

NOTE: the total number of bits is 5 for TDD Frame Structure Type II.

2) Random Access Response generated by MAC on DL-SCH:

- Semi-synchronous (within a flexible window of which the size is one or more TTI) with message 1;
- No HARQ;
- Addressed to RA-RNTI on L1/L2 control channel;
- Conveys at least RA-preamble identifier, Timing Alignment information, initial UL grant and assignment of Temporary C-RNTI (which may or may not be made permanent upon RRC Contention Resolution);
- Intended for a variable number of UEs in one DL-SCH message.

3) First scheduled UL transmission on UL-SCH:

- Uses HARQ;
- Size of the transport blocks depends on the UL grant conveyed in step 2 and is at least 80 bits.
- For initial access:
 - Conveys the RRC Connection Request generated by the RRC layer and transmitted via CCCH;
 - Conveys at least NAS UE identifier but no NAS message;
 - RLC TM: no segmentation;
- After radio link failure:
 - Conveys the RRC Connection Re-establishment Request generated by the RRC layer and transmitted via CCCH;
 - RLC TM: no segmentation;
 - Does not contain any NAS message.
- After handover, in the target cell:
 - Conveys the ciphered and integrity protected RRC Handover Confirm generated by the RRC layer and transmitted via DCCH;
 - Conveys the C-RNTI of the UE (which was allocated via the Handover Command);
 - Includes an uplink Buffer Status Report when possible.
- For other events:
 - Conveys at least the C-RNTI of the UE.

4) Contention Resolution on DL-SCH:

- Early contention resolution shall be used i.e. eNB does not wait for NAS reply before resolving contention
- Not synchronised with message 3;
- HARQ is supported;
- Addressed to:
 - The Temporary C-RNTI on L1/L2 control channel for initial access and after radio link failure;
 - The C-RNTI for UE in RRC_CONNECTED;
- HARQ feedback is transmitted only by the UE which detects its own UE identity, as provided in message 3, echoed in the RRC Contention Resolution message;
- For initial access and after radio link failure, no segmentation is used (RLC-TM).

The Temporary C-RNTI is promoted to C-RNTI for a UE which detects RA success and does not already have a C-RNTI; it is dropped by others. A UE which detects RA success and already has a C-RNTI, resumes using its C-RNTI.

10.1.5.2 Non-contention based random access procedure

The non-contention based random access procedure is outlined on Figure 10.1.5.2-1 below:

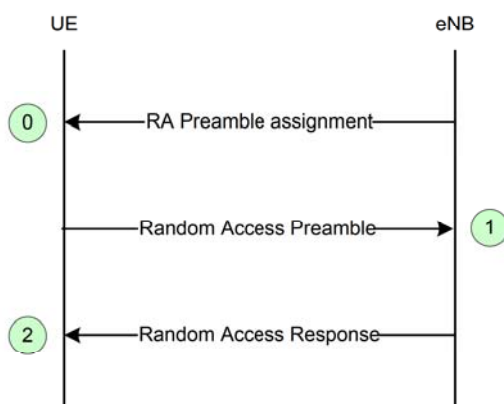


Figure 10.1.5.2-1: Non-contention based Random Access Procedure

The three steps of the non-contention based random access procedures are:

- 0) Random Access Preamble assignment via dedicated signalling in DL:
 - eNB assigns to UE a non-contention Random Access Preamble (a Random Access Preamble not within the set broadcasted on BCH).
 - Signalled via:
 - HO command generated by target eNB and sent via source eNB for handover;
 - MAC signalling (L1/L2 control channel or MAC control PDU is FFS) in case of DL data arrival.
- 1) Random Access Preamble on RACH in uplink:
 - UE transmits the assigned non-contention Random Access Preamble.
- 2) Random Access Response on DL-SCH:
 - Semi-synchronous (within a flexible window of which the size is one or more TTI) with message 1;
 - No HARQ;
 - Addressed to RA-RNTI on L1/L2 control channel;
 - Conveys at least:
 - Timing Alignment information and initial UL grant for handover;
 - Timing Alignment information for DL data arrival;
 - RA-preamble identifier.
 - Intended for one or multiple UEs in one DL-SCH message.

10.1.5.3 Interaction model between L1 and L2/3 for Random Access Procedure

Random access procedure described above is modelled in Figure 10.1.5.3-1 below from L1 and L2/3 interaction point of view. L2/L3 receives indication from L1 whether ACK is received or DTX is detected after indication of Random

Access Preamble transmission to L1. L2/3 indicates L1 to transmit first scheduled UL transmission (RRC Connection Request in case of initial access) if necessary or Random Access Preamble based on the indication from L1.

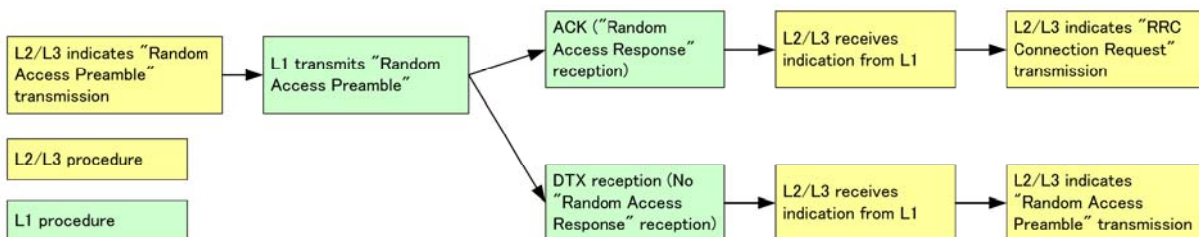


Figure 10.1.5.3-1: Interaction model between L1 and L2/3 for Random Access Procedure

10.1.6 Radio Link Failure

Two phases governs the behaviour associated to radio link failure as shown on Figure 10.1.6-1:

- First phase:
 - started upon radio problem detection;
 - leads to radio link failure detection;
 - no UE-based mobility;
 - based on timer or other (e.g. counting) criteria (T_1).
- Second Phase:
 - started upon radio link failure detection or handover failure;
 - leads to RRC_IDLE;
 - UE-based mobility;
 - Timer based (T_2).

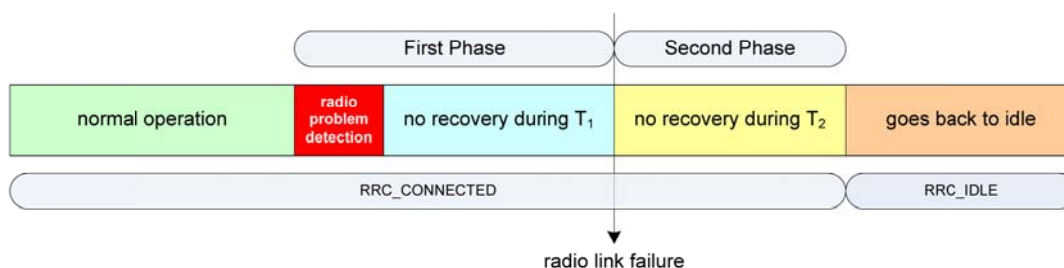


Figure 10.1.6-1: Radio Link Failure

Table 10.1.6-1 below describes how mobility is handled with respect to radio link failure:

Table 10.1.6-1: Mobility and Radio Link Failure

Cases	First Phase	Second Phase	T2 expired
UE returns to the same cell	Continue as if no radio problems occurred	Activity is resumed by means of explicit signalling between UE and eNB	Go via RRC_IDLE
UE selects a different cell from the same eNB	N/A	Activity is resumed by means of explicit signalling between UE and eNB	Go via RRC_IDLE
UE selects a cell of a prepared eNB (NOTE)	N/A	Activity is resumed by means of explicit signalling between UE and eNB	Go via RRC_IDLE
UE selects a cell of a different eNB that is not prepared (NOTE)	N/A	Go via RRC_IDLE (FFS)	Go via RRC_IDLE

NOTE: a prepared eNB is an eNB which has admitted the UE during an earlier executed HO preparation phase.

In the Second Phase, in order to resume activity and avoid going via RRC_IDLE when the UE returns to the same cell or when the UE selects a different cell from the same eNB, or when the UE selects a cell from a different eNB, the following procedure applies:

- The UE stays in RRC_CONNECTED;
- The UE accesses the cell through the random access procedure;
- The UE identifier used in the random access procedure for contention resolution (i.e. C-RNTI of the UE in the cell where the RLF occurred + physical layer identity of that cell + MAC based on the keys of that cell) is used by the selected eNB to authenticate the UE and check whether it has a context stored for that UE:
 - If the eNB finds a context that matches the identity of the UE, it indicates to the UE that its connection can be resumed;
 - If the context is not found, RRC connection is released and UE initiates procedure to establish new RRC connection. In this case UE may be required to go via RRC_IDLE (FFS).

10.1.7 Radio Access Network Sharing

E-UTRAN shall support radio access network sharing based on support for multi-to-multi relationship between E-UTRAN nodes and EPC nodes (S1-flex).

If the E-UTRAN is shared by multiple operators, the system information broadcasted in each shared cell contains the PLMN-id of each operator (up to 6) and a single tracking area code (TAC) valid within all the PLMNs sharing the radio access network resources.

The UE shall be able to read up to 6 PLMN-ids, to select one of the PLMN-ids at initial attachment and to indicate this PLMN-id to the E-UTRAN in subsequent instances of the Random Access procedures (e.g. as defined in subclause 10.1.5). The E-UTRAN shall select an appropriate MME for the PLMN indicated by the UE. Once attached to an MME, the UE shall be able to indicate the allocated MME in subsequent instances of the Random Access procedures. Whether the indication of the selected PLMN or the allocated MME is contained in the temporary UE identity or signalled separately is FFS.

Handling of area restrictions for UE in ECM-CONNECTED shall follow the principles specified in sub-clause 10.4.

10.1.8 Handling of Roaming and Area Restrictions for UEs in ECM-CONNECTED

Handling of roaming/area restrictions and handling of subscription specific preferences in ECM-CONNECTED is performed in the eNB based on information provided by the EPC over the S1 interface.

10.2 Inter RAT

Service-based redirection between GERAN / UTRAN and E-UTRAN is supported in both directions. This should not require inter-RAT reporting in RRC CONNECTION REQUEST.

10.2.1 Cell reselection

A UE in RRC_IDLE performs cell reselection. The principles of this procedure are as follows:

- The UE makes **measurements** of attributes of the serving and neighbour cells to enable the reselection process:
 - For a UE to search and measure neighbouring GERAN cells, the ARFCNs of the BCCH carriers need to be indicated in the serving cell system information (i.e., an NCL). The NCL does not contain BSICs or cell specific offsets and $Q_{rxlevmin}$ is given per frequency band.
 - For a UE to search and measure neighbouring UTRAN cells, the serving cell can indicate an NCL containing a list of carrier frequencies and scrambling codes.
 - Measurements may be omitted if the serving cell attribute fulfils particular search or measurement criteria.
- **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:
 - Inter-RAT reselection is based on absolute priorities where UE tries to camp on highest priority RAT available. Absolute priorities for inter-RAT reselection are provided only by the RPLMN and valid only within the RPLMN; priorities are given by the system information and valid for all UEs in a cell, specific priorities per UE can be signalled in the RRC Connection Release message. A validity time can be associated with UE specific priorities.
 - It should be possible to prevent the UE from reselecting to specific detected neighbouring cells;
 - The UE is allowed to "leave" the source E-UTRAN cell to read the target GERAN cell broadcast, in order to determine its "suitability", prior to completing the cell reselection;
 - Cell reselection can be speed dependent (speed detection based on UTRAN solution);

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") applicable for mobiles in RRC_IDLE mode.

When performing cell reselection while the UE is camped on another RAT, the principles of this procedure are as follows:

- The UE measures attributes of the E-UTRA neighbouring cells:
 - Only the carrier frequencies need to be indicated to enable the UE to search and measure E-UTRA neighbouring cells;
- 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:
 - For E-UTRA neighbouring cells, there is no need to indicate cell-specific cell reselection parameters i.e. these parameters are common to all neighbouring cells on an E-UTRA frequency;
- Cell reselection parameters are applicable to all UEs in a cell, but it is possible to configure specific reselection parameters per UE group or per UE.
- It should be possible to prevent the UE from reselecting to specific detected neighbouring cells.

10.2.2 Handover

Inter RAT HO is designed so that changes to GERAN and UTRAN are minimised. This can be done by following the principles specified for GERAN to/from UTRAN intersystem HO. In particular the following principles are applied to E-UTRAN Inter RAT HO design:

1. Inter RAT HO is network controlled through source access system. The source access system decides about starting the preparation and provides the necessary information to the target system in the format required by the target system. That is, the source system adapts to the target system. The actual handover execution is decided in the source system.
2. Inter RAT HO is backwards handover, i.e. radio resources are prepared in the target 3GPP access system before the UE is commanded by the source 3GPP access system to change to the target 3GPP access system.
3. To enable backwards handover, and while RAN level interfaces are not available, a control interface exists in CN level. In Inter RAT HO involving E-UTRAN access, this interface is between 2G/3G SGSN and corresponding MME/Serving Gateway.
4. The target access system will be responsible for giving exact guidance for the UE on how to make the radio access there (this includes radio resource configuration, target cell system information etc.). This information is given during the handover preparation and should be transported completely transparently through the source access system to the UE.
5. Mechanisms for avoiding or mitigating the loss of user data (i.e. forwarding) can be used until the 3GPP Anchor determines that it can send DL U-plane data directly to the target system.
6. The handover procedure should not require any UE to CN signalling in order for data to start to flow in the target system. This requires that the security context, UE capability context and QoS context is transferred (or translated) within the network between source and target system.
7. Similar handover procedure should apply for handovers of both real time and non-real time services.
8. Similar handover procedure should apply for both Inter RAT Handover and intra-LTE Handover with EPC node change.
9. Network controlled mobility is supported even if no prior UE measurements have been performed on the target cell and/or frequency i.e. "blind HO" is supported.

10.2.2a Inter-RAT cell change order to GERAN with NACC

For interworking towards GERAN, inter-RAT cell change order with NACC is supported even if no prior UE measurements have been performed on the system i.e. "blind NACC" is supported.

10.2.3 Measurements

10.2.3.1 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.

10.2.3.2 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.

10.2.3.3 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.

10.2.3.4 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.

10.2.4 Network Aspects

Inter-frequency/inter-RAT UE based mobility relies on a “priority based scheme”, where the network configures a list of RATs/frequencies to be taken as basis for UE’s inter-frequency/inter-RAT cell reselection decisions in priority order. E-UTRAN cells can enable inter-frequency/inter-RAT cell reselection by broadcasting a common priority valid for all UEs in a given cell in addition to other inter-frequency/inter-RAT information.

NOTE: The same principles apply in UTRAN.

These common priorities can be overwritten by E-UTRAN through dedicated signalling to individual UEs at RRC_CONNECTED to RRC_IDLE transition.

NOTE: In order to have consistent inter-RAT operation, the same principles apply to inter-RAT reselection to E-UTRAN. For UTRAN this includes also the transitions within RRC_CONNECTED state from CELL_DCH to CELL_PCH and URA_PCH.

Setting dedicated priorities by E-UTRAN can be based on subscription related information provided by the MME.

NOTE: The same principle have been taken as a working assumption in UTRAN (awaiting for SA2 decision on feasibility of providing subscription related information by the CN).

10.3 Mobility between E-UTRAN and Non-3GPP radio technologies

10.3.1 UE Capability Configuration

A UE shall be able to communicate with the E-UTRAN about its radio access capability, such as the system (including the release and frequency band) it supports and it’s receive and transmit capabilities (single/dual radio, dual receiver). UE shall transfer its capability about other radio technologies over E-UTRAN using the same procedure used to carry its E-UTRAN radio capability.

10.3.2 Mobility between E-UTRAN and cdma2000 network

This section describes the E-UTRAN mechanisms to support idle and active mode mobility between E-UTRAN and cdma2000 HRPD or 1xRTT. The overall system is described in [17].

10.3.2.1 Tunnelling of cdma2000 Messages over E-UTRAN between UE and cdma2000 Access Nodes

In order to efficiently support handover procedures when on E-UTRAN with a cdma2000 target system, cdma2000 messages are sent transparently to the target system over the E-UTRAN, with the eNB and MME acting as relay points.

To support the MME in its selection of the correct target system node to which it should route an Uplink tunnelled message and to provide the target system with information that is needed to resolve technology-specific measurement information (RouteUpdate and pilot strength measurements) that are delivered to the cdma2000 system each eNB cell is associated with a cdma2000 HRPD SectorID and/or with a cdma2000 1xRTT SectorID (generically referred to as cdma2000 reference cellid). This cdma2000 reference cellid is provided by the eNB to the MME using the cdma2000 message transfer capability over S1-AP and forwarded to the target system via the S101 interface and corresponding interface to the cdma2000 1xRTT system.

Tunnelling is achieved over the E-UTRAN radio interface by encapsulating tunnelled cdma2000 messages in the UL Information Transfer and DL Information Transfer RRC messages (e.g., similar to UMTS Uplink/Downlink Direct Transfer). A specific IE in these RRC messages is used to identify the type of information contained in the message (e.g., NAS, TunneledMsg). Additionally if the message is carrying a tunnelled message, an additional IE is included to carry RRC Tunnelling Procedure Information.

RRC Tunnelling Procedure Information in the UL direction will include:

- RAT type (1xRTT encapsulated, HRPD encapsulated);
- cdma2000 message type (e.g. pre-registration or handover initiation).

RRC Tunnelling Procedure Information in the DL direction will include:

- RAT type (1xRTT encapsulated, HRPD encapsulated).

AS level security will be applied for these UL Information Transfer and DL Information Transfer RRC messages as normal but there is no NAS level security for these tunnelled cdma2000 messages.

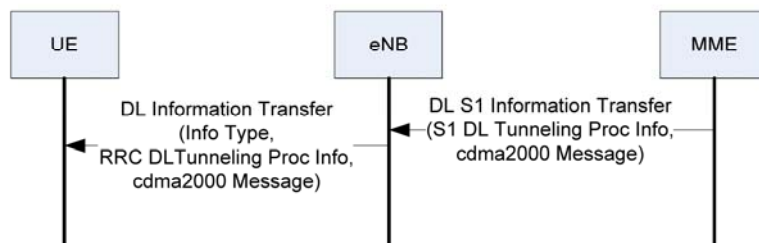


Figure 10.3.2.1-1: Downlink Direct Transfer

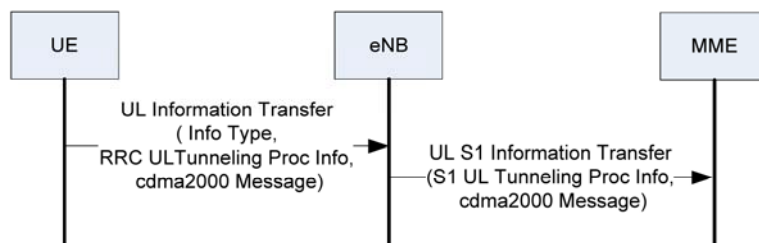


Figure 10.3.2.1-2: Uplink Direct Transfer

Tunnelling to the MME is achieved over the S1-MME interface by encapsulating the tunnelled cdma2000 message in a new S1-MME S1 Information Transfer message. These S1-MME messages carry S1 Tunnelling Procedure Information as well as the tunnelled message.

S1 Tunnelling Procedure Information in the UL direction will include:

- cdma2000 Reference Cell Id;

- RAT type (1xRTT encapsulated, HRPD encapsulated);
- cdma2000 message type (e.g. pre-registration or handover initiation).

S1 Tunnelling Procedure Information in the DL direction will include:

- RAT type (1xRTT encapsulated, HRPD encapsulated);
- cdma2000 message type (e.g. pre-registration or handover completion);
- Data forwarding information if required.

10.3.2.2 Mobility between E-UTRAN and HRPD

10.3.2.2.1 Mobility from E-UTRAN to HRPD

10.3.2.2.1.1 HRPD System Information Transmission in E-UTRAN

The HRPD system information block (SIB) shall be sent on the E-UTRAN BCCH. The UE shall monitor the E-UTRAN BCCH during the RRC_IDLE and RRC_CONNECTED modes to retrieve the HRPD system information for the preparation of cell reselection or handover from the E-UTRAN to HRPD system. HRPD system information may also be provided to the UE by means of dedicated signalling. The following HRPD system information is transmitted on E-UTRAN BCCH:

- HRPD pre-registration allowed;
- HRPD Pre-registration Zone;
- HRPD Neighbour Bandclass;
- HRPD Neighbour Frequency;
- HRPD Neighbour PN Sequence Offset;
- HRPD Pilot PN sequence offset index increment;
- HRPD Timing Reference;
- HRPD Searching Window Size;
- Number of HRPD Neighbour Bandclass;
- Number of HRPD Neighbour Frequency;
- Number of HRPD Neighbour PN Sequence Offset;
- HRPD Start Measuring E-UTRAN Signal Quality Threshold;
- HRPD Start Measuring E-UTRAN Rx Power Strength Threshold.

