE without a need for UE to listen to unicast transmission from another cell in parallel;
    - The MBMS transmission can be received in parallel to unicast transmission from another cell if UE capability allows it;
    - The occurrence of paging messages on the frequency layer dedicated to MBMS transmission is FFS:
    - If paging messages were allowed, the UE could answer in a non-E-UTRA cell e.g. UTRA cell (FFS).
    - The possible multi-cell p-t-m transmission with SFN operation on the MCH of the SFN area is semi-statically configured e.g. by O&M.
    - The possible single-cell p-t-m transmission.
- When a cell does not belong to a frequency layer dedicated to MBMS transmissions (mixed cell):
    - Transmission of both unicast and MBMS transmissions in the cell is done in a co-ordinated manner on DL-SCH and or MCH (FFS);
    - The possible SFN operation on the MCH of the SFN area is semi-statically configured e.g. by O&M; or the SFN area is dynamic and may be based on counting mechanisms (FFS).
    - The possibility to use counting;

- The possible p-t-p transmission on DL-SCH.

There may be two types of MBMS transmissions in E-UTRA/E-UTRAN:

a) Single-cell transmission (no SFN operation):

  - The MBMS service, e.g. message distribution, is transmitted only on the coverage of a specific cell;
  - The MBMS service (MTCH and MCCH) may be transmitted on DL-SCH or MCH (FFS);
  - Combining of MBMS transmission from multiple cells is not supported;
  - Counting for switching between p-t-p and p-t-m radio bearer may be supported (FFS);
  - For broadcast services on p-t-m radio bearers; or
  - For multicast services on p-t-p or p-t-m radio bearers: the p-t-m/p-t-p switching points are either dynamically decided based on counting mechanism or semi-statically configured by O&M (FFS).

b) Multi-cell transmission (SFN operation):

  - The MBMS service (MTCH and MCCH) is transmitted on MCH;
  - Combining is supported with SFN;
  - Synchronous transmission.

Figure 11.3 below summarized the possible p-t-m transmission scenarios for MBMS transmission in E-UTRAN:

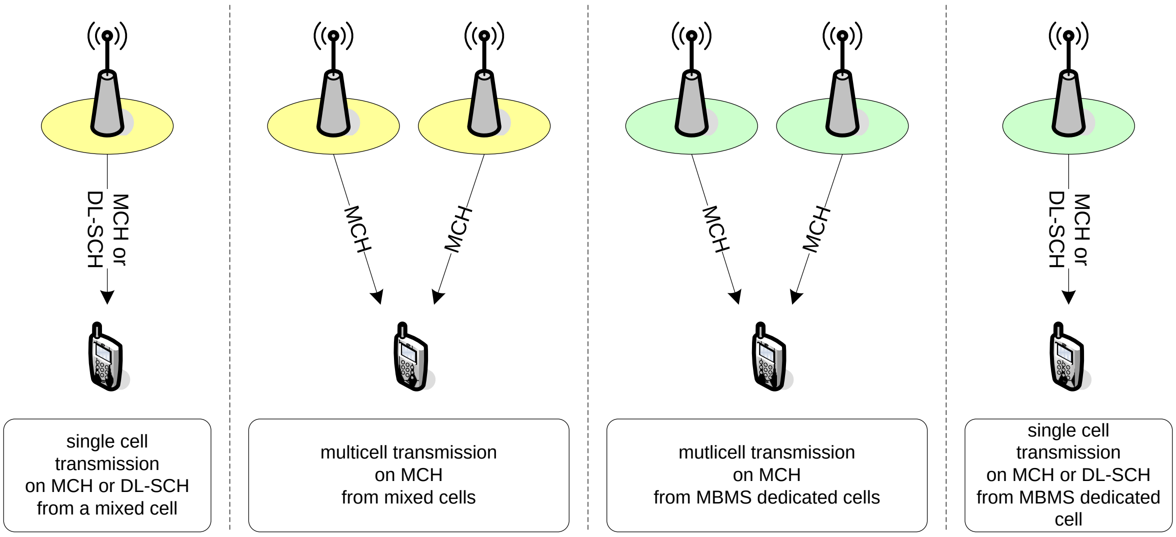

Figure 11.3: MBMS p-t-m Transmissions

The BCCH indicates where the MCCH(s) are:

- One (or none) MCCH per cell for cell specific transmission;
- MCCH(s) sent in SFN area for non-cell specific transmission.

Having a feedback mechanism for MTCH transmission is FFS: statistical feedback, TTI based NACK or something else. Also is FFS if the re-transmission is a single cell transmission in all cases.

11.4 Synchronization requirements for MBMS

MBMS Multi-cell transmission in SFN area can use combining in air to improve the performance on cell boundary. For this purpose there exist three layers synchronization requirements.

1) Physical layer frame timing synchronization where:

- The physical frame timing of each eNB in SFN area should be strictly aligned at the start boundary of each frame to guarantee the physical layer framing time synchronization. The precision requirement is in microsecond level.

2) L2 content transmission synchronization where:

- The same content of an MBMS service should be transmitted at the same time by each eNB in SFN area to guarantee that the same content can be combined in time at the UE.

3) Resource block allocation synchronization where:

- The physical resource block allocation pattern in each TTI should be coincident for all eNBs in SFN area to guarantee that the same resource block is used for the same MBMS service data in different eNBs.

The Figure 11.4 shows an example of these three layers synchronization requirements:

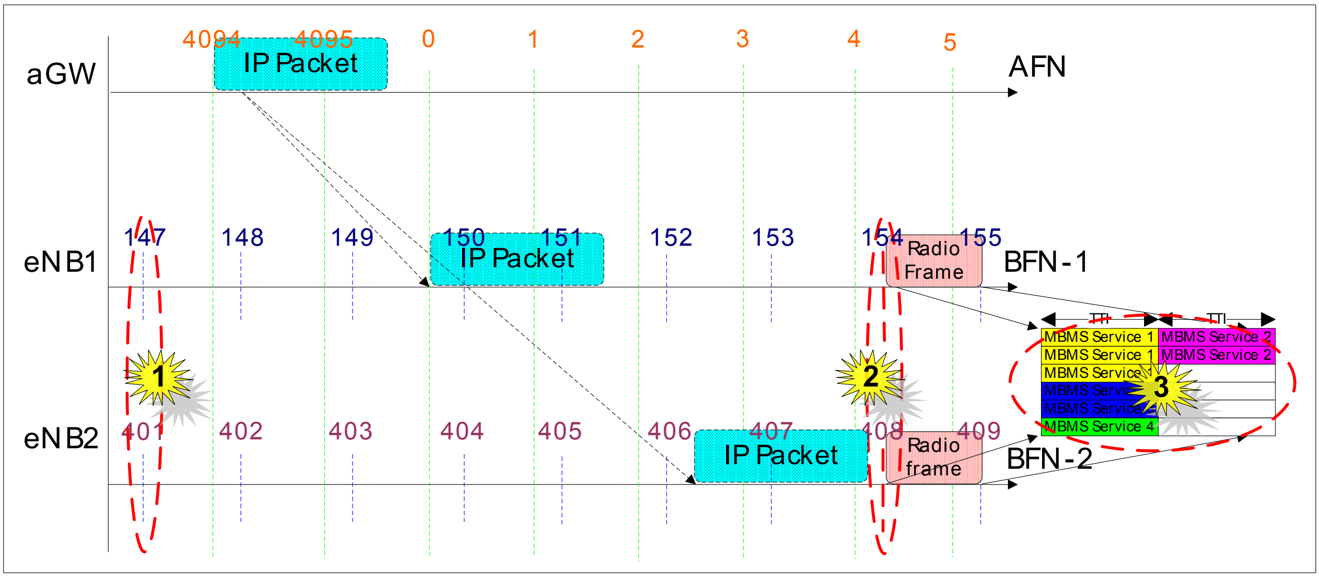

Figure11.4: Three layers synchronization requirements for MBMS RF combining in LTE SFN

NOTE: BFN is eNB frame number counter as the network synchronization reference, which is range from 0 to 4095. AFN is aGW frame number counter as the network synchronization reference, which is range from 0 to 4095.