10.3.2.2.1.2 Measuring HRPD from E-UTRAN

Measurement events and parameters for HRPD measurements are to be aligned with those defined in section 10.2.3.

10.3.2.2.1.2.1 Idle Mode Measurement Control

UE shall be able to make measurements on the HRPD cells in RRC_IDLE mode to perform cell re-selection.

The intra-3GPP inter-RAT idle mode measurement control is re-used to control the idle mode measurements on HRPD. The UE performs measurement on HRPD when the signal quality from E-UTRAN serving cell falls below a given threshold.

10.3.2.2.1.2.2 Active Mode Measurement Control

In RRC_CONNECTED mode, the UE shall perform radio measurements on the HRPD network when directed by the E-UTRAN network. The network provides the required HRPD neighbour cell list information and measurement controls to the UE through dedicated RRC signalling. When needed the eNB is responsible for configuring and activating the HRPD measurements on the UE via the dedicated RRC signalling message. Periodic and event-triggered measurements are supported.

For single-radio terminals, measurement gaps are needed to allow the UE to switch into the HRPD network and do radio measurements. These measurement gaps are network-controlled. The eNB is responsible for configuring the gap pattern and providing it to the UE through RRC dedicated signalling. Terminals with a dual receiver perform measurements on HRPD neighbour cells without tuning away from the E-UTRAN network. No DL gap patterns will be required for UEs which are capable of simultaneous reception on the involved frequency bands. No UL gap patterns will be required for UEs which are capable simultaneous transmission in one access and measuring on another access.

10.3.2.2.1.2.3 Active Mode Measurement

In RRC_CONNECTED mode, the UE measures the strengths of each of the HRPD neighbour cells and reports them in an RRC message.

10.3.2.2.1.3 Pre-registration to HRPD Procedure

Pre-registration allows a UE to establish a presence with an HRPD system in advance of a cell re-selection or handover. E-UTRAN network instructs the UE whether the pre-registration is needed over broadcast channel and in a dedicated RRC message.

E-UTRAN does not need to know whether a specific UE is pre-registered or not. The procedure is transparent to E-UTRAN network. In the pre-registration to HRPD, messages shall be tunnelled inside RRC and S1-AP messages between the UE and MME and in a generic "transfer" message between source MME and target RNC.

The UE is responsible for maintaining the HRPD context e.g. by performing periodic re-registrations if needed. The UE will use "HRPD Pre-registration Zone" to decide whether a re-registration shall be performed. A dual-receiver UE can ignore the parameter. E-UTRAN will provide the "HRPD Pre-registration Zone" parameter on the E-UTRAN system information broadcast channel or dedicated RRC signalling (unless it is determined that the UE will read the E-UTRAN system information broadcast channel in RRC_CONNECTED). Re-registrations are only allowed in areas where pre-registration is requested.

10.3.2.2.1.4 E-UTRAN to HRPD Cell Re-selection

The pre-condition for cell re-selection from E-UTRAN to HRPD is that the UE has previously established a presence in the target HRPD network, either through the pre-registration procedure or previous HRPD attachment. The UE performs Cell re-selection to HRPD while in RRC_IDLE.

Cell reselection from E-UTRAN to HRPD should be aligned with 3GPP inter RAT cell reselection mechanism. . .

10.3.2.2.1.5 E-UTRAN to HRPD Handover

The pre-condition for the E-UTRAN to HRPD Handover procedure is that the UE is attached in the E-UTRAN network in E-UTRAN_ACTIVE state and has pre-registered with the HRPD network. Based on measurement reports received from the UE the eNB initiates a handover by sending an RRC message to the UE to indicate to the UE that it should begin the handover procedure. This message shall include the specified target type and any cdma2000 specific HRPD parameters needed by the UE to create the appropriate HRPD messages needed to request a connection. These HRPD parameters are transparent to E-UTRAN. The set of the required HRPD parameters are out of scope of this specification.

The UE can continue to send and receive data on the E-UTRAN radio until it receives the "handover command". After the "handover command" is received by the UE, the UE shall leave the E-UTRAN radio and start acquiring the HRPD traffic channel. The HRPD handover signalling is tunnelled between the UE and HRPD network. The HRPD network sends the high level progress of the ongoing HRPD signalling (e.g. Handover Success, Handover Failure) to E-UTRAN.

10.3.2.2.2 Mobility from HRPD to E-UTRAN

Mobility from HRPD to E-UTRAN has no impact on the E-UTRAN.

10.3.2.3 Mobility between E-UTRAN and cdma2000 1xRTT

10.3.2.3.1 Mobility from E-UTRAN to cdma2000 1xRTT

10.3.2.3.1.1 cdma2000 1xRTT System Information Transmission in E-UTRAN

The cdma2000 1xRTT system information block (SIB) shall be sent on E-UTRAN BCCH. The UE shall monitor the E-UTRAN BCCH during the LTE_IDLE and RRC_CONNECTED modes to retrieve the 1xRTT system information for the preparation of handover from the E-UTRAN to cdma2000 1xRTT system. 1xRTT system information may also be provided to the UE by means of dedicated signalling. The following cdma2000 1xRTT system information shall be carried on E-UTRAN BCCH:

- cdma2000 1X Neighbour Bandclass;
- cdma2000 1X Neighbour Frequency;
- cdma2000 1X Neighbour PN Sequence Offset;
- cdma2000 1X Pilot PN sequence offset index increment;
- cdma2000 1X Timing Reference;
- cdma2000 1x Searching Window Size;
- Number of cdma2000 1X Neighbour Bandclass;
- Number of cdma2000 1X Neighbour Frequency;
- Number of cdma2000 1X Neighbour PN Sequence Offset;
- cdma2000 1X Start Measuring E-UTRAN Signal Quality Threshold;
- cdma2000 1X Start Measuring E-UTRAN Rx Power Strength Threshold.

10.3.2.3.1.2 Measuring cdma2000 1xRTT from E-UTRAN

Measurement events and parameters for 1xRTT measurements are to be aligned with those defined in section 10.2.3.

10.3.2.3.1.2.1 Idle Mode Measurement Control

UE shall be able to make measurements on the 1xRTT system cells in LTE_IDLE mode to perform cell re-selection. UE shall perform cdma2000 1xRTT neighbour cell measurements during DRX periods, between paging occasions.

The intra-3GPP inter-RAT idle mode measurement control is re-used to control the idle mode measurements on cdma2000 1xRTT. The UE performs measurement on cdma2000 1xRTT when the signal quality from E-UTRAN serving cell falls below a given threshold.

10.3.2.3.1.2.2 Active Mode Measurement Control

In the E-UTRAN network, in RRC_CONNECTED mode, the UE shall perform radio measurements on the cdma2000 1xRTT network when directed by the E-UTRAN network. The network provides the required cdma2000 1xRTT neighbour cell list information and measurement controls to the UE through dedicated RRC signalling. When needed the eNB is responsible for configuring and activating the cdma2000 1xRTT measurements on the UE via the dedicated RRC signalling message. As for intra-3GPP inter-RAT measurement reporting, periodic and event-triggered measurements are supported.

For single-radio terminals, measurement gaps are needed to allow the UE to switch into the cdma2000 1xRTT network and do radio measurements. These Measurement gaps are network-controlled. The eNB is responsible for configuring the gap pattern and providing it to the UE through RRC dedicated signalling. Terminals with a dual receiver perform measurements on cdma2000 1xRTT neighbour cells without tuning away from the E-UTRAN network. No DL gap patterns will be required for UEs which are capable of simultaneous reception on the involved frequency bands. No UL gap patterns will be required for UEs which are capable simultaneous transmission in one access and measuring on another access.

10.3.2.3.1.2.3 Active Mode Measurement

In RRC_CONNECTED mode, the UE measures the strengths of each of the cdma2000 1xRTT neighbour cells and reports them in an RRC Message.

10.3.2.3.1.3 E-UTRAN to cdma2000 1xRTT Cell Re-selection

UE performs Cell re-selection to cdma2000 1xRTT while in RRC_IDLE.

Cell reselection from E-UTRAN to 1xRTT should be aligned with 3GPP inter RAT cell reselection mechanism.

10.3.2.3.1.4 E-UTRAN to cdma2000 1xRTT Handover

In the high level procedure for handover from E-UTRAN to cdma2000 1xRTT, registration and handover is performed directly after the handover decision has been made. Based on measurement reports received from the UE the eNB initiates a handover by sending a RRC message to the UE to indicate to the UE that it should begin the handover procedure. This message shall include the specified target type and any cdma2000 specific 1xRTT access parameters needed by the UE to create the appropriate 1xRTT Origination Request message. The 1xRTT access parameters are transparent to E-UTRAN. The set of the required 1xRTT access parameters are out of scope of this specification.

10.3.2.3.2 Mobility from cdma2000 1xRTT to E-UTRAN

Mobility from cdma2000 1xRTT has no impact on E-UTRAN.

10.4 Area Restrictions

Information on which area restrictions to be applied during ECM-CONNECTED state is provided by the MME at context setup over the S1 interface.

The eNB shall store the UE restriction information and use it to determine whether the UE has access to radio resources in the E-UTRAN. The source eNB should apply restriction handling when selecting a target eNB.

The available UE restriction information shall be propagated by the source eNB over X2 at intra E-UTRAN handover.

10.5 Mobility to and from CSG cells

10.5.1 Inbound mobility to CSG cells

10.5.1.1 RRC_IDLE

Cell selection/reselection to CSG cells is based on a UE autonomous search function. The search function determines itself when/where to search.

It is FFS whether specific UE procedures or performance requirements will be specified.

UE checks the suitability of CSG cells (identified by the 1 bit indicator) based on the CSG whitelist in the UE (provided by upper layers). A CSG cell is only suitable for a UE if it belongs to its whitelist.

The automated searching for the CSG cells by the UE shall be disabled by the search function, if the CSG whitelist configured in the UE is empty.

In addition, manual selection of CSG cells is supported.

Cell selection/reselection to CSG cells does not require the network to provide neighbour cell information to the UE. The neighbour cell information can be provided to help the UE in specific cases, e.g. where the network wishes to trigger the UE to search for CSG cells.

10.5.1.2 RRC_CONNECTED

UE autonomously searches for CSG cells and can indicate the need for measurement gaps to the network (e.g. to check the suitability of the CSG cell). Upon network decision measurement gaps might be granted.

The automated searching for the CSG cells by the UE shall be disabled by the search function, if the CSG whitelist configured in the UE is empty.

UE checks the suitability of CSG cells (identified by the 1 bit indicator) based on the CSG whitelist in the UE (provided by upper layers). The UE shall report suitable CSG cells and/or any CSG cells including an indication that particular CSG cells are suitable to the serving cell.

Measurement reporting of CSG cells does not require the network to provide neighbour cell information to the UE. The neighbour cell information can be provided to help the UE in specific cases, e.g. where the network wishes to trigger the UE to search for CSG cells.

NOTE: in some case it might require that appropriate gaps are given to the UE.

10.5.2 Outbound mobility from CSG cells

10.5.2.1 RRC_IDLE

For a UE leaving a CSG cell in idle mode normal cell reselection based on configuration from the BCCH of the CSG cell applies.

10.5.2.2 RRC_CONNECTED

For a UE leaving a CSG cell in active mode normal network controlled mobility applies.

11 Scheduling and Rate Control

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.

11.1 Basic 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.

The scheduler should take account of the traffic volume and the QoS requirements of each UE and associated radio bearers, when sharing resources between UEs. Only “per UE” grants are used to grant the right to transmit on the UL-SCH (i.e. there are no “per UE per RB” grants).

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 physical resource blocks (PRB) and MCS. Allocations for time periods longer than one TTI might also require additional information (allocation time, allocation repetition factor...).

11.1.1 Downlink Scheduling

In the downlink, E-UTRAN can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on L1/L2 control channel(s). A UE always monitors the L1/L2 control channel(s) in order to find possible allocation when its downlink reception is enabled (activity governed by DRX).

In addition, E-UTRAN can allocate persistent downlink resources for the first HARQ transmissions to UEs. When required, retransmissions are explicitly signalled via the L1/L2 control channel(s). In the sub-frames where the UE has persistent resource, if the UE cannot find its C-RNTI on the L1/L2 control channel(s), a downlink transmission according to the persistent allocation that the UE has been assigned in the TTI is assumed. Otherwise, in the sub-frames

where the UE has persistent resource, if the UE finds its C-RNTI on the L1/L2 control channel(s), the L1/L2 control channel allocation overrides the persistent allocation for that TTI and the UE does not decode the persistent resources.

11.1.2 Uplink Scheduling

In the uplink, E-UTRAN can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on L1/L2 control channel(s). A UE always monitors the L1/L2 control channel(s) in order to find possible allocation for uplink transmission when its downlink reception is enabled (activity governed by DRX).

In addition, E-UTRAN can allocate a persistent uplink resource for the first HARQ transmissions and potentially retransmissions to UEs:

- RRC defines the periodicity of the persistent grant;
- PDCCH indicates whether the UL grant is a persistent one i.e. whether it can be implicitly reused in the following TTIs according to the periodicity defined by RRC.

In the sub-frames where the UE has persistent resource, if the UE cannot find its C-RNTI on the L1/L2 control channel(s), an uplink transmission according to the persistent allocation that the UE has been assigned in the TTI can be made. The network performs decoding of the pre-defined PRBs according to the pre-defined MCS. Otherwise, in the sub-frames where the UE has persistent resource, if the UE finds its C-RNTI on the L1/L2 control channel(s), the L1/L2 control channel allocation overrides the persistent allocation for that TTI and the UE's transmission follows the L1/L2 control, not the persistent allocation. Retransmissions are either implicitly allocated in which case the UE uses the persistent allocation, or explicitly allocated via L1/L2 control channel(s) in which case the UE does not follow the persistent allocation.

NOTE: there is no blind decoding in uplink and when the UE does not have enough data to fill the allocated resource, padding is used.

11.2 Void

11.3 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 UE's radio environment.

Uplink buffer status reports (BSR) are needed to provide support for QoS-aware packet scheduling. In E-UTRAN uplink buffer status reports refer to the data that is buffered in for a group of radio bearers (RBG) in the UE. Four RBGs and two formats are used for reporting in uplink:

- A short format for which only one BSR (of one RBG) is reported;
- A long format for which all four BSRs (of all four RBGs) are reported.

Uplink buffer status reports are transmitted using MAC signalling.

11.4 Rate Control of GBR and AMBR

11.4.1 Downlink

The eNB guarantees the downlink GBR associated with a GBR bearer and enforces the downlink AMBR associated with a group of Non-GBR bearers.

11.4.2 Uplink

The UE has an uplink rate control function which manages the sharing of uplink resources between radio bearers. RRC controls the uplink rate control function by giving each bearer a priority and a prioritised bit rate (PBR). The values signalled may not be related to the ones signalled via S1 to the eNB.

The uplink rate control function ensures that the UE serves its radio bearer(s) in the following sequence:

1. All the radio bearer(s) in decreasing priority order up to their PBR;
2. All the radio bearer(s) in decreasing priority order for the remaining resources assigned by the grant.

NOTE1: In case the PBRs are all set to zero, the first step is skipped and the radio bearer(s) are served in strict priority order: the UE maximises the transmission of higher priority data.

NOTE2: By limiting the total grant to the UE, the eNB can ensure that the AMBR is not exceeded.

If more than one radio bearer has the same priority, the UE shall serve these radio bearers equally.

11.5 CQI reporting for Scheduling

The time and frequency resources used by the UE to report CQI are under the control of the eNB. CQI reporting can be either periodic or aperiodic. A UE can be configured to have both periodic and aperiodic reporting at the same time. In case both periodic and aperiodic reporting occurs in the same subframe, only the aperiodic report is transmitted in that subframe.

For efficient support of localized, distributed and MIMO transmissions, E-UTRA supports three types of CQI reporting:

- Wideband type: providing channel quality information of entire system bandwidth of the cell;
- Multi-band type: providing channel quality information of some subset(s) of system bandwidth of the cell;
- MIMO type: FFS.

Periodic CQI reporting is defined by the following characteristics:

- When the UE is allocated PUSCH resources in a subframe where a periodic CQI report is configured to be sent, the periodic CQI report is transmitted together with uplink data on the PUSCH. Otherwise, the periodic CQI reports are sent on the PUCCH.

Aperiodic CQI reporting is defined by the following characteristics:

- The report is scheduled by the eNB via the PDCCH;
- Transmitted together with uplink data on PUSCH.

When a CQI report is transmitted together with uplink data on PUSCH, it is multiplexed with the transport block by L1 (i.e. the CQI report is not part of the uplink the transport block).

The eNB configures a set of sizes and formats of the reports. Size and format of the report depends on whether it is transmitted over PUCCH or PUSCH and whether it is a periodic or aperiodic CQI report.

12 DRX in RRC_CONNECTED

In order to enable reasonable UE battery consumption, DRX in E-UTRAN is characterised by the following:

- Per UE mechanism (as opposed to per radio bearer);
- No RRC or MAC substate to distinguish between different levels of DRX;

- Available DRX values are controlled by the network and start from non-DRX up to x seconds. Value x may be as long as the paging DRX used in ECM-IDLE;
- Measurement requirement and reporting criteria can differ according to the length of the DRX interval i.e. long DRX intervals may experience more relaxed requirements;
- The UE may omit measurements of neighbouring cells when the DRX interval is above a threshold and if the radio quality of the serving cell is above another threshold. To configure this behaviour in the UE, the two thresholds may be indicated by the eNB;
- Irrespective of DRX, UE may use first available RACH opportunity to send an UL measurement report;
- Immediately after sending a measurement report, the UE may change its DRX. This mechanism would be pre-configured by the eNB;
- HARQ operation related to data transmission is independent of DRX operation and the UE wakes up to read the PDCCH for possible retransmissions and/or ACK/NAK signalling regardless of DRX. In the downlink, a timer is used to limit the time the UE stays awake awaiting for a retransmission;
- When DRX is configured, the UE may be further configured with an "on-duration" timer during which time the UE monitors the L1/L2 control channels for possible allocations;
- When DRX is configured, periodic CQI reports can only be sent by the UE during the "on-duration";
- A timer in the UE is used to detect need for obtaining timing advance.

The following definitions apply to DRX in E-UTRAN:

- **on-duration:** duration in downlink subframes that the UE waits for, after waking up from DRX, to receive PDCCHs. If the UE successfully decodes a PDCCH, the UE stays awake and starts the inactivity timer;
- **inactivity-timer:** duration in downlink subframes (during wake time) that the UE waits to successfully decode a PDCCH, from the last successful decoding of a PDCCH, failing which it re-enters DRX. The UE shall restart the inactivity timer following a single successful decoding of a PDCCH for a first transmission only (i.e. not for retransmissions).
- **active-time:** total duration that the UE is awake. This includes the "on-duration" of the DRX cycle, the time UE is performing continuous reception while the inactivity timer has not expired and the time UE is performing continuous reception while waiting for a DL retransmission after one HARQ RTT. Based on the above the minimum active time is of length equal to on-duration, and the maximum is undefined (infinite);

Of the above parameters the on-duration and inactivity-timer are of fixed lengths, while the active-time is of varying lengths based on scheduling decision and UE decoding success. Only on-duration and inactivity-timer duration are signalled to the UE by the eNB:

- There is only one DRX configuration applied in the UE at any time;
- UE shall apply an on-duration on wake-up from DRX sleep;

NOTE: this is also applicable for the case where the UE has only one service (e.g. Real Time) that is being handled through the allocation of predefined resources; this allows for other signalling such as RRC to be sent during the remaining portion of the active time.

- New transmissions can only take place during the active-time (so that when the UE is waiting for one retransmission only, it does not have to be "awake" during the RTT).
- If PDCCH has not been successfully decoded during the on-duration, the UE shall follow the DRX configuration (i.e. the UE can enter DRX sleep if allowed by the DRX configuration):
 - This applies also for the sub-frames where the UE has been allocated predefined resources.
- If it successfully decodes a PDCCH for a first transmission, the UE shall stay awake and start the inactivity timer (even if a PDCCH is successfully decoded in the sub-frames where the UE has also been allocated predefined resources) until a MAC control message tells the UE to re-enter DRX, or until the inactivity timer expires. In both cases, the DRX cycle that the UE follows after re-entering DRX is given by the following rules:

- If a short DRX cycle is configured; the UE first follows the short DRX cycle and after a longer period of inactivity the UE follows the long DRX cycle;
- Else the UE follows the long DRX cycle directly.