12 Migration and compatibility

Editor's note: This clause will have a closer look at the evolution in terms of migration scenario and interaction with previous releases. It will summarize what will be described in 25.912 and 25.913 from a protocol architecture viewpoint. SA1 and SA2 should lead the way.

Editor's note: From R2-051759: concept of having two stacks in the UE with a legacy stack connecting to legacy CN via Iu, and a new stack. where E-RRC replaces NAS+RRC. Dual IP addresses.

12.1 Migration scenario

12.2 Interaction with previous releases

12.3 Interoperability

13 UE capabilities

Editor's note: This clause will deal with the UE capabilities from a RAN2 viewpoint (e.g. signalling support).

Editor's note: From R2-051759: Mandating dual Receiver should be discussed early (different views, UE manufacturers prefer single receiver; dual-receiver likely to be an optimisation (UE cap?). Possibility to have separate capability for 20MHz. Will need signalling support of capabilities.

14 Impact on specifications

14.1 Specification methodology

14.2 Affected specifications

Editor's note: This subclause will list the specifications that are affected – if any.

14.3 New specifications

Editor's note: This subclause will list the specifications that are affected – if any.

Annex A: RACH and Contention Resolution

The contention channel i.e. RACH, allows achieving the following:

- Synchronising the L1 timing (timing advance);
- Transmission of a X bits message towards the network MAC e.g. 16 bits;
- RAN1 should combine both if possible to gain time.

The X bits may have a different content depending on the case where the RACH is used. This is TBD:

- Some information on UL resources needed, priority, establishment cause, and random ID to assist in contention resolution;
- UE ID already allocated by the network to the UE.

In the case of the initial access, means for the network to prioritise the various requests should be possible.

After the X bits have been received by the network, the network is responsible to send to the UE:

- If necessary, timing advance information to be used on the UL SCH;
- If necessary, C-RNTI;
- Allocation of UL resources on UL SCH.

Contention resolution takes place using the UL/DL-SCH.

The RACH L1 channel may have multiple signatures in UL (to help resolving collisions). To be checked with RAN1.

Transmission of L3 messages, MAC data or control PDU, only takes place on the UL-SCH, possibly after the RACH procedure used to get an uplink allocation.

Resources for RACH are indicated by the network.

The RACH procedure can be used for (exact list TBD, details of its use/content of X bits TBD):

- Initial access to get UL SCH resources to send RRC connection request;
- To obtain L1 synchronisation;
- To request resources when no UL resources are available;
- In case of mobility.