13 QoS

13.1 QoS concept and bearer service architecture

The EPS bearer service layered architecture is depicted in Figure 13.1-1 below, where:

- An UL TFT in the UE binds an SDF to an EPS bearer in the uplink direction. Multiple SDFs can be multiplexed onto the same EPS bearer by including multiple uplink packet filters in the UL TFT.
- A DL TFT in the PDN GW binds an SDF to an EPS bearer in the downlink direction. Multiple SDFs can be multiplexed onto the same EPS bearer by including multiple downlink packet filters in the DL TFT.
- A radio bearer transports the packets of an EPS bearer between a UE and an eNB. There is a one-to-one mapping between an EPS bearer and a radio bearer.
- An S1 bearer transports the packets of an EPS bearer between an eNodeB and a Serving GW.
- An S5/S8 bearer transports the packets of an EPS bearer between a Serving GW and a PDN GW.
- A UE stores a mapping between an uplink packet filter and a radio bearer to create the binding between an SDF and a radio bearer in the uplink.
- A PDN GW stores a mapping between a downlink packet filter and an S5/S8a bearer to create the binding between an SDF and an S5/S8a bearer in the downlink.
- An eNB stores a one-to-one mapping between a radio bearer and an S1 to create the binding between a radio bearer and an S1 bearer in both the uplink and downlink.
- A Serving GW stores a one-to-one mapping between an S1 bearer and an S5/S8a bearer to create the binding between an S1 bearer and an S5/S8a bearer in both the uplink and downlink.

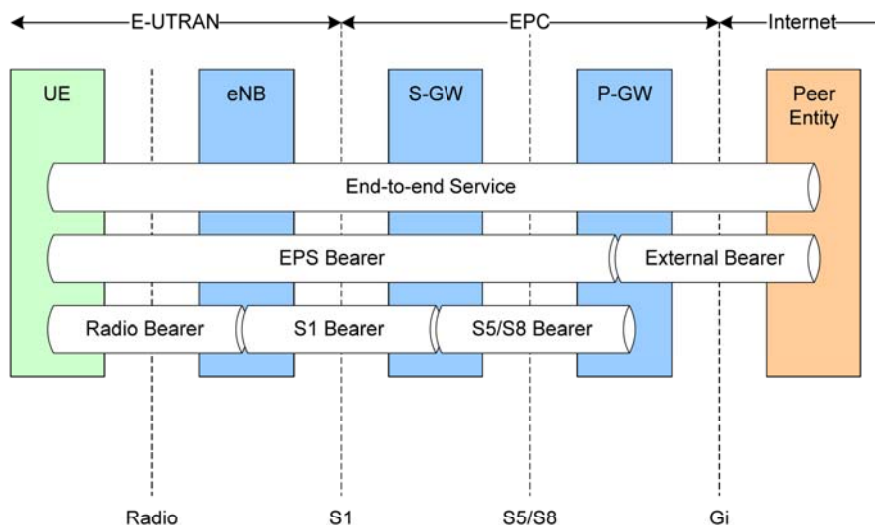


Figure 13.1-1: EPS Bearer Service Architecture

13.2 Resource establishment and QoS signalling

14 Security

14.1 Overview and Principles

The following principles apply to E-UTRAN security:

- The keys used for NAS and AS protection shall be dependent on the algorithm with which they are used;
- The eNB keys are cryptographically separated from the EPC keys used for NAS protection (making it impossible to use the eNB key to figure out an EPC key).
- The AS (RRC and UP) and NAS keys are derived in the EPC/UE from key material that was generated by a NAS (EPC/UE) level AKA procedure (K_{ASME}) and identified with a key identifier (KSI_{ASME}).
- The eNB key (K_{eNB}) is sent from the EPC to the eNB when the UE is entering ECM-CONNECTED state (i.e. during RRC connection or S1 context setup).
- Separate AS and NAS level security mode command procedures are used. AS level security mode command procedure configures AS security (RRC and user plane) and NAS level security mode command procedure configures NAS security. Both integrity protection and ciphering for RRC are activated within the same AS SMC procedure, but not necessarily within the same message. User plane ciphering is activated at the same time as RRC ciphering.
- Keys stored inside eNBs shall never leave a secure environment within the eNB (except when done in accordance with this or other 3GPP specifications), and user plane data ciphering/deciphering shall take place inside the secure environment where the related keys are stored.
- Key material for the eNB keys is sent between the eNBs during ECM-CONNECTED intra-E-UTRAN mobility.
- A sequence number is used as input to the ciphering and integrity protection. A given sequence number must only be used once for a given eNB key (except for identical re-transmission). The same sequence number can be used for both ciphering and integrity protection.
- A hyper frame number (HFN) (i.e. an overflow counter mechanism) is used in the eNB and UE in order to limit the actual number of sequence number bits that is needed to be sent over the radio. The HFN needs to be synchronized between the UE and eNB.
- If corruption of keys is detected, UE has to restart radio level attachment procedure (e.g. similar radio level procedure to idle-to-connected mode transition or initial attachment).
- No integrity protection initialisation number (FRESH).

The MME invokes the AKA procedures by requesting authentication vectors to the HE (Home environment). The HE sends an authentication response back to the MME that contains a fresh authentication vector, including a base-key named K_{ASME} . Thus, as a result of an AKA run, the EPC and the UE share K_{ASME} . From K_{ASME} , the NAS, (and indirectly) K_{eNB} keys are derived. The K_{ASME} never leaves the EPC, but the K_{eNB} key is transported to the eNB from the EPC when the UE transitions to ECM-CONNECTED. From the K_{eNB} , the eNB and UE can derive the UP and RRC keys. When the UE goes into ECM-IDLE, the K_{eNB} , UP and RRC keys are deleted from the eNB. The key hierarchy is depicted on Figure 14.1-1 below, where:

- K_{NASint} is a key, which shall only be used for the protection of NAS traffic with a particular integrity algorithm. This key is derived by UE and MME from K_{ASME} , as well as an identifier for the integrity algorithm.
- K_{NASenc} is a key, which shall only be used for the protection of NAS traffic with a particular encryption algorithm. This key is derived by UE and MME from K_{ASME} , as well as an identifier for the encryption algorithm.
- K_{eNB} is a key derived by UE and MME from K_{ASME} . K_{eNB} shall only be used for the derivation of keys for RRC traffic and the derivation of keys for UP traffic and the derivation of K_{eNB*} during HO.

- K_{eNB^*} is a key derived by UE and source eNB from K_{eNB} . K_{eNB^*} shall only be used by UE and target eNB at handover for the derivation of a new K_{eNB} for RRC and UP traffic;
- K_{UPenc} is a key, which shall only be used for the protection of UP traffic with a particular encryption algorithm. This key is derived by UE and eNB from K_{eNB} , as well as an identifier for the encryption algorithm.
- K_{RRCint} is a key, which shall only be used for the protection of RRC traffic with a particular integrity algorithm. K_{RRCint} is derived by UE and eNB from K_{eNB} , as well as an identifier for the integrity algorithm.
- K_{RRCenc} is a key, which shall only be used for the protection of RRC traffic with a particular encryption algorithm. K_{RRCenc} is derived by UE and eNB from K_{eNB} as well as an identifier for the encryption algorithm.

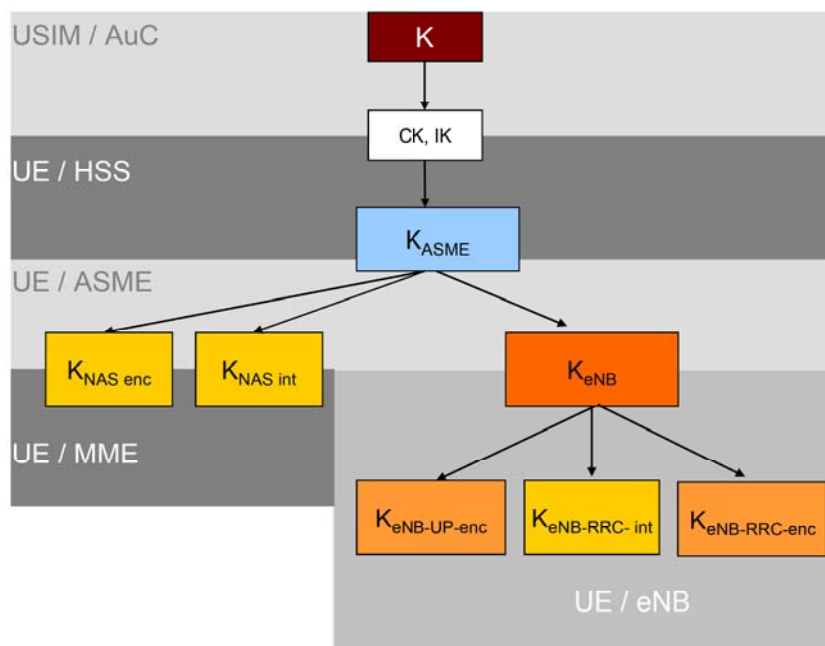


Figure 14.1-1: Key Hierarchy

COUNT-C reusing avoidance for the same radio bearer identity in RRC_CONNECTED mode without K_{eNB} change is left to eNB implementation e.g. by using intra-cell handover, smart management of radio bearer identities or triggering a transition to RRC_IDLE.

In case of HFN de-synchronisation in RRC_CONNECTED mode between the UE and eNB, the UE is pushed to IDLE.

14.2 Security termination points

The table below describes the security termination points.

Table 14.2-1 Security Termination Points

	Ciphering	Integrity Protection
NAS Signalling	Required and terminated in MME	Required and terminated in MME
U-Plane Data	Required and terminated in eNB	Not Required (NOTE 1)
RRC Signalling (AS)	Required and terminated in eNB	Required and terminated in eNB
MAC Signalling (AS)	Not required (NOTE 2)	Not required (NOTE 2)
NOTE 1: Integrity protection for U-Plane is not required and thus it is not supported between UE and Serving Gateway or for the transport of user plane data between eNB and Serving Gateway on S1 interface.		
NOTE 2: SA3 needs to further study on whether buffer status reports from UEs to the eNBs in MAC layer need to be protected.		

14.3 State Transitions and Mobility

14.3.1 RRC_IDLE to RRC_CONNECTED

As a general principle, on RRC_IDLE to RRC_CONNECTED transitions, RRC protection keys and UP protection keys shall be generated while keys for NAS protection as well as higher layer keys are assumed to be already available in the MME. These higher layer keys may have been established in the MME as a result of an AKA run, or as a result of a transfer from another MME during handover or idle mode mobility.

14.3.2 RRC_CONNECTED to RRC_IDLE

On RRC_CONNECTED to RRC_IDLE transitions, eNBs shall delete the keys they store such that state for idle mode UEs only has to be maintained in MME. It is also assumed that eNB does no longer store state information about the corresponding UE and deletes the current keys from its memory. In particular, on connected to idle transitions:

- The eNB deletes K_{eNB} , K_{RRcenc} , K_{RRcint} and K_{UPenc}
- MME keeps K_{ASME} stored.

14.3.3 Intra E-UTRAN Mobility

The key hierarchy does not allow, as is, explicit key updates, but RRC and UP keys are derived based on the algorithm identifiers, K_{eNB} , and certain dynamic parameters (e.g. C-RNTI), which result as new RRC and UP keys at every handover (FFS for intra-eNB):

- Source eNB and UE independently create K_{eNB^*} from the current K_{eNB} ;
- K_{eNB^*} is given to Target eNB during the HO preparation phase;
- Both Target eNB and UE derive the new K_{eNB} based on K_{eNB^*} and C-RNTI allocated by the target eNB to UE.

The handling of HFN and PDCP SN at handover depends on the type of radio bearer:

- SRB: HFN and PDCP SN are reset.
- RLC-UM bearers: HFN and PDCP SN are reset.
- RLC-AM bearers: PDCP SN and HFN are maintained (10.1.2.3).

NOTE: COUNT-C reusing avoidance is left to network implementation.

14.4 AS Key Change in RRC_CONNECTED

If AS Keys (K_{UPenc} , K_{RRCint} and K_{RRCenc}) need to be changed in RRC_CONNECTED, something along the line of an intra-cell handover is used (FFS).

14.5 Security Interworking

If user plane ciphering is activated in the source RAN, it shall remain activated in the target RAN.

For E-UTRAN to UTRAN/GERAN mobility, the MME shall derive and transfer to the SGSN a confidentiality key and an integrity key from K_{ASME} . Based on this information, the SGSN can in turn derive appropriate keys to be used in the target RAN.

Similarly for UTRAN/GERAN to E-UTRAN mobility, the SGSN shall derive and transfer to the MME a confidentiality key and an integrity key. Based on this information, the MME can in turn derive K_{ASME} .

15 MBMS

For MBMS, the following definitions are introduced:

MBSFN Synchronization Area: an area of the network where all NodeBs/eNodeBs can be synchronized and perform MBSFN transmissions. MBSFN Synchronization Areas are capable of supporting one or more MBSFN Areas. On a given frequency layer, a NodeB/eNodeB can only belong to one MBSFN Synchronization Area. MBSFN Synchronization Areas are independent from the definition of MBMS Service Areas

MBSFN Transmission or a transmission in MBSFN mode: a simulcast transmission technique realised by transmission of identical waveforms at the same time from multiple cells. An MBSFN Transmission from multiple cells within the MBSFN Area is seen as a single transmission by a UE.

MBSFN Area: a MBSFN Area consists of a group of cells within an MBSFN Synchronization Area of a network, which are co-ordinated to achieve a MBSFN Transmission. A cell within an MBSFN Synchronization Area may form part of multiple MBSFN Areas, each characterized by different transmitted content and participating set of cells.

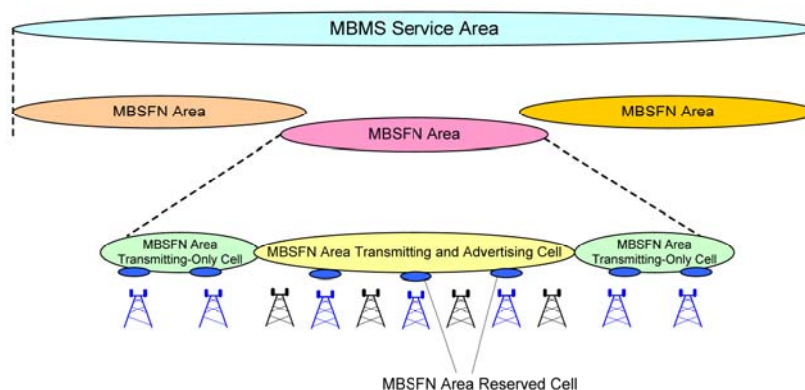


Figure 15-1: MBMS Definitions

MBSFN Area Transmitting and Advertising Cell: A cell within a MBSFN Area which is contributing to the MBSFN Transmission and advertises within the cell the availability of the MBSFN Transmission.

MBSFN Area Transmitting-Only Cell: A cell within a MBSFN Area which is contributing to the MBSFN Transmission but does not advertise within the cell the availability of the MBSFN Transmission. The need for this type of cell is FFS.

MBSFN Area Reserved Cell: A cell within a MBSFN Area which does not contribute to the MBSFN Transmission. The cell may be allowed to transmit for other services but at restricted power on the resource allocated for the MBSFN transmission e.g. PTP for users at the centre of the cell.

15.1 General

In E-UTRAN, MBMS can be provided on a frequency layer dedicated to MBMS (set of cells dedicated to MBMS transmission i.e. set of "MBMS dedicated cells") and/or on a frequency layer shared with non-MBMS services (set of cells supporting both unicast and MBMS transmissions i.e. set of "Unicast/MBMS mixed cells"). In both cases, single frequency network mode of operation is possible for MBMS transmission (MBSFN).

MBMS reception is possible for UEs in RRC_CONNECTED or RRC_IDLE states. Whenever receiving MBMS services, a user shall be notified of an incoming call, and originating calls shall be possible.

15.1.1 E-MBMS Logical Architecture

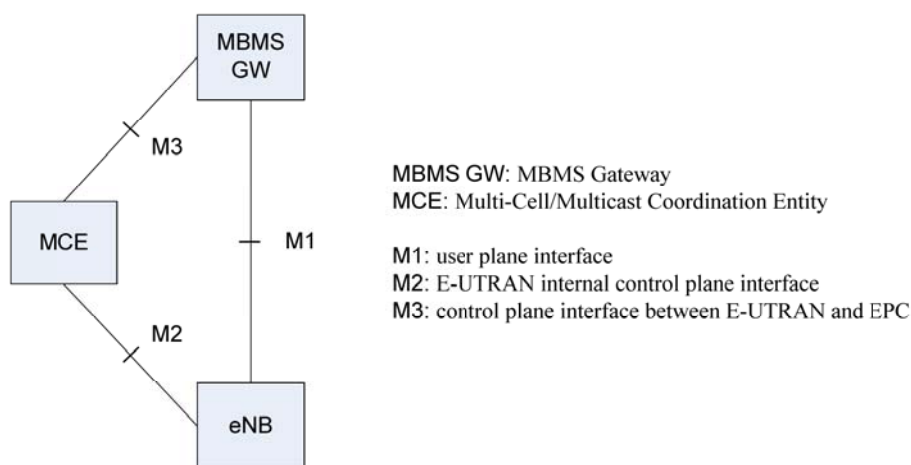


Figure 15.1.1-1: E-MBMS Logical Architecture

Figure 15.1.1-1 depicts the E-MBMS Logical Architecture.

NOTE: Additional horizontal interfaces e.g. MCE to MCE is FFS.

Multi-cell/multicast Coordination Entity (MCE)

The MCE is a logical entity – this does not preclude the possibility that it may be part of another network element – whose functions are the allocation of the radio resources used by all eNBs in the MBSFN area for multi-cell MBMS transmissions using MBSFN operation. Besides allocation of the time/ frequency radio resources this also includes deciding the further details of the radio configuration e.g. the modulation and coding scheme. The MCE is involved in MBMS Session Control Signalling. The MCE does not perform UE - MCE signalling.

E-MBMS Gateway (MBMS GW)

The MBMS GW is a logical entity – this does not preclude the possibility that it may be part of another network element – that is present between the BMSC and eNBs whose principal functions is the sending/broadcasting of MBMS packets with the SYNC protocol to each eNB transmitting the service. The MBMS GW hosts the PDCP layer of the user plane and uses IP Multicast as the means of forwarding MBMS user data to the eNB. The MBMS GW performs MBMS Session Control Signalling (Session start/stop) towards the E-UTRAN.

Control Plane Interfaces

“M3” Interface: MCE – MBMS GW

An Application Part is defined for this interface between E-MBMS Gateway and MCE. This application part allows for MBMS Session Control Signalling on EPS bearer level (i.e. does not convey radio configuration data). The procedures comprise e.g. MBMS Session Start and Stop. SCTP is used as signalling transport i.e. Point-to-Point signalling is applied.

“M2” Interface: MCE – eNB

An Application Part is defined for this interface, which conveys at least radio configuration data for the multi-cell transmission mode eNBs and Session Control Signalling. SCTP is used as signalling transport i.e. Point-to-Point signalling is applied.

User Plane Interface

“M1” Interface: MBMS GW – eNB

This interface is a pure user plane interface. Consequently no Control Plane Application Part is defined for this interface. IP Multicast is used for point-to-multipoint delivery of user packets for both single cell and multi-cell transmission.

Deployment consideration

It is not precluded that M3 interface can be terminated in eNBs. In this case MCE is considered as being part of eNB. Therefore M2 does not exist in this scenario. This is depicted in Figure 15.1.1-2 which depicts two envisaged deployment alternatives. In the scenario depicted on the left MCE is deployed in a separate node. In the scenario on the right MCE is part of the eNBs. These eMBMS architecture deployment alternatives shall be applicable to both multi-cell and single cell transmission mode.

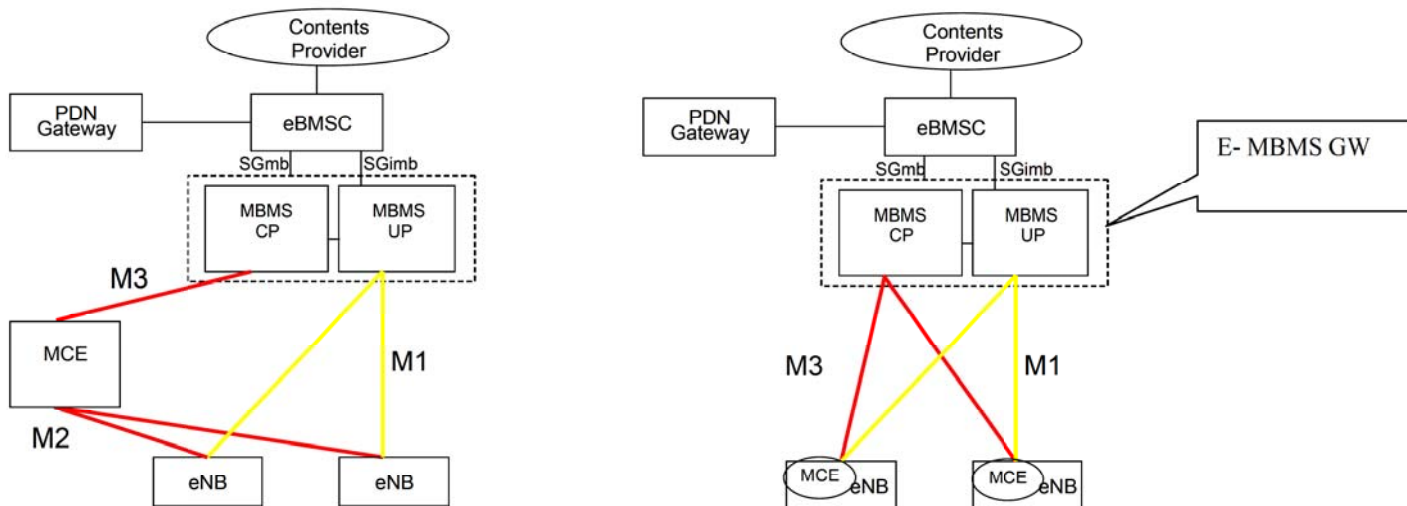


Figure 15.1.1-2: eMBMS Architecture deployment alternatives

15.1.2 E-MBMS User Plane Protocol Architecture

The overall U-plane architecture of content synchronization is shown in Figure 15.1-1. This architecture is based on the functional allocation for Unicast and the SYNC protocol layer is defined additionally on transport network layer to support content synchronization mechanism.

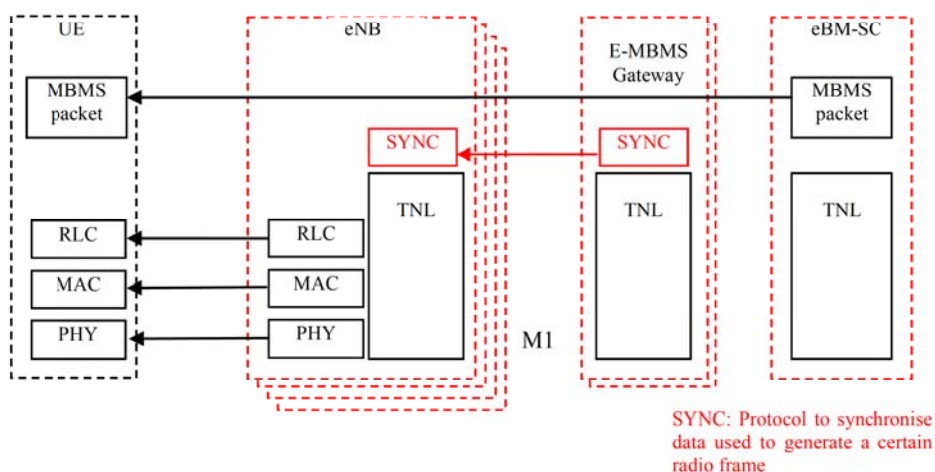


Figure 15.1.2-1: The overall u-plane architecture of the MBMS content synchronization

The SYNC protocol is defined as a protocol to carry additional information that enable eNBs to identify the timing for radio frame transmission and detect packet loss. The SYNC protocol is applicable to DL and may be specified as a part of GTP-U, or as an independent protocol.

If PDCP (Header Compression) is used, it is located in the E-MBMS GW for both multi-cell and single-cell transmission.

Complying with the content synchronization mechanism is required for an eNB distributing a MBMS service for Multi-Cell transmission. An eNB transmitting a service in single cell only should not be required to comply with the stringent timing requirements indicated by SYNC protocol.

15.2 MBMS Cells

An E-UTRAN cell supporting MBMS is either an MBMS-dedicated cell or an MBMS/Unicast-mixed cell.

15.2.1 MBMS-dedicated cell

When a cell belongs to a frequency layer dedicated to MBMS transmission:

- MTCH and MCCH are mapped on MCH or DL-SCH (FFS) for p-t-m transmission;
- No uplink;
- No counting mechanism in another (unicast) cell supported;
- No support for unicast data transfer in the cell;
- 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);

15.2.2 MBMS/Unicast-mixed cell

When a cell does not belong to a frequency layer dedicated to MBMS transmission:

- MTCH and MCCH are mapped on MCH or DL-SCH for p-t-m transmission;
- Transmission of both unicast and MBMS in the cell is done in a co-ordinated manner.

15.3 MBMS Transmission

15.3.1 General

Transmission of MBMS in E-UTRAN is either a single-cell transmission or a multi-cell transmission. In both cases, MCCH terminates at the eNB.

15.3.2 Single-cell transmission

Single-cell transmission of MBMS is characterized by:

- MBMS is transmitted only on the coverage of a specific cell;
- Combining of MBMS transmission from multiple cells is not supported;
- MTCH and MCCH are mapped on DL-SCH for p-t-m transmission;
- Scheduling is done by the eNB;
- Multiple UEs can be allocated dedicated uplink feedback channels identical to those used in unicast transmission, which enables them to report HARQ Ack/Nack and CQI. Where such a feedback mechanism is configured, AMC is applied, and HARQ retransmissions are made on DL-SCH using a group (service specific) RNTI in a time frame that is co-ordinated with the original MTCH transmission. All UEs are able to receive the retransmissions and combine them with the original transmissions at the HARQ level.
- UEs that are allocated a dedicated uplink feedback channel are in RRC_CONNECTED state.
- To avoid unnecessary MBMS transmission on MTCH in a cell where there is no MBMS user, MCCH may announce only the availability of MBMS service(s) and the network can detect the presence in a cell of at least one MBMS user interested in the MBMS service (e.g. by polling or through UE service request) before starting the transmission on MTCH. It is FFS whether or not it is needed to count to a greater granularity the number of UEs in a cell interested in an MBMS service.

For single-cell transmission, an eNB is not required to comply with the stringent timing requirements indicated by SYNC protocol. The following principles still applies for the single transmission:

1. An E-MBMS GW sends/broadcasts MBMS packet with the SYNC protocol to each eNB transmitting the service.
2. The SYNC protocol provides additional information so that the eNBs identify the transmission radio frame(s). The E-MBMS GW does not need accurate knowledge of radio resource allocation in terms of exact time division (e.g. exact start time of the radio frame transmission).
3. The segmentation/concatenation is needed for MBMS packets and should be totally up to the RLC/MAC layer in eNB, without taking into account any indication in the SYNC protocol.

15.3.3 Multi-cell transmission

Multi-cell transmission of MBMS is characterized by:

- Synchronous transmission of MBMS within its MBSFN Area;
- Combining of MBMS transmission from multiple cells is supported;
- MTCH and MCCH are mapped on MCH for p-t-m transmission;
- The MBSFN Synchronization Area, the MBSFN Area, and the MBSFN Transmitting, Advertising, and Reserved cells are semi-statically configured e.g. by O&M.
- Scheduling of each MCH is done by the MCE.
- AMC based on non-AS level feedback is FFS.

A carrier frequency may support more than one MCH, where the physical resource allocation to a specific MCH is made by specifying a pattern of subframes, not necessarily adjacent in time, to that MCH. This pattern is called a MCH Subframe Allocation Pattern (MSAP). Multiple MBMS services can be mapped to the same MCH and one MCH contains data belonging to only one MBSFN Area. Whether there is a 1-to-1 mapping between MCH and MBSFN Area is FFS. The MSAP for every MCH carrying MTCH is signalled on MCCH. At such an MSAP occasion:

- The eNB applies MAC multiplexing of different MTCH's to be transmitted on this MCH. The transmission order of MTCHs is signalled (FFS whether implicitly or explicitly) in the MCCH;
- Dynamic scheduling information can be provided in the MSAP occasion to assist the UE in choosing which subframes it needs to receive, both when services are multiplexed onto the MCH and when only a single service is transmitted on the MCH. It is FFS how the scheduling information is carried (e.g. in a MAC control element, or a separate logical channel MSCH). The dynamic scheduling information carries the mapping of MTCHs to the sub-frames of the associated MSAP occasion. This mapping is based on the indexing of sub-frames belonging to one MSAP occasion.

The content synchronization for multi-cell transmission is provided by the following principles:

1. All eNBs in a given MBSFN Synchronization Area have a synchronised radio frame timing such that the radio frames are transmitted at the same time.
2. All eNBs have the same configuration of RLC/MAC/PHY for each MBMS service, and identical information (e.g. time information, transmission order/priority information) such that synchronized dynamic scheduling in the eNBs is ensured. These are indicated in advance by the MCE.
3. An E-MBMS GW sends/broadcasts MBMS packet with the SYNC protocol to each eNB transmitting the service.
4. The SYNC protocol provides additional information so that the eNBs identify the transmission radio frame(s). The E-MBMS GW does not need accurate knowledge of radio resource allocation in terms of exact time division (e.g. exact start time of the radio frame transmission).
5. eNB buffers MBMS packet and waits for the transmission timing indicated in the SYNC protocol.
6. The segmentation/concatenation is needed for MBMS packets and should be totally up to the RLC/MAC layer in eNB.
7. The SYNC protocol provides means to detect packet loss(es) and supports a recovery mechanism robust against loss of consecutive PDU packets (MBMS Packets with SYNC Header).
8. For the packet loss case the transmission of radio blocks potentially impacted by the lost packet should be muted.
9. The mechanism supports indication or detection of MBMS data burst termination (e.g. to identify and alternately use available spare resources related to pauses in the MBMS PDU data flow).

15.3.4 MBMS Reception States

UEs that are receiving MTCH transmissions and are taking part in at least one MBMS feedback scheme will be in RRC_CONNECTED state. UEs receiving MTCH transmissions without taking part in an MBMS feedback mechanism can be in RRC_IDLE or RRC_CONNECTED state.

For the reception of single-cell transmission of MTCH, an eNB can require a UE to be in RRC_CONNECTED state. The signalling by which a UE is triggered to move to RRC_CONNECTED state solely for single-cell reception purposes is carried on MCCH.

15.3.5 MCCH Structure

The following principles govern the MCCH structure:

- BCCH indicates the scheduling of one or two Primary MCCH (one for single cell transmission on DL-SCH, one for multi-cell transmission on MCH) where the Primary MCCH on MCH can also point to additional Secondary MCCH(s) on MCH if any.

NOTE: the need for Secondary MCCH(s) when the Primary MCCH is mapped on DL-SCH is FFS.

- BCCH only points to the resources where the Primary MCCH(s) can be found i.e. it does not indicate the availability of the services.
- The primary MCCH is sent on DL-SCH for single cell transmission and on MCH for multi-cell transmission on an MBSFN area.
- Multiple overlapping MTCH-MBSFN areas can result in multiple MCCHs, for which using different MBSFN areas should be possible (using Secondary MCCHs).
- The MCCH-MBSFN area is not necessarily the same as the MTCH-MBSFN area i.e. MCCH can be either on a different MCH than the MCH carrying “advertised” MTCH, or multiplexed on the same MCH as the one carrying “advertised” MTCH.

15.4 Service Continuity

As combinations of the possible MBMS cell types and transmission modes, various deployment scenarios come into question. Among them, E-UTRAN provides the necessary optimization mechanisms to support seamless MBMS continuity between:

- 1) MBSFN and single-cell transmission on a shared frequency layer;
- 2) MBSFN on a dedicated frequency layer and single-cell transmission on a shared frequency layer;
- 3) Cells providing single-cell transmission on a shared frequency layer.

For the reception of single-cell transmission of MTCH, UEs that are receiving MBMS service(s) in RRC_CONNECTED state (either directed to the state to receive the MBMS service or in the state already for other reasons and the eNB is aware that the UE is receiving the particular MBMS service(s)), can be provided with target cell MTCH information for these services via the handover related signalling. The serving eNB will trigger the target eNB to prepare for the handover e.g. to obtain the MBMS service if necessary.

UEs that are receiving MBMS service(s) in RRC_IDLE state performing cell reselection or are in RRC_CONNECTED state and which do not receive target cell information as part of handover signalling, should obtain target cell MTCH information from the target cell MCCH or, if supported, serving cell MCCH information (FFS). If the UE was in RRC_CONNECTED state and the source eNB was aware that it is receiving the particular MBMS service(s) the serving eNB could trigger the target eNB to prepare for the handover e.g. to obtain the MBMS service if necessary.

15.5 Network sharing

Network sharing of MBMS resources among multiple operators of the same country is supported, with focus on, but not limited to, sharing of a dedicated-carrier MBSFN. MBMS network sharing shall not require unicast network sharing. Unicast mobility shall not be affected by the sharing of MBMS resources by operators.

NOTE: it is FFS whether this is based on dual-receiver solutions.

15.6 Network Functions for Support of Multiplexing

Considerable gain in radio resource efficiency can be achieved by multiplexing several E-MBMS services on a single MCH. The services that share the resources are called E-MBMS Service Multiplex. The amount of common radio resources allocated to such an E-MBMS Service Multiplex can be smaller than the sum of radio resources, which would need to be allocated for the individual services without multiplexing. This represents the statistical multiplexing gain.

The entity managing the E-MBMS Service Multiplex e.g. deciding which services are to be multiplexed is FFS. The duration of each E-MBMS service may be different, so there is may be a need to manage the Service Multiplex dynamically, i.e. addition or removal of services into/from the E-MBMS Service Multiplex. The MCE allocates the optimal amount of resources to multiplexed services, using service related information. MBSFN transmission is ensured by identical multiplexing of the services within the MBMS-GW or different eNBs. The location of the multiplexing function is FFS.

These functions are supported by respective signalling and by the SYNC protocol on M1, the details are FFS.

15.7 Procedures

15.7.1 Procedures for Broadcast mode

15.7.1.1 Session Start procedure

The purpose of the MBMS Session Start procedure is to request the E-UTRAN to notify UEs about an upcoming MBMS Session of a given MBMS Bearer Service and to establish an MBMS SAE bearer for this MBMS Session. The MBMS Session Start procedure is triggered by the EPC.

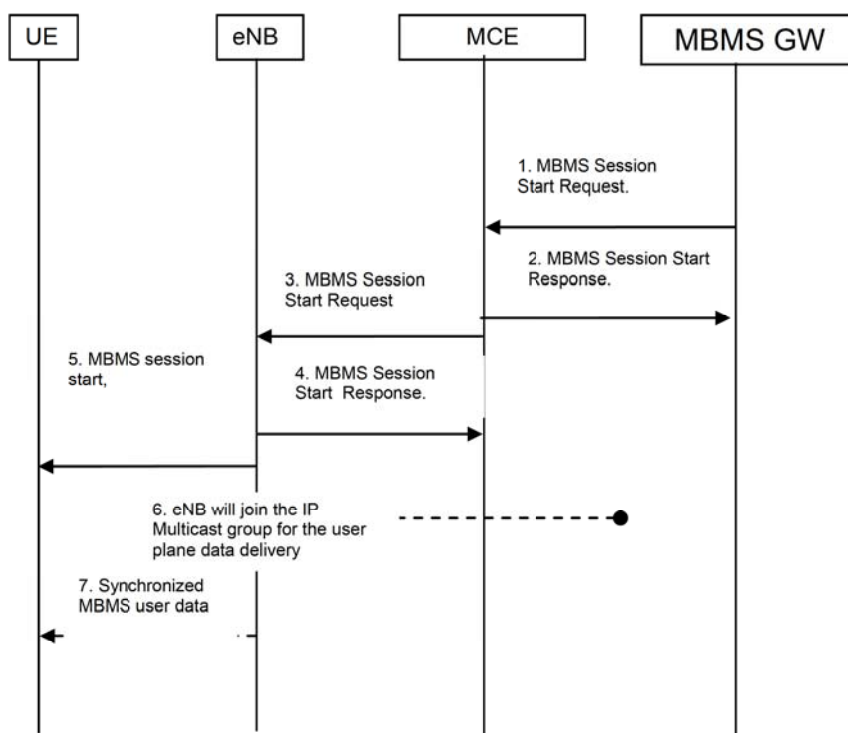


Figure 15.7.1.1-1. Session Start procedure

1. The MBMS GW entity sends MBMS session start request message to the MCE(s) controlling eNBs in the targeted MBMS service area. The message includes the IP multicast address and session attributes.
2. MCE confirms the reception of the MBMS Session Start request to the MBMS GW. It is FFS whether this message is transmitted after message 4.
3. MCE sends the MBMS Session Start message to the eNBs in the targeted MBMS service area. In addition to the session attributes this message provides radio bearer configuration for MBSFN transmission.
4. eNB confirms the reception of the MBMS Session Start message.
5. eNB sends the MBMS Session Start message to UEs. The location of the message is FFS, other positions are after messages 6 or 7. The message details are FFS.
6. eNB joins the IP multicast group to receive the MBMS User Plane data.
7. eNB sends the MBMS data to radio interface at the determined time.

15.7.1.2 Session Stop procedure

The MBMS Session Stop procedure is to request the E-UTRAN to notify UEs about the end of a given MBMS Session and to release the corresponding MBMS SAE bearer this MBMS Session. The MBMS Session Stop procedure is triggered by the EPC.

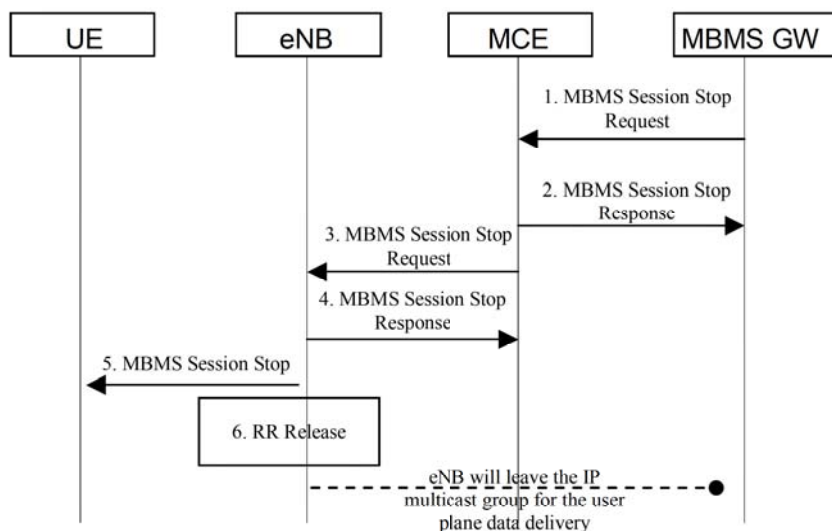


Figure 15.7.1.2-1. Session Stop procedure

1. The MBMS GW entity sends MBMS session stop request message to the MCE(s) controlling eNBs in the targeted MBMS service area.
2. MCE confirms the reception of the MBMS Session stop request to the MBMS GW.
3. MCE forwards the MBMS Session stop message to the eNBs in the targeted MBMS service area.
4. eNB confirms the reception of the MBMS Session stop message.
5. eNB sends the MBMS Session stop message to UEs. The message details are FFS.
6. The corresponding SAE bearer is released, and eNB leaves the the IP multicast group.

16 Radio Resource Management aspects

The purpose of radio resource management (RRM) is to ensure the efficient use the available radio resources and to provide mechanisms that enable E-UTRAN to meet radio resource related requirements identified in sub-clause 10 of 3GPP TR 25.913 [2]. In particular, RRM in E-UTRAN provides means to manage (e.g. assign, re-assign and release) radio resources taking into account single and multi-cell aspects.

16.1 RRM functions

16.1.1 Radio Bearer Control (RBC)

The establishment, maintenance and release of Radio Bearers involve the configuration of radio resources associated with them. When setting up a radio bearer for a service, radio bearer control (RBC) takes into account the overall resource situation in E-UTRAN, the QoS requirements of in-progress sessions and the QoS requirement for the new service. RBC is also concerned with the maintenance of radio bearers of in-progress sessions at the change of the radio resource situation due to mobility or other reasons. RBC is involved in the release of radio resources associated with radio bearers at session termination, handover or at other occasions.