Annex B:
Architecture Progress

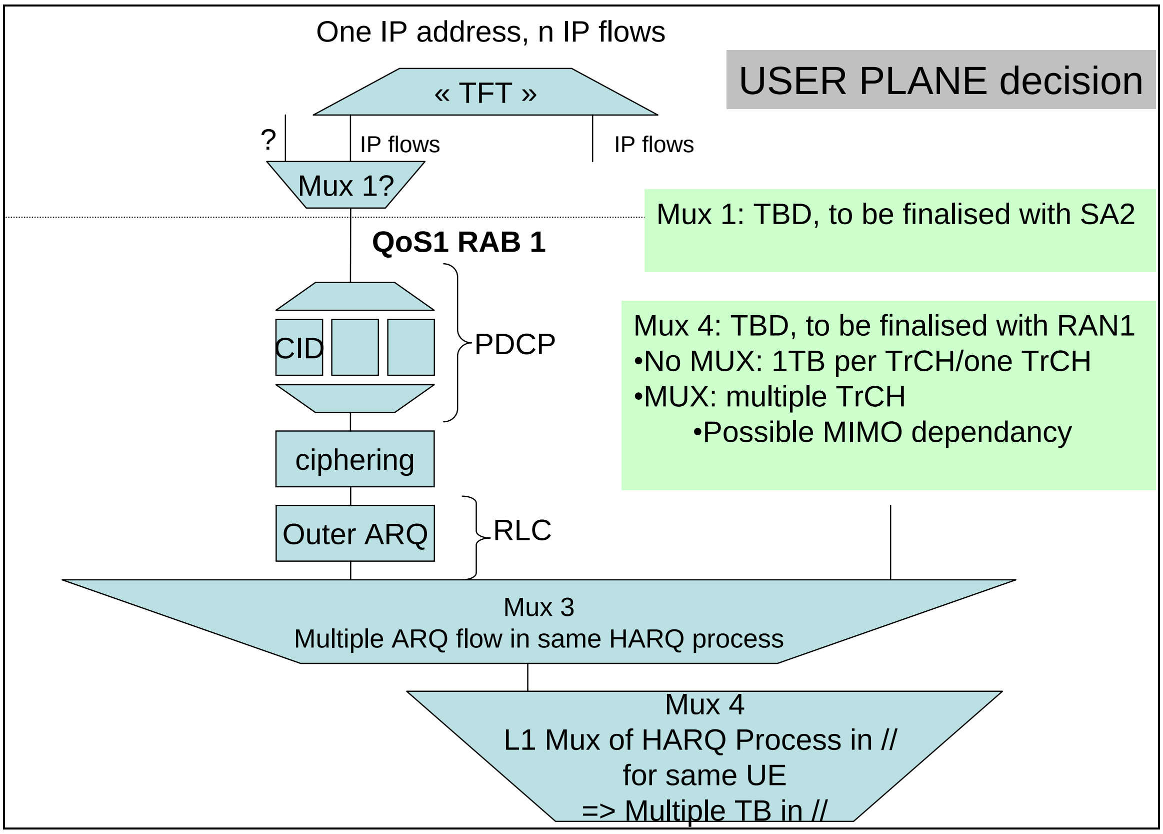

Figure B1: User Plane

Table B1: Location of Control Plane Functions

Function	eNB	aGW	Comment
Broadcast	+		Originated from aGW or O&M
Paging	+		Originated from aGW
aGW connection handling		+	NAS
Security control		+	
Mobility handling for LTE_ACTIVE state	+		
Measurement configuration and reporting for mobility	+		
Mobility handling for LTE_IDLE state		+	NAS
RAB/QoS control		+	NAS
Node-B level configuration	+		
Assignment of radio resources	+		
Identification and mapping of logical channels	+		
Scheduling for all channels incl BCH and PCH	+		
Measurements for scheduling	+		