RBC is located in the eNB.

16.1.2 Radio Admission Control (RAC)

The task of radio admission control (RAC) is to admit or reject the establishment requests for new radio bearers. In order to do this, RAC takes into account the overall resource situation in E-UTRAN, the QoS requirements, the priority levels and the provided QoS of in-progress sessions and the QoS requirement of the new radio bearer request. The goal of RAC is to ensure high radio resource utilization (by accepting radio bearer requests as long as radio resources available) and at the same time to ensure proper QoS for in-progress sessions (by rejecting radio bearer requests when they cannot be accommodated).

RAC is located in the eNB.

16.1.3 Connection Mobility Control (CMC)

Connection mobility control (CMC) is concerned with the management of radio resources in connection with idle or connected mode mobility. In idle mode, the cell reselection algorithms are controlled by setting of parameters (thresholds and hysteresis values) that define the best cell and/or determine when the UE should select a new cell. Also, E-UTRAN broadcasts parameters that configure the UE measurement and reporting procedures. In connected mode, the mobility of radio connections has to be supported. Handover decisions may be based on UE and eNB measurements. In addition, handover decisions may take other inputs, such as neighbour cell load, traffic distribution, transport and hardware resources and Operator defined policies into account.

CMC is located in the eNB.

16.1.4 Dynamic Resource Allocation (DRA) - Packet Scheduling (PS)

The task of dynamic resource allocation (DRA) or packet scheduling (PS) is to allocate and de-allocate resources (including buffer and processing resources and resource blocks (i.e. chunks)) to user and control plane packets. DRA involves several sub-tasks, including the selection of radio bearers whose packets are to be scheduled and managing the necessary resources (e.g. the power levels or the specific resource blocks used). PS typically takes into account the QoS requirements associated with the radio bearers, the channel quality information for UEs, buffer status, interference situation, etc. DRA may also take into account restrictions or preferences on some of the available resource blocks or resource block sets due to inter-cell interference coordination considerations.

DRA is located in the eNB.

16.1.5 Inter-cell Interference Coordination (ICIC)

Inter-cell interference coordination has the task to manage radio resources (notably the radio resource blocks) such that inter-cell interference is kept under control. ICIC is inherently a multi-cell RRM function that needs to take into account information (e.g. the resource usage status and traffic load situation) from multiple cells. The preferred ICIC method may be different in the uplink and downlink.

ICIC is located in the eNB.

16.1.6 Load Balancing (LB)

Load balancing has the task to handle uneven distribution of the traffic load over multiple cells. The purpose of LB is thus to influence the load distribution in such a manner that radio resources remain highly utilized and the QoS of in-progress sessions are maintained to the extent possible and call dropping probabilities are kept sufficiently small. LB algorithms may result in hand-over or cell reselection decisions with the purpose of redistribute traffic from highly loaded cells to underutilized cells.

LB is located in the eNB.

16.1.7 Inter-RAT Radio Resource Management

Inter-RAT RRM is primarily concerned with the management of radio resources in connection with inter-RAT mobility, notably inter-RAT handover. At inter-RAT handover, the handover decision may take into account the

involved RATs resource situation as well as UE capabilities and Operator policies. The importance of Inter-RAT RRM may depend on the specific scenario in which E-UTRAN is deployed. Inter-RAT RRM may also include functionality for inter-RAT load balancing for idle and connected mode UEs.

16.1.8 Subscriber Profile ID for RAT/Frequency Priority

The RRM strategy in E-UTRAN may be based on user specific information.

The Subscriber Profile ID for RAT/Frequency Priority (SPID) parameter received by the eNB via the S1 interface is an index referring to user information (e.g. mobility profile, service usage profile and roaming restrictions). The information is UE specific and applies to all its Radio Bearers.

This index is mapped by the eNB to locally defined configuration in order to apply specific RRM strategies (e.g. to define RRC_IDLE mode priorities and control inter-RAT/inter frequency handover in RRC_CONNECTED mode).

16.2 RRM architecture

16.2.1 Centralised Handling of certain RRM Functions

16.2.2 De-Centralised RRM

Historical information about the UE is transferred between the eNBs over the X2 interface during the handover preparation procedure. For instance, an activity level description of the UE in the source eNB is transferred to the target eNB.

16.2.3 Load balancing control

17 RF aspects

17.1 Spectrum deployments

18 UE capabilities

RRC signalling carries RRC capability and NAS signalling carries NAS capability. Some capability information may be stored in the EPC. In the uplink, some capability information may be sent early in e.g.

RRC_CONNECTION_REQUEST. In the downlink, inquiry procedure of the UE capability may be supported.

For emergency services, a minimum MBMS UE capability is defined. Whether such a minimum capability should be a mandatory UE capability is FFS.

19 S1 Interface

19.1 S1 User plane

The S1 user plane interface (S1-U) is defined between the eNB and the S-GW. The S1-U interface provides non guaranteed delivery of user plane PDUs between the eNB and the S-GW. The user plane protocol stack on the S1 interface is shown in Figure 19.1-1. The transport network layer is built on IP transport and GTP-U is used on top of UDP/IP to carry the user plane PDUs between the eNB and the S-GW.

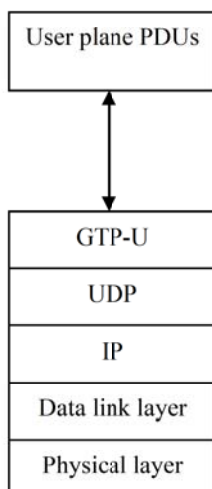


Figure 19.1-1: S1 Interface User Plane (eNB - S-GW)

19.2 S1 Control Plane

The S1 control plane interface (S1-MME) is defined between the eNB and the MME. The control plane protocol stack of the S1 interface is shown on Figure 19.2-1. The transport network layer is built on IP transport, similarly to the user plane but for the reliable transport of signalling messages SCTP is added on top of IP. The application layer signalling protocol is referred to as S1-AP (S1 Application Protocol).

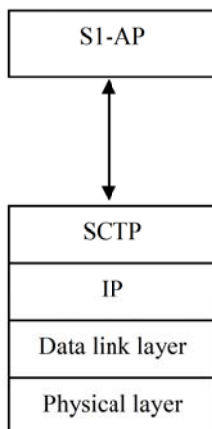


Figure 19.2-1: S1 Interface Control Plane (eNB-MME)

The SCTP layer provides the guaranteed delivery of application layer messages.

In the transport IP layer point-to-point transmission is used to deliver the signalling PDUs.

A single SCTP association per S1-MME interface instance shall be used with one pair of stream identifiers for S1-MME common procedures. Only a few pairs of stream identifiers should be used for S1-MME dedicated procedures. The upper limit for the number of stream identifiers for dedicated procedures is FFS and will be decided during the stage 3 work.

MME communication context identifiers that are assigned by the MME for S1-MME dedicated procedures and eNB communication context identifiers that are assigned by the eNB for S1-MME dedicated procedures shall be used to distinguish UE specific S1-MME signalling transport bearers. The communication context identifiers are conveyed in the respective S1-AP messages.

19.2.1 S1 Interface Functions

Note: The following list of S1 functions reflects the status of agreements in RAN3, might be extended in forthcoming meetings.

- EPS Bearer Service Management function:
 - Setup, Modify, release.
- Mobility Functions for UEs in ECM-CONNECTED:
 - Intra-LTE Handover;
 - Inter-3GPP-RAT Handover.
- S1 Paging function:
- NAS Signalling Transport function;
- S1-interface management functions:
 - Error indication;
 - Reset.
- Network Sharing Function;
- Roaming and Area Restriction Support function;
- NAS Node Selection Function;
- Initial Context Setup Function;
- UE Context Modification Function.

19.2.1.1 S1 Paging function

The paging function supports the sending of paging requests to all cells of the TA(s) the UE is registered.

Paging requests are sent to the relevant eNBs according to the mobility information kept in the UE's MM context in the serving MME.

19.2.1.2 S1 UE Context Management function

In order to support UEs in ECM-CONNECTED, UE contexts need to be managed, i.e. established and released in the eNodeB and in the EPC to support user individual signalling on S1.

19.2.1.3 Initial Context Setup Function

The Initial Context Setup function supports the establishment of the necessary overall initial UE Context including EPS Bearer context, Security context, roaming restriction, UE capability information, Subscriber Profile ID for RAT/Frequency Priority, UE S1 signalling connection ID, etc. in the eNB to enable fast Idle-to-Active transition.

In addition to the setup of overall initial UE Contexts, Initial Context Setup function also supports the piggy-backing of the corresponding NAS messages. Initial Context Setup is initiated by the MME.

19.2.1.3a UE Context Modification Function

The UE Context Modification function supports the modification of UE Context in eNB for UEs in active state.

19.2.1.4 Mobility Functions for UEs in ECM-CONNECTED

19.2.1.4.1 Intra-LTE Handover

The Intra-LTE-Handover function supports mobility for UEs in ECM-CONNECTED and comprises the preparation, execution and completion of handover via the X2 and S1 interfaces.

19.2.1.4.2 Inter-3GPP-RAT Handover

The Inter-3GPP-RAT Handover function supports mobility to and from other 3GPP-RATs for UEs in ECM-CONNECTED and comprises the preparation, execution and completion of handover via the S1 interface.

19.2.1.5 EPS Bearer Service Management function

The EPS Bearer Service management function is responsible for establishing, modifying and releasing E-UTRAN resources for user data transport once a UE context is available in the eNB. The establishment and modification of E-UTRAN resources is triggered by the MME and requires respective QoS information to be provided to the eNB. The release of E-UTRAN resources is triggered by the MME either directly or following a request received from the eNB (optional).

NOTE: Whether EPS bearer related NAS messages are included in S1AP EPS Bearer Management procedures piggybacking or if NAS messages are sent with S1-AP Direct Transfer is FFS:

19.2.1.6 NAS Signalling Transport function

The NAS Signalling Transport function provides means to transport a NAS message (e.g. for NAS mobility management) for a specific UE on the S1 interface.

19.2.1.7 NAS Node Selection Function

The interconnection of eNBs to multiple MME/Serving S-GWs is supported in the LTE/SAE architecture. Therefore a NAS node selection function is located in the eNB to determine the MME association of the UE, based on the UE's temporary identifier, which was assigned to the UE by the MME.

This functionality is located in the eNB only and enables proper routing via the S1 interface. On S1, no specific procedure corresponds to the NAS Node Selection Function.

19.2.1.8 S1-interface management functions

The S1-interface management functions provide

- means to ensure a defined start of S1-interface operation (reset)
- means to handle different versions of application part implementations and protocol errors (error indication)

19.2.2 S1 Interface Signalling Procedures

Note: The following list of S1 procedures reflects the status of agreements in RAN3, might be extended in forthcoming meetings.

- EPS Bearer signalling procedures:
 - EPS Bearer Setup procedure;
 - EPS Bearer Modification procedure;
 - EPS Bearer Release procedure (MME initiated);
 - EPS Bearer Release procedure (eNB initiated).
- Handover signalling procedures;

- Handover Preparation procedure;
- Handover Resource Allocation procedure;
- Handover Completion procedure;
- Handover Cancellation procedure.
- Paging procedure;
- NAS transport procedure:
 - UL direction (Initial UE Message);
 - UL direction (Uplink NAS transport);
 - DL direction (Downlink NAS transport).
- Error Indication procedure:
 - eNB initiated error indication procedure;
 - MME initiated error indication procedure.
- Reset procedure:
 - eNB initiated Reset procedure;
 - MME initiated Reset procedure.
- Initial Context Setup procedure;
- UE Context Modification procedure.

19.2.2.1 Paging procedure

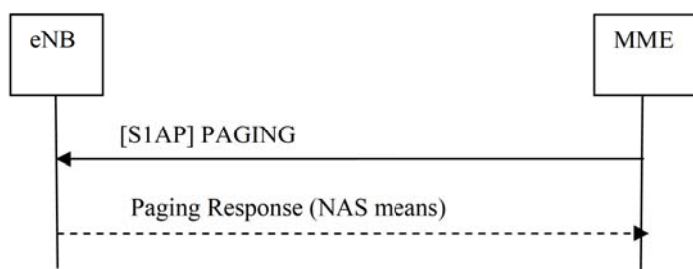


Figure 19.2.2.1-1: Paging procedure

The MME initiates the paging procedure by sending the PAGING message to each eNB with cells belonging to the tracking area(s) in which the UE is registered. Each eNB can contain cells belonging to different tracking areas, whereas each cell can only belong to one TA.

The paging response back to the MME is initiated on NAS layer and is sent by the eNB based on NAS-level routing information.

19.2.2.2 S1 UE Context Release procedure

The S1 UE Context Release procedure causes the eNB to remove all UE individual signalling resources and the related user data transport resources. This procedure is initiated by the EPC and may be triggered on request of the serving eNB.

19.2.2.2.1 S1 UE Context Release (EPC triggered)

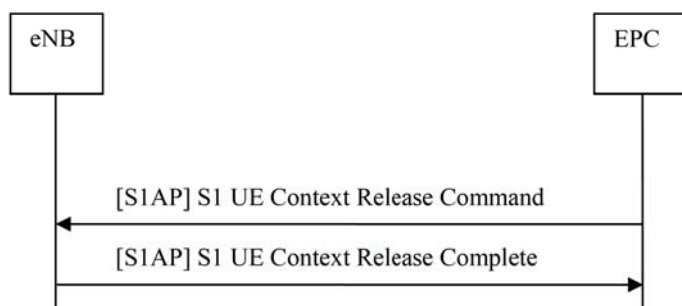


Figure 19.2.2.2.1-1: S1 UE Context Release procedure (EPC triggered)

- The EPC initiates the UE Context Release procedure by sending the S1 UE Context Release Command towards the E-UTRAN. The eNodeB releases all related signalling and user data transport resources.
- The eNB confirms the S1 UE Context Release activity with the S1 UE Context Release Complete message.
- In the course of this procedure the EPC releases all related resources as well, except context resources in the EPC for mobility management and the default EPS Bearer configuration.

19.2.2.2.2 S1 UE Context Release Request (eNB triggered)

The S1 UE Context Release Request procedure is initiated for E-UTRAN internal reasons and comprises the following steps:

- The eNB sends the S1 UE Context Release Request message to the EPC.
- The EPC triggers the EPC initiated UE context release procedure.

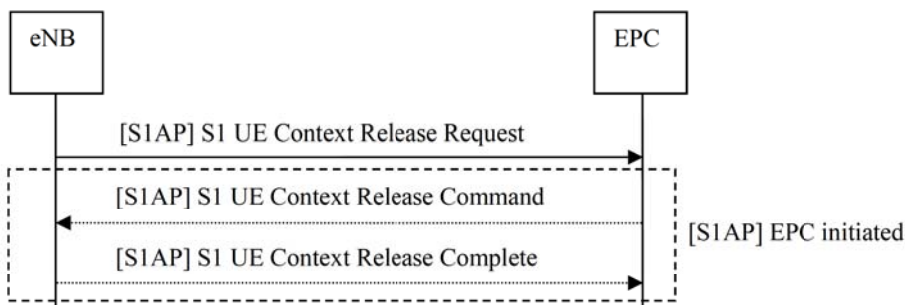


Figure 19.2.2.2.2-1: S1 UE Context Release Request procedure (eNB triggered) and subsequent S1 UE Context Release procedure (EPC triggered)

19.2.2.3 Initial Context Setup procedure

The Initial Context Setup procedure establishes the necessary overall initial UE context in the eNB in case of an Idle-to-Active transition. The Initial Context Setup procedure is initiated by the MME.

The Initial Context Setup procedure comprises the following steps:

- The MME initiates the Initial Context Setup procedure by sending INITIAL CONTEXT SETUP REQUEST to the eNB. This message may include general UE Context (e.g. security context, roaming restrictions, UE capability information, UE S1 signalling connection ID, etc.), EPS bearer context (Serving GW TEID, QoS information), and may be piggy-backed with the corresponding NAS message.
- Upon receipt of INITIAL CONTEXT SETUP REQUEST, the eNB setup the context of the associated UE, and perform the necessary RRC signalling towards the UE, e.g. Radio Bearer Setup procedure.

- The eNB responds with INITIAL CONTEXT SETUP COMPLETE to inform a successful operation, and with INITIAL CONTEXT SETUP FAILURE to inform an unsuccessful operation.

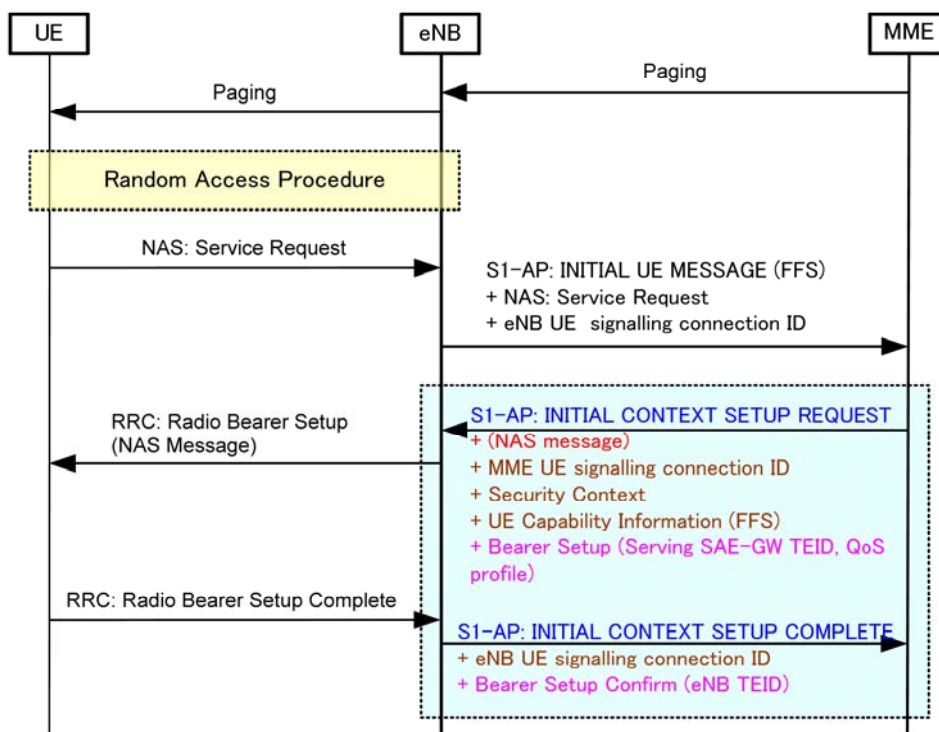


Figure 19.2.2.3-1: Initial Context Setup procedure (highlighted in blue) in Idle-to-Active procedure

19.2.2.3a UE Context Modification procedure

The UE Context Modification procedure enables the MME to modify the UE context in the eNB for UEs in active state. The UE Context Modification procedure is initiated by the MME.

The UE Context Modification procedure comprises the following steps:

- The MME initiates the UE Context Modification procedure by sending UE CONTEXT MODIFICATION REQUEST to the eNB to modify the UE context in the eNB for UEs in active state.
- The eNB responds with UE CONTEXT MODIFICATION RESPONSE to inform a successful operation, and with UE CONTEXT MODIFICATION FAILURE to inform an unsuccessful operation.

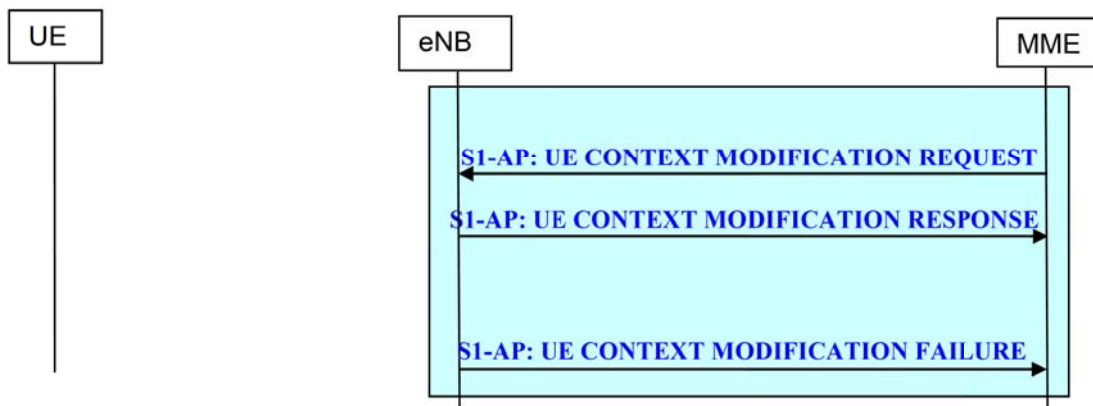


Figure 19.2.2.3a-1: UE Context Modification procedure

19.2.2.4 EPS Bearer signalling procedures

19.2.2.4.1 EPS Bearer Setup procedure

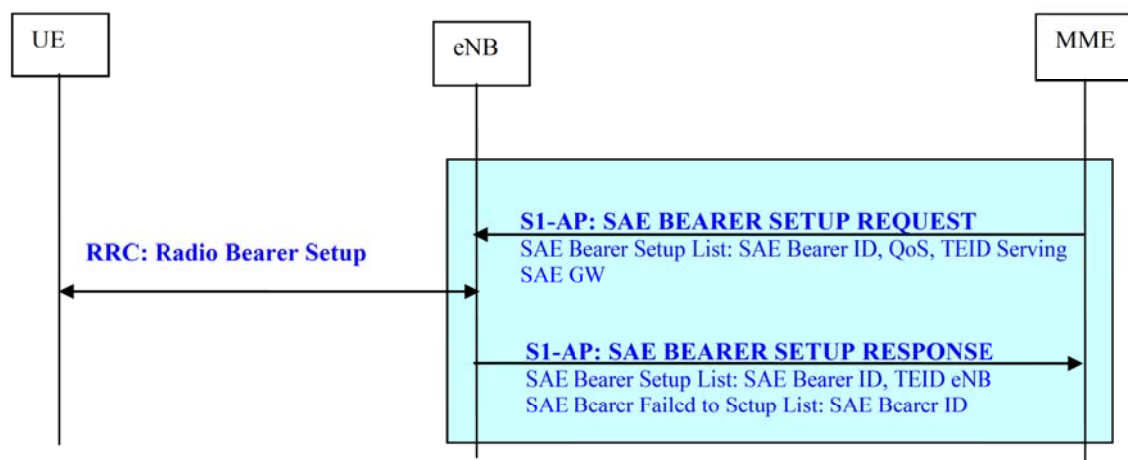


Figure 19.2.2.4.1-1: EPS Bearer Setup procedure

The EPS Bearer Setup procedure is initiated by the MME to support:

- Assignment of resources to a dedicated EPS bearer.
- Assignment of resources for a default EPS bearer (FFS)
- Setup of S1 Bearer (on S1) and Radio Bearer (on Uu)

The EPS Bearer Setup procedure comprises the following steps:

- The EPS BEARER SETUP REQUEST is sent by the MME to the eNB to setup resources on S1 and Uu for one or several EPS Bearer(s). The EPS BEARER SETUP REQUEST message contains the Serving GW TEID and QoS indicator(s) per EPS bearer within the EPS Bearer Setup List.
- Upon receipt of the EPS BEARER SETUP REQUEST the eNB establishes the Radio Bearer(s) (RRC: Radio Bearer Setup) and resources for S1 Bearers.
- The eNB responds with a EPS BEARER SETUP RESPONSE messages to inform whether the setup of resources and establishment of an EPS Bearer was successful or unsuccessful, with the EPS bearer Setup (EPS Bearer ID , eNB TEID) and the EPS Bearer Failed to Setup list (EPS bearer ID). The eNB also creates the binding between the S1 bearer(s) (DL/UL TEID) and the Radio Bearer(s).

19.2.2.4.2 EPS Bearer Modification procedure

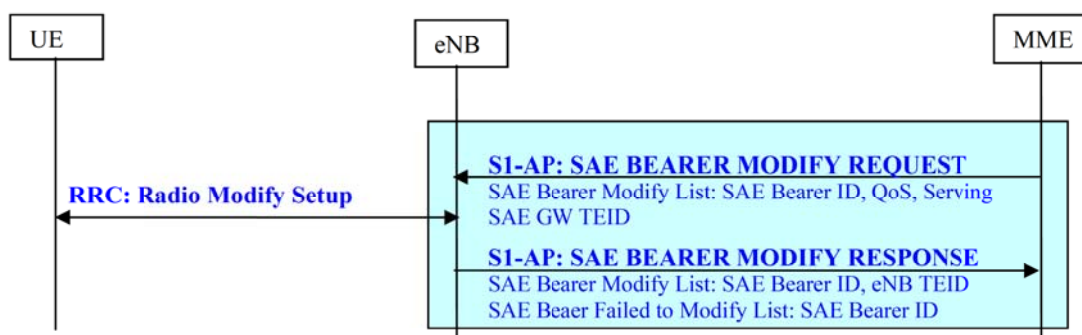


Figure 19.2.2.4.2-1: EPS Bearer Modification procedure

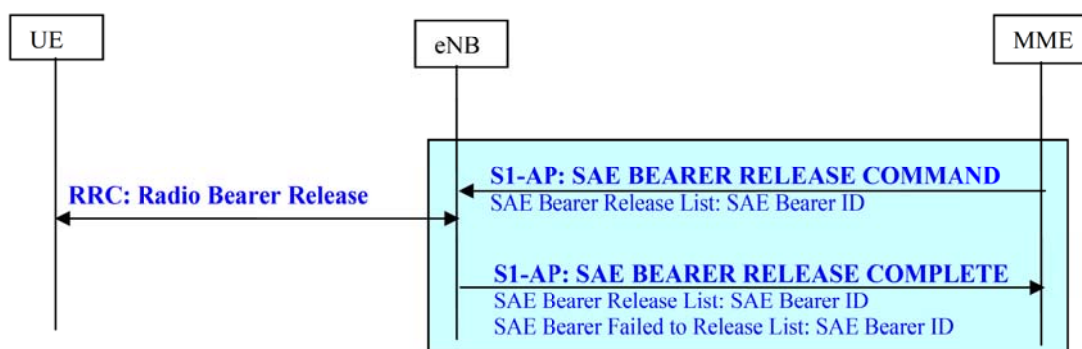
The EPS Bearer Modification procedure is initiated by the MME to support the modification of already established EPS Bearer configurations:

- Modify of S1 Bearer (on S1) and Radio Bearer (on Uu)

The EPS Bearer Modification procedure comprises the following steps:

- The EPS BEARER MODIFY REQUEST is sent by the MME to the eNB to modify one or several EPS Bearer(s). The EPS BEARER MODIFY REQUEST message contains the QoS indicator(s) and Serving GW TEID per EPS bearer in the EPS Bearer Modify List.
- Upon receipt of the EPS BEARER MODIFY REQUEST the eNB modifies the Radio Bearer configuration (RRC procedure to modify the Radio bearer).
- The eNB responds with an EPS BEARER MODIFY RESPONSE message to inform whether the EPS Bearer modification has succeeded or not indicating with the EPS bearer Modify list and EPS bearer Failed to Modify list. With EPS Bearer ID(s) in the EPS Bearer Modify List the eNB identifies the EPS bearer(s) successfully modified or failed to modify.

19.2.2.4.3 EPS Bearer Release procedure (MME initiated)

**Figure 19.2.2.4.3-1: EPS Bearer Release procedure (MME initiated)**

The EPS Bearer Release procedure is initiated by the MME to release resources for the indicated EPS Bearers.

The EPS Bearer Release procedure comprises the following steps:

- The EPS BEARER RELEASE COMMAND is sent by the MME to the eNB to release resources on S1 and Uu for one or several EPS Bearer(s). With the EPS Bearer ID(s) in the EPS bearer Release List contained in EPS BEARER RELEASE COMMAND the MME identifies, the EPS Access Bearer(s) to be released.
- Upon receipt of the EPS BEARER RELEASE COMMAND the eNB releases the Radio Bearers (RRC: Radio bearer release) and S1 Bearers.
- The eNB responds with an EPS BEARER RELEASE COMPLETE message containing EPS bearer Release list and EPS bearer Failed to Release list. With the EPS Bearer IDs in the EPS Bearer Release List/EPS Bearer Failed to Release List the eNB identifies the EPS bearer(s) successfully released or failed to release.

19.2.2.4.4 EPS Bearer Release procedure (eNB initiated)

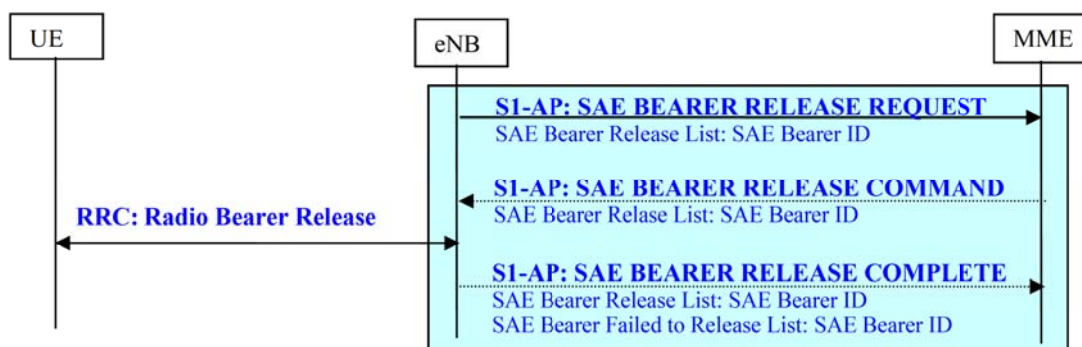


Figure 19.2.2.4.4-1: EPS Bearer Release (eNB initiated) procedure

The EPS Bearer Release function enables the E-UTRAN to request the release of resources for one or several EPS Bearers. The eNB initiated EPS Bearer Release procedure comprises the following steps:

- The eNB initiates the EPS Bearer Release procedure by sending the EPS BEARER RELEASE REQUEST message to the MME in order to release of one or more EPS Bearer(s). With the EPS Bearer ID(s) in the EPS Bearer Release List the eNB identifies the EPS bearer(s) requested to be released. The EPS BEARER RELEASE REQUEST message shall include the reason to release the resources for the EPS bearer, for example user inactivity.
- Upon receipt the MME initiates the EPS Bearer Release procedure (EPS BEARER RELEASE COMMAND/ EPS BEARER RELEASE COMPLETE) to request release of resources for the EPS Bearer(s).

19.2.2.5 Handover signalling procedures

Handover signalling procedures support both, inter-eNB handover and inter-RAT handover.

Inter-RAT handovers shall be initiated via the S1 interface.

Inter-eNB handovers shall be initiated via the X2 interface except if any of the following conditions are true:

- there is no X2 between source and target eNB.
- the source eNB has been configured to initiate handover to the particular target eNB via S1 interface in order to enable the change of an EPC node (MME and/or Serving GW).
- the source eNB has attempted to start the inter-eNB HO via X2 but receives a negative reply from the target eNB with a specific cause value.

NOTE: Handling of cases where the target eNB does not reply is FFS.

Inter-eNB handovers shall be initiated via the S1 interface, if one of the above conditions applies.

NOTE: Affects on Home eNBs should be looked at.

It is foreseen to re-use Handover principles from the Iu interface for inter-eNB handovers which are initiated via the S1 interface.

19.2.2.5.1 Handover Preparation procedure

The Handover preparation procedure is initiated by the source eNB if it determines the necessity to initiate the handover via the S1 interface.

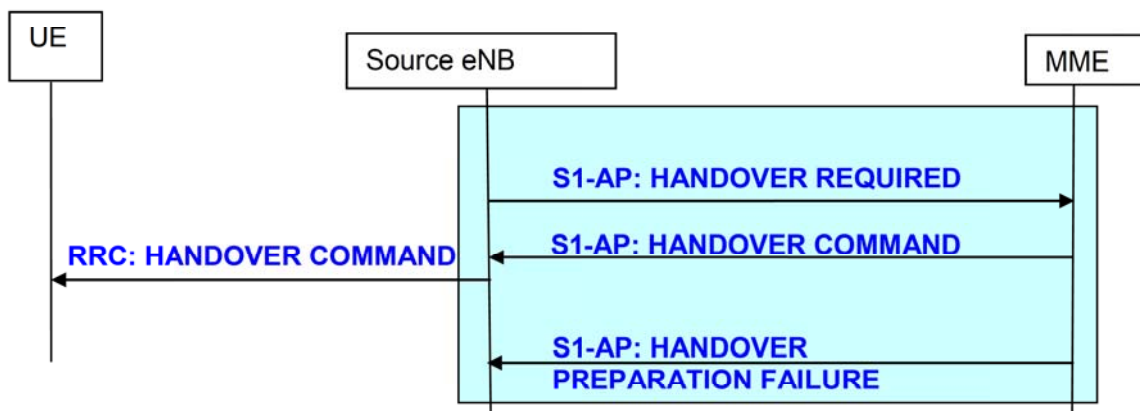


Figure 19.2.2.5.1-1: Handover preparation procedure

The handover preparation comprises the following steps:

- The HANDOVER REQUIRED message is sent to the MME.
- The handover preparation phase is finished upon the reception of the HANDOVER COMMAND in the source eNB, which includes at least radio interface related information (HO Command for the UE), successfully established EPS Bearer(s) and EPS bearer(s) which failed to setup.
- In case the handover resource allocation is not successful (e.g. no resources are available on the target side) the MME responds with the HANDOVER PREPARATION FAILURE message instead of the HANDOVER COMMAND message.

19.2.2.5.2 Handover Resource Allocation procedure

The handover resource allocation comprises the following steps:

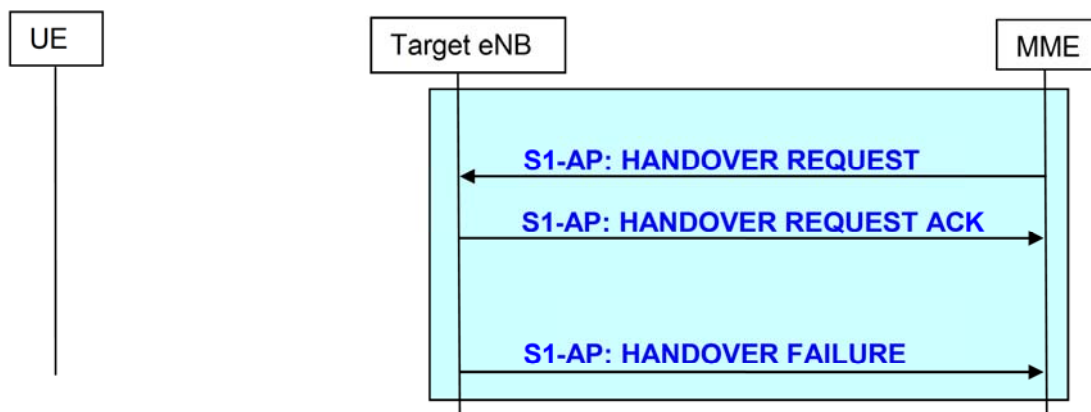


Figure 19.2.2.5.2-1: Handover resource allocation procedure

- The MME sends the HANDOVER REQUEST message including the EPS Bearer(s) which needs to be setup by the target eNB.
- The target eNB responds with the HANDOVER REQUEST ACK message after the required resources for all accepted EPS Bearers are allocated. The HANDOVER REQUEST ACK message contains successfully established EPS bearer(s), EPS Bearer(s) which failed to setup and radio interface related information (HO Command for the UE), which is later sent transparently via the EPC/CN from the target RAT to the source RAT.

If no resources are available on the target side, the target eNB responds with the HANDOVER FAILURE message instead of the HANDOVER REQUEST ACK message.

19.2.2.5.3 Handover Notification procedure

The Handover Completion for S1 initiated handovers comprises the following steps:

- The HANDOVER NOTIFY message is sent by the target eNB to the MME when the UE has successfully been transferred to the target cell.

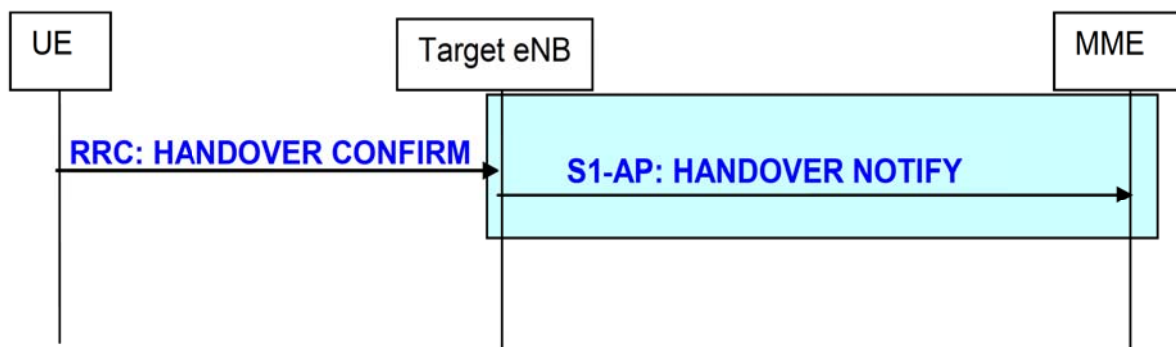


Figure 19.2.2.5.3-1: Handover completion procedure

19.2.2.5.4 Handover Cancellation

This functionality is located in the source eNB to allow a final decision regarding the outcome of the handover, i.e. either to proceed or to cancel the handover procedure.

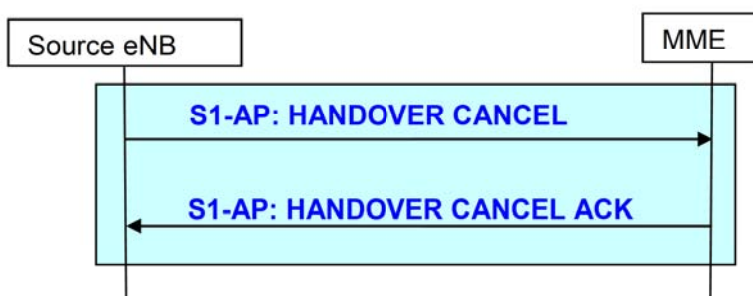


Figure 19.2.2.5.4-1: Handover cancellation procedure

- The source eNB sends a HANDOVER CANCEL message to the MME indicating the reason for the handover cancellation.
- The MME confirms the reception of the HANDOVER CANCEL message by returning the HANDOVER CANCEL ACK message.

19.2.2.5.5 Path Switch procedure

The handover completion phase for X2 initiated handovers comprises the following steps:

- The PATH SWITCH message is sent by the target eNB to the MME when the UE has successfully been transferred to the target cell. The PATH SWITCH message includes the outcome of the resource allocation: successfully established EPS Bearer(s).
- The MME responds with the PATH SWITCH ACK message which is sent to the eNB.
- The MME responds with the PATH SWITCH FAILURE message in case a failure occurs in the EPC.

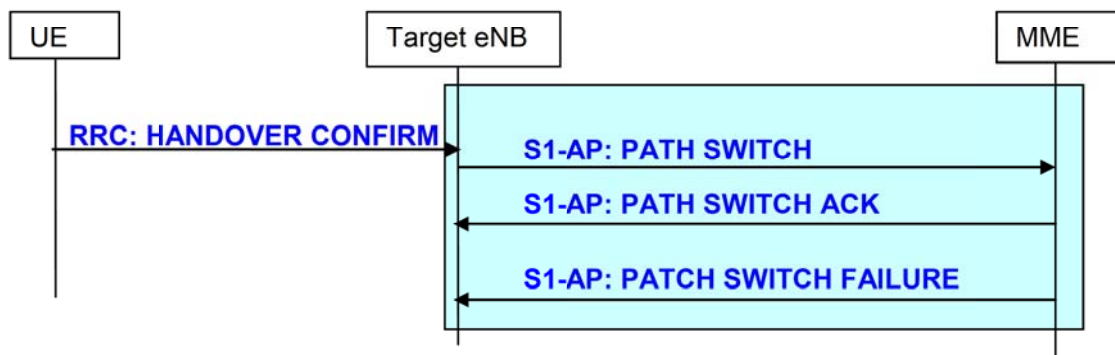


Figure 19.2.2.5.5-1: Path Switch procedure

19.2.2.6 NAS transport procedures

A NAS signalling message is transferred on the S1 interface in both directions. The procedures providing this functionality are

- Initial UE Message procedure (eNB initiated)
- Uplink NAS transport procedure (eNB initiated)
- Downlink NAS transport procedure (MME initiated)
- Downlink NAS non delivery indication procedure

i) Initial UE Message procedure

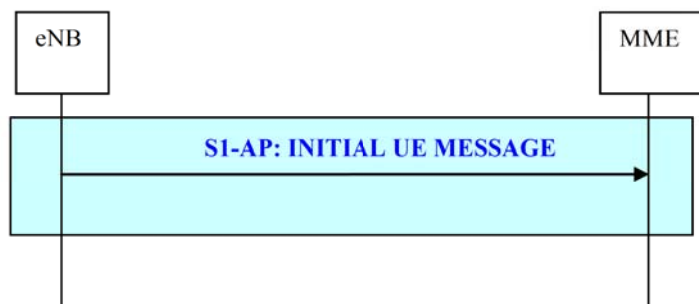


Figure 19.2.2.6-1: Initial UE Message procedure

- The INITIAL UE MESSAGE procedure is initiated by the eNB by sending the INITIAL UE MESSAGE message to the MME. The INITIAL UE MESSAGE contains a NAS message (e.g. Service Request), the UE signalling reference ID and other S1 addressing information.

ii) NAS Transport procedure (eNB initiated).