Annex C: Change history

Change history							
Date	**TSG#**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2005-08	RAN2#48	R2-051787			Proposed Skeleton for RAN2#48		0.0.0
2005-08	RAN2#48	R2-052241			Proposed Skeleton for RAN2#48	0.0.0	0.0.1
2005-10	RAN2#49	R2-052730			Transport channels and Logical Channels added in Section 5	0.0.1	0.0.2
2005-11	RAN2#49	R2-053071			Presence of both HARQ and ARQ Overview of the E-UTRAN Architecture added	0.0.2	0.1.0
2006-01	RAN2#50	R2-060128			Editorship updated for MBMS section	0.1.0	0.1.1
2006-01	RAN2#50	R2-060133			Descriptive text for Handovers added in Section 9; Update of the transport channels in Section 5; Annex added to reflect agreements on RACH; Function for MAC, RRC and RLC listed in section 5; Termination points for security captured in section 10.1; Figure of logical channels to transport channels added in section 5. RRC States described in section 5.	0.1.1	0.2.0
2006-01	RAN2#50	R2-060146			Various editorial changes and clarifications	0.2.0	0.3.0
2006-02	RAN2#51	R2-060309			Update of the Nomenclature and removal of some editor's notes	0.3.0	0.3.1
2006-02	RAN2#51	R2-060760			Inclusion of the agreed MAC architecture	0.3.1	0.4.0
2006-02	RAN2#51	R2-060798			Editorial Corrections	0.4.0	0.4.1
2006-02	RAN2#51	R2-060803			Addition of the Chairman Notes of RAN2#51 in Annex C	0.4.1	0.5.0
2006-03	RAN#31	RP-060176			Agreement on the state names reflected throughout the document	0.5.0	0.5.1
2006-03	RAN2#52	RP-060825			Agreements of RAN#31 and from RP-060122 + SRJ-060059 included: ARQ and RRC in eNB, SAE Bearer + Radio Bearer	0.5.1	0.6.0
2006-03	RAN2#52	R2-061062			Section 5 updated to keep ARQ as a sublayer	0.6.0	0.6.1
2006-03	RAN2#52	R2-061063			Miscellaneous clarifications and updates	0.6.1	0.6.2
2006-03	RAN2#52	R2-061070			RLC introduced as a sublayer of layer 2 Agreements on ARQ, HARQ and their interaction captured State names updated for RRC: connected and idle	0.6.2	0.7.0
2006-03	RAN2#52	R2-061085			Generic description of the scheduler added Miscellaneous clarifications and corrections	0.7.0	0.7.1
2006-03	RAN2#52	R2-061092			Miscellaneous clarifications	0.7.1	0.7.2
2006-03	RAN2#52	R2-061099			Agreed text proposals on bandwidth scenario (R2-061098), ARQ/HARQ (R2-061098), UE identities (R2-061094) and handover scenarios (R2-061089) included	0.7.2	0.8.0
2006-03	RAN2#52	R2-061102			Minor updates following email review	0.8.0	0.8.1
2006-03	RAN2#52	R2-061103			Table of content updated. Reordering at MAC layer added as FFS in section 5.3.1.1.	0.8.1	0.8.2
2006-04	NA	Reflector			Proposed editorial corrections and clean up.	0.8.2	0.8.3
2006-04	NA	Reflector			Proposed editorial corrections and clean up following comments on the RAN2 email reflector	0.8.3	0.8.4
2006-05	RAN2#53	R2-061115			Proposed editorial corrections and clean up following comments on the RAN2 email reflector	0.8.4	0.8.5
2006-05	RAN2#53	R2-061769			Transport of NAS signalling described in section 5.5.3 Text proposals agreed at RAN2#53 included: - R2-061134 on Measurement Clarifications; - R2-061699 on Functions of the Physical Layer; - R2-061713 on Data handling upon intra EUTRAN handover; - R2-061714 on Intra-LTE Handover operation; - R2-061716 on PDCP sublayer; - R2-061783 on Cell Selection and Reselection; - R2-061792 on MBMS.	0.8.5	0.9.0
2006-05	RAN2#53	Reflector			Clarifications regarding the removal of NCH	0.9.0	0.9.1
2006-05	RAN2#53	R2-061814			Minor Clarifications after comments received on the reflector	0.9.1	0.9.2

2006-06	RAN2#53	Reflector			Agreement from RAN3#52 on RRM server (R3-060953) reflected in section 5.1: RRM server removed.	0.9.2	1.0.0
2006-06	RAN2#53	R2-061820			One clarification on the RRM Server.	1.0.0	1.0.1
2006-06	RP-32	RP-060390	-		Approved at TSG-RAN #32 and placed under Change Control	1.0.1	7.0.0
2006-09	RP-33	RP-060629	0001	3	MBMS Transmissions & synchronization requirements and removal of note 1	7.0.0	7.1.0