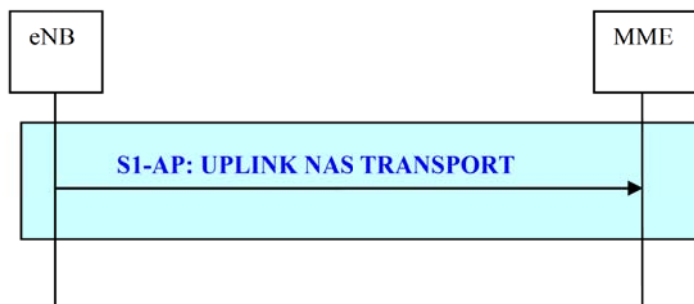


Figure 19.2.2.6-2: Uplink NAS Transport procedure

- The Uplink NAS Transport procedure is initiated by the eNB by sending the UPLINK NAS TRANSPORT message to the MME. The UPLINK NAS TRANSPORT message contains a NAS message, UE identification and other S1 related addressing information.

iii) NAS Transport procedure (MME initiated)

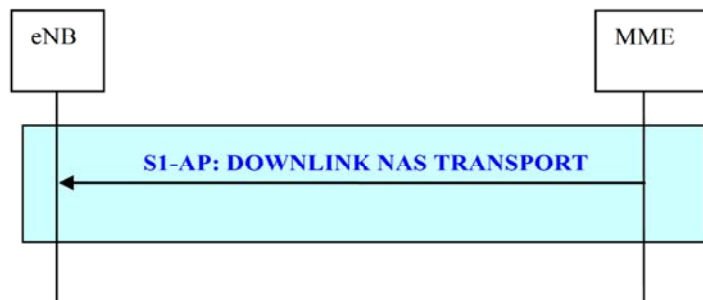


Figure 19.2.2.6-3: Downlink NAS Transport procedure

- The Downlink NAS Transport procedure is initiated by the MME by sending the DOWNLINK NAS TRANSPORT message to the eNB. The DOWNLINK NAS TRANSPORT contains a NAS message, UE identification and other S1 related addressing information.

iv) Downlink NAS non delivery procedure



Figure 19.2.2.6-4: Downlink NAS Non Delivery Indication procedure

- When the eNB decides to not start the delivery of a NAS message that has been received from MME, it shall report the non-delivery of this NAS message by sending a DOWNLINK NAS NON DELIVERY INDICATION message to the MME including the non-delivered NAS message and an appropriate cause value.

19.2.2.7 S1 interface Management procedures

19.2.2.7.1 Reset procedure

The purpose of the Reset procedure is to initialize the peer entity after node setup and after a failure event occurred. This procedure is initiated by both the eNB and MME.

19.2.2.7.1a eNB initiated Reset procedure

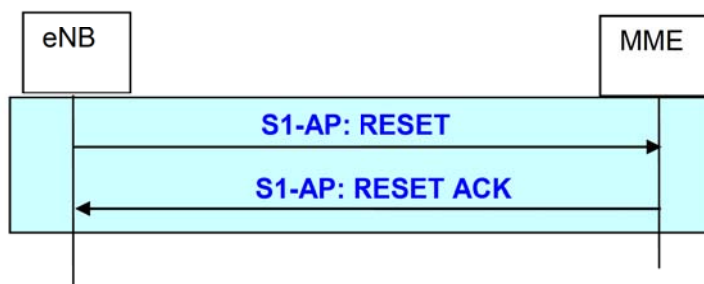


Figure 19.2.2.7.1a-1: eNB initiated Reset procedure

- The eNB triggers the RESET message to indicate that an initialisation in the MME is required. The MME releases the corresponding references and resources.
- Afterwards the MME sends the RESET ACK message to confirm that the resources and references are cleared.

19.2.2.7.1b MME initiated Reset procedure

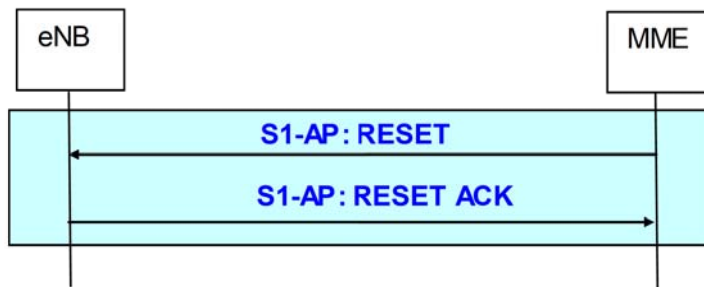


Figure 19.2.2.7.1b-1: MME initiated Reset procedure

- The MME triggers the RESET message to indicate that an initialisation in the eNB is required. The eNB releases the corresponding references and resources.
- Afterwards the eNB sends the RESET ACK message to confirm that the resources and references are cleared.

19.2.2.7.2 Error Indication functions and procedures

The Error Indication procedure is initiated by the eNB and the MME, to report detected errors in one incoming message, if an appropriate failure message cannot be reported to the sending entity.

19.2.2.7.2a eNB initiated error indication

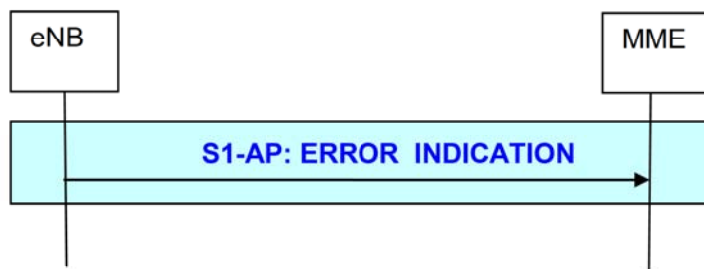


Figure 19.2.2.7.2a-1: eNB initiated Error Indication procedure

- The eNB sends the ERROR INDICATION message to report the peer entity which kind of error occurs.

19.2.2.7.2b MME initiated error indication

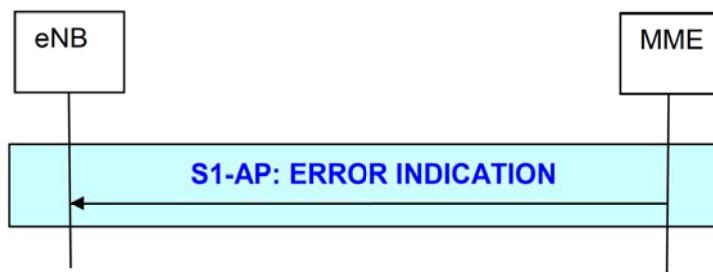


Figure 19.2.2.7.2b-1: MME initiated Error Indication procedure

- The MME sends the ERROR INDICATION message to report the peer entity which kind of error occurs.

20 X2 Interface

20.1 User Plane

The X2 user plane interface (X2-U) is defined between eNBs. The X2-U interface provides non guaranteed delivery of user plane PDUs. The user plane protocol stack on the X2 interface is shown in Figure 20.1-1. The transport network layer is built on IP transport and GTP-U is used on top of UDP/IP to carry the user plane PDUs.

The X2-UP interface protocol stack is identical to the S1-UP protocol stack.

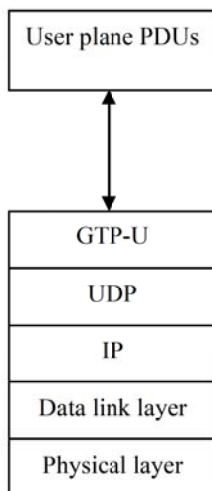


Figure 20.1-1: X2 Interface User Plane (eNB-eNB)

20.2 Control Plane

The X2 control plane interface (X2-CP) is defined between two neighbour eNBs. The control plane protocol stack of the X2 interface is shown on Figure 20.2-1 below. The transport network layer is built on SCTP on top of IP. The application layer signalling protocol is referred to as X2-AP (X2 Application Protocol).

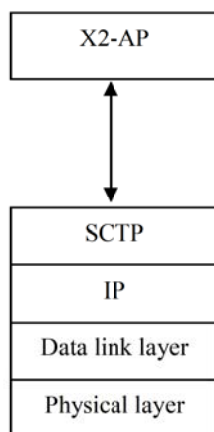


Figure 20.2-1: X2 Interface Control Plane

A single SCTP association per X2-C interface instance shall be used with one pair of stream identifiers for X2-C common procedures. Only a few pairs of stream identifiers should be used for X2-C dedicated procedures. The upper limit for the number of stream identifiers for dedicated procedures is FFS and will be decided during the stage 3 work.

Source-eNB communication context identifiers that are assigned by the source-eNB for X2-C dedicated procedures, and target-eNB communication context identifiers that are assigned by the target-eNB for X2-C dedicated procedures, shall be used to distinguish UE specific X2-C signalling transport bearers. The communication context identifiers are conveyed in the respective X2AP messages.

20.2.1 X2-CP Functions

The X2AP protocol supports the following functions:

- Intra LTE-Access-System Mobility Support for UE in ECM-CONNECTED:
 - Context transfer from source eNB to target eNB;
 - Control of user plane tunnels between source eNB and target eNB;
 - Handover cancellation.
- Uplink Load Management;
- General X2 management and error handling functions:
 - Error indication.

20.2.2 X2-CP Procedures

The elementary procedures supported by the X2AP protocol are listed in Table 20.2.2-1 below:

Table 20.2.2-1: X2-CP Procedures

Elementary Procedure	Initiating Message	Response Message of Successful Outcome	Response Message of Unsuccessful Outcome	Description & comments
Handover Preparation	HANDOVER REQUEST	HANDOVER REQUEST ACKNOWLEDGE	HANDOVER PREPARATION FAILURE	Used by source eNB to request a handover to the target eNB
Handover Cancellation	HANDOVER CANCEL			Used by the source eNB to cancel a previously requested handover in a target eNB
Release Resource	RELEASE RESOURCE	-	-	Used by the target eNB to signal to source eNB that control plane resources for the handed over UE context can be released.
Error Indication	ERROR INDICATION	-	-	Used by the eNB to report errors in a received message provided they cannot be reported by an appropriate response message.
Load Management	LOAD INDICATOR	-	-	Used by the eNB to report its load conditions to its neighbour eNBs.

Note: this initial list might be extended.

20.2.2.1 Handover Preparation procedure

The Handover preparation procedure is initiated by the source eNB if it determines the necessity to initiate the handover via the X2 interface.

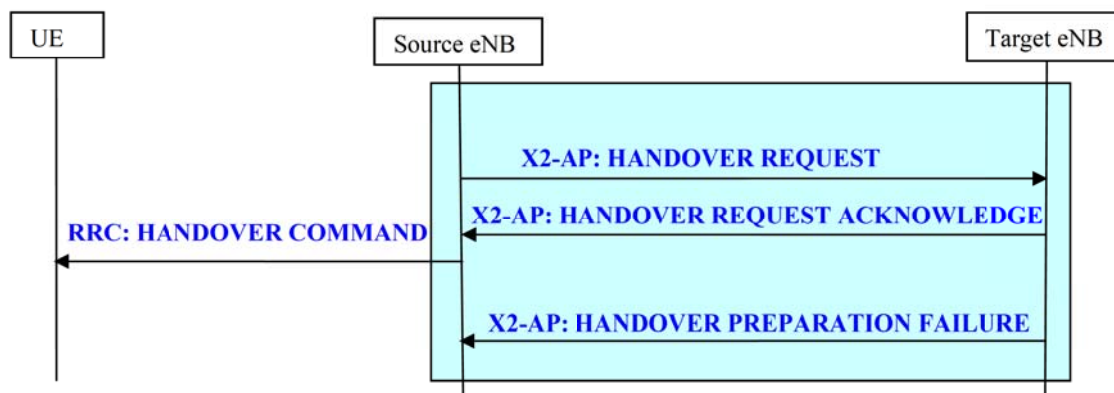


Figure 20.2.2.1-1: Handover Preparation procedure

The source eNB sends a HANDOVER REQUEST to the target eNB including the bearers to be setup by the target eNB.

The handover preparation phase is finished upon the reception of the HANDOVER REQUEST ACKNOWLEDGE in the source eNB, which includes at least radio interface related information (HO Command for the UE), successfully established EPS Bearer(s) and failed established EPS Bearer(s).

In case the handover resource allocation is not successful (e.g. no resources are available on the target side) the target eNB responds with the HANDOVER PREPARATION FAILURE message instead of the HANDOVER REQUEST ACKNOWLEDGE message.

If eNB received NAS message from MME during X2 handover procedure, it shall be acted as specified in subclause 19.2.2.6.

20.2.2.2 Handover Cancellation procedure

This functionality is located in the source eNB to allow cancellation of the handover procedure.

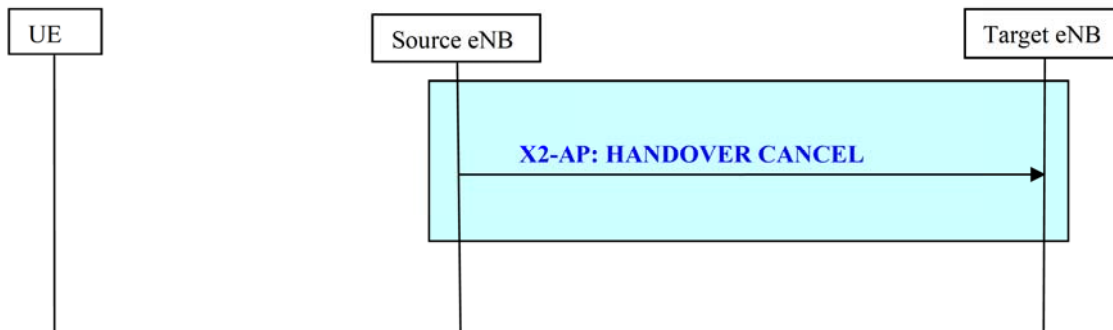


Figure 20.2.2.2-1: Handover Cancellation procedure

The source eNB sends a HANOVER CANCEL message to the target eNB indicating the reason for the handover cancellation.

20.2.3 Inter-cell Load Management

Inter-cell load management in E-UTRAN is performed through the X2 interface. In case of variation in the load condition, the eNodeB signals the new load condition to its neighbour eNodeBs e.g. the neighbour eNodeBs for which an X2 interface is configured due to mobility reasons.

The LOAD INDICATOR message is used to signal the load conditions between eNodeBs.

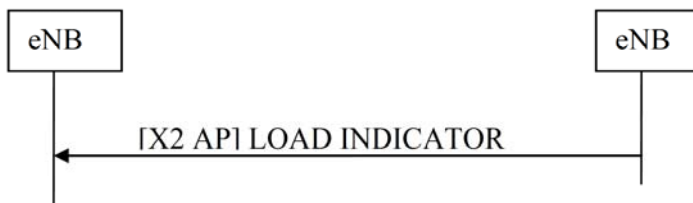


Figure 20.2.3-1: LOAD INDICATOR message over X2

21 System and Terminal complexity

21.1 Overall System complexity

21.2 Physical layer complexity

21.3 UE complexity

22 Support for self-configuration and self-optimisation

22.1 Definitions

This concept includes several different functions from eNB activation to radio parameter tuning. Figure 22.1-1 is a basic framework for all self-configuration /self-optimization functions.

Self-configuration process is defined as the process where newly deployed nodes are configured by automatic installation procedures to get the necessary basic configuration for system operation.

This process works in pre-operational state. Pre-operational state is understood as the state from when the eNB is powered up and has backbone connectivity until the RF transmitter is switched on.

As described in Figure 21.1, functions handled in the pre-operational state like:

- Basic Setup and
- Initial Radio Configuration

are covered by the Self Configuration process.

NOTE: depending on the final chosen functional distribution in RAN, the feasibility of following items should be studied e.g.:

- To obtain the necessary interface configuration;
- Automatic registration of nodes in the system can be provided by the network;
- Alternative possibilities for nodes to obtain a valid configuration;
- The required standardization scope.

Self-optimization process is defined as the process where UE & eNB measurements and performance measurements are used to auto-tune the network.

This process works in operational state. Operational state is understood as the state where the RF interface is additionally switched on.

As described in Figure 21.1, functions handled in the operational state like:

- Optimization / Adaptation

are covered by the Self Optimization process.

NOTE: depending on the final chosen functional distribution in RAN the feasibility of following items should be studied e.g.:

- The distribution of data and measurements over interfaces relevant to RAN3;
- Functions/entities/nodes in charge of data aggregation for optimization purpose;
- Dependencies with O&M and O&M interfaces, in the self optimization process;
- The required standardization scope.

The architecture of logical self-configuration/optimization functionality is FFS.

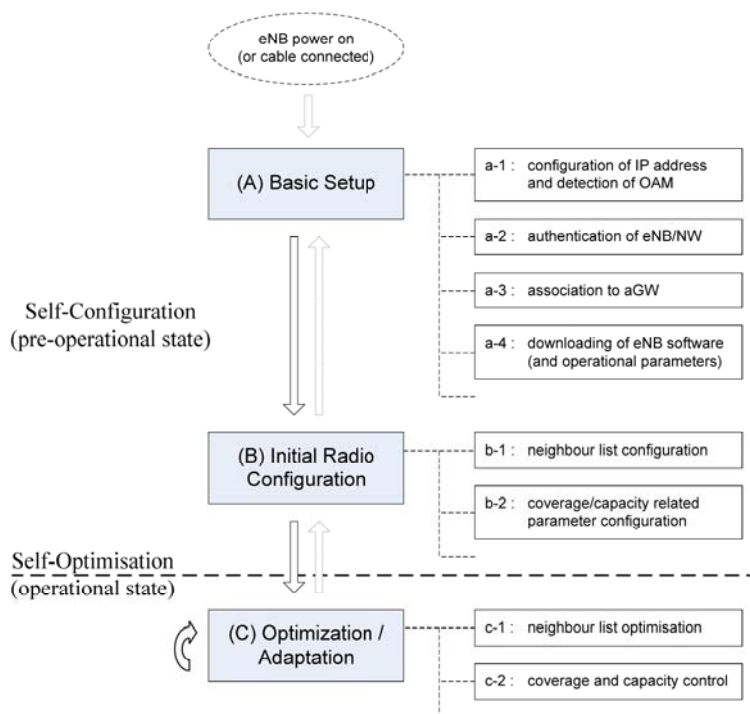


Figure 22.1-1: Ramifications of Self-Configuration /Self-Optimization functionality

22.2 UE Support for self-configuration and self-optimisation

UE shall support measurements and procedures which can be used for self-configuration and self-optimisation of the E-UTRAN system.

- UE shall support measurements and measurement reporting to support self-optimisation of the E-UTRAN system. Measurements and reports used for the normal system operation, should be used as input for the self-optimisation process as far as possible.

NOTE: the UE impact should be carefully investigated and taken into account.

- The network is able to configure the measurements and the reporting for self-optimisation support by RRC signalling messages.
- It shall be possible to associate measurements for self-optimisation purpose with location information depending on UE capability (details are [FFS]).

22.3 Self-configuration

22.3.1 Dynamic configuration of the S1-MME interface

22.3.1.1 Prerequisites

The following prerequisites are assumed:

- An initial remote IP end point to be used for SCTP initialisation is provided to the eNB for each MME in the pre operational state.

How the eNB gets the remote IP end point(s) and its own IP address are FFS.

- Other relevant information from/to eNB to/from MME to self-configure S1-MME are FFS

22.3.1.2 SCTP initialization

- For each MME the eNodeB tries to initialize a SCTP association as described in RFC2960 [8], using a known initial remote IP Endpoint as the starting point, until SCTP connectivity is established.

22.3.1.3 Application layer initialization

Once SCTP connectivity has been established, the eNodeB and MME are in a position to exchange application level configuration data over the S1-MME application protocol needed for the two nodes to interwork correctly on the S1 interface. The details of the information exchange outlined below are FFS, and dependent on the further standardization of the S1 interface.

- The eNodeB provides the relevant information to the MME, which may include node ID, list of supported TA(s), etc. Details of the relevant information needed to setup the S1-MME interface is subject to stage3 discussion and is left FFS.
- The MME provides the relevant information to the eNodeB, which may include node ID, PLMN ID, etc. Details of the relevant information needed to setup the S1-MME interface is subject to stage3 discussion and is left FFS.
- When the application layer initialization is successfully concluded, and has been mutually acknowledged by the two peer nodes, the dynamic configuration procedure is completed, and the S1-MME interface is operational.

22.3.2 Dynamic Configuration of the X2 interface

Editors Note: The Dynamic configuration of the X2 interface is expected to work in a similar manner as the Dynamic Configuration of the S1-MME interface (section 22.3.1).

22.3.2.1 Prerequisites

22.3.2.2 SCTP initialization

22.3.2.3 Application layer initialization

22.3.3 Automatic Neighbour Relation Function

The ANR (Automatic Neighbor Relation) function relies on cells broadcasting their identity on global level, Cell Global-Cell-Identifier (Global-CID).

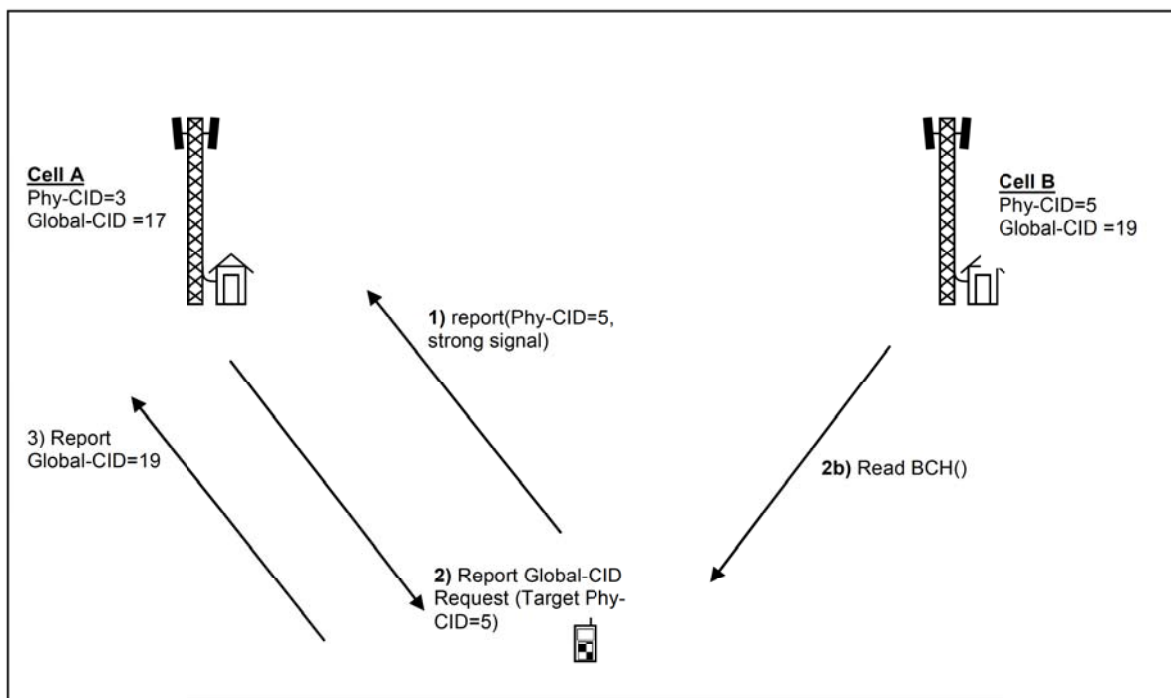


Figure 22.3.3-1: Automatic Neighbor Relation Function

It is assumed that this function executes under the constraints of the O&M system which can manage:

ANR Blacklist: List of cells to which the eNB shall neither establish nor keep a neighbour relation.

ANR Whitelist: List of cells to which the eNB shall always establish and maintain a neighbour relation.

It is also assumed that the O&M system is informed about changes in the eNB neighbour relation list.

The function works as follows:

The eNodeB serving cell A has an ANR function. As a part of the normal call procedure, the eNodeB instructs each UEs to perform measurements on neighbor cells. The eNodeB may use different policies for instructing the UE to do measurements, and when to report them to the eNodeB.

1. The UE sends a measurement report regarding cell B. This report contains Cell B's Phy-CID, but not its Global-CID.

When the eNodeB receives a UE measurement report containing Phy-CID, the following sequence may be used.

2. The eNodeB instructs the UE, using the newly discovered Phy-CID as parameter, to read the Global-CID of the related neighbor cell. It is FFS how this is achieved.
3. When the UE has found out the new cell's Global-CID, the UE reports the detected Global-CID to the serving cell eNodeB.
4. The eNodeB decides to add this neighbor relation, and can use Phy-CID and Global-CID to:
 - a Lookup a transport layer address to the new eNodeB (FFS if this needs to be standardized by 3GPP).
 - b Update its Neighbor Relation List.
 - c If needed, setup a new X2 interface towards this eNodeB. The setup of the X2 interface is described in section 22.3.2.

The exchange of further information for ANR optimisation purposes is FFS.

23 Others

23.1 Support for real time IMS services

23.2 Subscriber and equipment trace

Support for subscriber and equipment trace for LTE and SAE shall be as specified in 3GPP specifications 32.421, 32.422, 32.423 and 3GPP Trace IRP 32.441, 32.442 and 32.443.

All traces are initiated by the core network, even if the trace shall be carried out in the radio network.

The following functionality is needed on the S1 and X2 interface:

- Support for inclusion of subscriber and equipment trace information in INITIAL CONTEXT SETUP REQUEST and EPS BEARER SETUP REQUEST messages over the S1 interface.
- Support for inclusion of subscriber and equipment trace information in the HANDOVER REQUEST message over the X2 interface.

A trace setup in the radio network will be propagated on the X2 interface at handover and on the S1 interface if the handover is carried out between MMEs.

Annex A (informative): NAS Overview

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

A.1 Services and Functions

The main services and functions of the NAS sublayer include:

- EPS Bearer control (see 3GPP TR 23.401 [17]);
- ECM-IDLE mobility handling;
- Paging origination;
- Configuration and control of Security.

A.2 NAS protocol states & state transitions

The NAS state model is based on a two-dimensional model which consists of EPS Mobility Management (EMM) states describing the mobility management states that result from the mobility management procedures e.g. Attach and Tracking Area Update procedures, and of EPS Connection Management (ECM) states describing the signalling connectivity between the UE and the EPC (see 3GPP TS 23.401 [17]).

NOTE: The ECM and EMM states are independent of each other and when the UE is in EMM-CONNECTED state this does not imply that the user plane (radio and S1 bearers) is established.

The relation between NAS and AS states is characterised by the following principles:

- EMM-DEREGISTERED & ECM-IDLE \Rightarrow RRC_IDLE:
 - Mobility: PLMN selection;
 - UE Position: not known by the network.
- EMM-REGISTERED & ECM-IDLE \Rightarrow RRC_IDLE:
 - Mobility: cell reselection;
 - UE Position: known by the network at tracking area level.
- EMM-REGISTERED & ECM-CONNECTED with radio bearers established \Rightarrow RRC_CONNECTED.
 - Mobility: handover;
 - UE Position: known by the network at cell level.

Annex B (informative): MAC and RRC Control

The E-UTRA supports control signalling in terms of MAC control signalling (L1/L2 control channel and MAC control PDU) and RRC control signalling (RRC message).

B.1 Difference between MAC and RRC control

The different characteristics of MAC and RRC control are summarized in the table below.

Table B.1-1: Summary of the difference between MAC and RRC control

	MAC control		RRC control
Control entity	MAC		RRC
Signalling	L1/L2 control channel	MAC control PDU	RRC message
Signalling reliability	$\sim 10^{-2}$ (no retransmission)	$\sim 10^{-3}$ (after HARQ)	$\sim 10^{-6}$ (after ARQ)
Control delay	Very short	Short	Longer
Extensibility	None or very limited	Limited	High
Security	No integrity protection No ciphering	No integrity protection No ciphering	Integrity protected Ciphering (FFS)

The main difference between MAC and RRC control lies in the signalling reliability. Due to the signalling reliability, signalling involving state transitions and radio bearer configurations should be performed by RRC. Basically, all signalling performed by RRC in UTRA should also be performed by RRC also for E-UTRA.

B.2 Classification of MAC and RRC control functions

The table below illustrates the classification of MAC and RRC control functions for E-UTRAN.

Table B.2-1: Classification of MAC and RRC control functions

		Controlled configuration/parameters
MAC control signalling	L1/L2 control channel	Short-lived (PRB) and dynamic (MCS) allocation Long-lived (PRB) and fixed (MCS) allocation (FFS) Timing Advance (FFS)
	MAC control PDU	Timing Advance (FFS) RLC related control PDU (FFS)
RRC control signalling	RRC message	Long-lived (PRB) and fixed (MCS) allocation (FFS) Activation/deactivation of long-lived (PRB) and/or fixed (MCS) allocation (FFS) TTI configuration for variable TTI length control (FFS) Static parameter configuration for UE inactivity control within RRC_ACTIVE (e.g. DRX/DTX periods)

Annex C (informative): System Information

This annex provides an overview of the classification and division of system information between static and flexible parts. Considerations about dedicated distribution of system information are also included.

C.1 SI classification

Five categories are identified for system information classification:

1. Information valid across multiple cells;
2. Information needed at cell/PLMN search;
3. Information needed prior to cell camping;
4. Information needed before cell access;
5. Information needed while camping on a cell.

From UEs' point of view, the information that is needed at cell selection and prior to camping are very similar. Before a UE can camp on a cell, it needs to know if the access is allowed in that cell. Thus it would be very beneficial to know all access restrictions already at cell search phase.

C.1.1 Information valid across multiple cells

The pieces of information that can be valid across multiple cells are:

- A-GNSS assistance data;
- PLMN identity(ies);
- Tracking area identity;

Note: the above text will be revised if it is agreed that a cell can be a member of more than one tracking area.

- Predefined configuration information;
- System Frame Number if it does not change from cell to cell (in case of synchronized network);
- Some measurement/mobility information (FFS).

C.1.2 Information needed at cell/PLMN search

In order to support full mobility within the serving frequency layer, the UEs need to perform cell search rather often and thus it is seen very important that the information needed in cell search phase is readily available, thereby improving cell search times and minimizing UE power consumption. If system information decoding is needed for identifying a cell, fast system information reception is needed in order to avoid too long identification times. For optimising PLMN search and make PLMN search fast and non-complex, the information needed for PLMN search should be easily available. The pieces of information that are needed at cell/PLMN search are:

- PLMN identity(ies): in order to acquire information to which PLMN the cell belongs, UEs need to receive PLMN identity(ies);

NOTE: There may be multiple PLMN identities for one cell.

- Measurement cell identity (FFS): there needs to be a cell identity in the system information, in order to allow UEs to identify the cell reliably for measurement purposes.

NOTE: UEs may identify the cell also based on the reference sequence detection; There is another cell identity that identifies the cell within e.g. PLMN.

NOTE: UEs may have to check possible cell access restrictions before selecting cell/PLMN; For cell/PLMN search UEs might need some L1 parameters.

C.1.3 Information needed prior to cell camping

Before a UE can camp on a cell, it needs to know any access related parameters in order to avoid camping on cells where access is forbidden. Thus prior to camping on a cell, a UE needs to know the following information:

- Any cell access restriction parameters, e.g.:
 - Tracking area identity: if the forbidden TA concept is adopted from legacy systems, then the UE needs to know whether the cell belongs to such forbidden TA.

Note: the above text will be revised if it is agreed that a cell can be a member of more than one tracking area.

- Cell barring status and cell reservation status (FFS if needed per PLMN): the UE needs to know whether the cell is barred or reserved in order to avoid camping on a barred cell. Possibly also barring time might be needed in order to avoid UE to poll barring time frequently from the system information. Another option is that barring status is indicated also in the neighbour cell list.
- Radio access limitation parameters:
 - Any radio condition parameters that limit the access to the cell e.g. similar to GSM C1/S criteria;
 - It is FFS if we need to have some band information indication also, in order to allow UEs to check possible band support before camping on the cell.

NOTE: UE may need some L1 parameters prior to camping.

C.1.4 Information needed prior to cell access

Once a UE has camped on a cell, the information needed prior to cell access (transmission/reception) includes at least:

- System Frame Number (SFN) (FFS)
 - SFN is probably needed by the UE to understand the scheduling parameters (e.g. scheduling information for secondary SI, RACH, PCH, E-MBMS etc.)
- L1 information, example set of needed L1 parameters:

Note: RAN1 needs to define what parameters are needed at this phase.

- Carrier Bandwidth: FFS if separate bandwidths for UL and DL are needed;
- Carrier center frequency (FFS);
- Cyclic Prefix parameters: in order to decode DL-SCH UE needs to know the CP length arrangements;
- MIMO related parameters: in order to take advantage of the multi-antenna transmissions like MIMO, the UE needs to know parameters of number of TX antennas, DL/UL pre-coding matrices, etc...;
- Band Information: may be needed if the same DL carrier frequency has variable UL carrier frequency;
- L1/L2 signalling channel structure parameters: if L1/L2 signalling channel has variable configurations, the UE may need to know its channel structure at least partly. L1/L2 signalling is crucial to receive any allocation information. If Random Access Response is transmitted without L1/L2 signalling (e.g. synchronous transmission with Random Access Preamble), this information might not be required;
- RACH parameters (needed by the UE to start usage of RACH):

- RACH scheduling information: UE needs to know where in time (sub-frame) and frequency (Physical Resource Units) the RACH channel is located;
- RACH sequences: UE needs to know the RACH set of sequences to choose from. The sequences may not be fully of equal meaning (e.g. CQI can be classified for the sequences in a specific way);
- Access class restrictions: access class restrictions might be needed to limit the number of possible UEs using RACH;
- Persistence values: possible persistence value scheme parameters are needed for RACH usage;
- Other parameters related to RACH: UE needs to know the timers and parameters related to RACH e.g. how often the UE retransmits RACH and how many times the retransmission is allowed etc;
- RACH power control parameters: UE needs to know parameters related to UL power control.

C.1.5 Information needed while camping on a cell

When a UE has camped on a cell, it needs to continue measuring the neighbouring cells in order to stay camped. The pieces of information required for that are:

- Measurement parameters:
 - In order for the UE to start mobility procedures, it needs to receive parameters e.g. of reporting periods, reporting event parameters, time to trigger etc. UEs in RRC_IDLE state need cell reselection parameters. UEs in RRC_CONNECTED state need parameters of the neighbour cells e.g. for handover and for error recovery cases.
 - Neighbour cell lists are needed to start neighbour cell measurements. UEs in different states may use different sets of neighbour cell lists. Neighbour cell list may contain following parameters:
 - Some L1 parameters: FFS what parameters are needed in the neighbour cell list;
 - All information that is needed for camping: see sub-clauses C.2.2 and C.2.3 (FFS);
 - Synchronization information: indicating whether the neighbouring cell is synchronized to the current cell i.e. the cell sending the neighbour cell list (FFS);
 - PLMN identity(ies) & tracking area identity (FFS);

Note: The above text will be revised if it is agreed that a cell can be a member of more than one tracking area.

- Other 3GPP RAT information: e.g. neighbour cell information of GERAN/UTRAN cells;
- Information of non-3GPP access systems (e.g. WIMAX).
- Secondary NAS parameters:
 - Any NAS parameters that were not presented earlier e.g. cell identity uniquely identifying cell within wide area e.g. PLMN;
 - Cell identity (PLMN level) (FFS if this should be in category "Information needed prior to cell access").
- Secondary UE timer values: any timer values that affect UE's behaviour.
- Paging parameters: UEs in ECM-IDLE state need to receive paging parameters e.g. DRX periods and scheduling.
- Clock time (FFS): the network might send system clock in order to let UEs update their clock time e.g. in the user interface;
- MBMS service parameters: any parameters needed for MBMS reception e.g. MBMS multiplexing parameters, MBMS frequency;

NOTE: the presence of these parameters also indicate the presence of MBMS service in the cell (dedicated or mixed cell).

- Signalling Radio Bearer parameters: may be broadcasted unless they are standardized.

C.1.6 Thoughts about category division

From UEs' point of view the categories in sub-clauses C.1.2 and C.1.3 are very similar. Thus it is questionable whether we need to differentiate procedures between cell search/selection/camping and PLMN search.

From UEs' point of view, the difference between the procedure for cell search during RRC_CONNECTED and the procedure for cell search during RRC_IDLE state may be small. When the UE is in RRC_CONNECTED state, it measures the neighbour cell and executes handovers commanded by the network.

C.2 Division of SI between static and flexible parts

System information distribution can be classified into two distinctive parts: static and flexible. Static part is sent more often, say once per frame, in the cell and has quite a limited capacity for information transfer. The flexible part has flexible amount of scheduled resources available and thus most of the SI information is contained there.

C.2.1 Static part

The static parts of the System Information are:

- L1 information in order to decode the rest of the information

Note: detailed information on the required information will be defined by RAN1;

- Measurement Cell identity (FFS): it may be possible that L1 channels do not identify the cell. Then some Cell identity needs to be sent on system information part;
- Any cell access restriction parameters e.g.:
 - Tracking area identity: if forbidden TA concept is adopted from legacy systems then UEs need to know whether the cell belongs to forbidden TA;

Note: the above text will be revised if it is agreed that a cell can be a member of more than one tracking area.

- Cell barring and cell reservation status (FFS if needed per PLMN): UEs need to know whether cell is barred or reserved in order to avoid camping on barred cell. Possibly also barring time might be needed in order to avoid UEs to poll barring time frequently from the system information;
- Radio access limitation parameters: any radio condition parameters that limit the access to the cell e.g. similar to GSM C1/S criteria;
- PLMN identity(ies): in order to acquire information to which PLMN cell belongs, UEs need to receive PLMN identity(ies).

NOTE: there may be multiple PLMN identities for one cell.

- Scheduling parameters:
 - All of the scheduling information of flexible part or part of scheduling information (e.g. scheduling block) of flexible part. If static part consists of multiple SI blocks then it may be necessary to have scheduling information of those blocks in the static part.
 - Scheduling block defines, from where (time and frequency resources) to decode the SI blocks of the scheduled flexible part. It may be possible that scheduling of scheduling block is standardized, then this information can be omitted from the static part. If several types of scheduling blocks are defined, scheduling information might be sent for each scheduling block.
- Value_tag(s): informs whether the information transmitted on the flexible part has changed. This is needed in order to avoid UEs from reading any unchanged information repeatedly. Another possibility is to send this information in L1/L2 signalling channel, but possibly it would cause too much overhead.

NOTE: It also is possible to include Value_tag for SI on the flexible part indicating more precisely what changes have occurred in the system information.

NOTE: There may be a need for indicating changes in static part with value tag also, if static part consists of multiple SI blocks.

Table C.2.1-1 gives an estimate of the size of the elements mentioned above.

Table C.2.1-1: Initial rough estimates for static part capacity requirement

Information element	Bits
Cyclic Prefix (FFS)	2
Carrier BW (FFS)	3-8
MIMO parameters (FFS)	2 (+ 3)
Cell Id (FFS)	9
Tracking Area Id (+ FFS how many additional)	[16-28]
Cell Barring status+ possible Time of barring	1+4
Cell reservation status	[2]
Radio access limitation parameters	12
PLMN id(s) maximum of 5 (24 bits per one) - see Note	120
Scheduling parameters	(12-108)
Value Tag	4
SFN (FFS)	11

NOTE: It might not be necessary to send the Mobile Country Code part of the PLMN identity for each indicated PLMN to limit the number of bits.

C.2.2 Flexible part

The flexible part has different types of Information Elements which require independent scheduling in order to allow fast enough reception and not to waste transmission capacity. For example, the requirement to receive cell access parameters is very different than e.g. the clock time. Thus following flexible part division should be considered:

- Scheduling block: scheduling information of the secondary part of the System Information.
- Access parameters:
 - All parameters not present in the primary part (e.g. some L1 parameters);
 - RACH parameters;
 - Power control parameters;
 - Paging parameters;
 - Any timer values needed for operating in the cell and in the network.
- Measurement related parameters:
 - Neighbour cell lists;
 - Cell selection/reselection parameters;

NOTE: Some of these parameters are included in the static part element "Radio access limitation parameters."

- Measurement control information;
- Non vital information:
 - Clock time;
 - Positioning (A-GNSS etc.) information;

- Service parameters (e.g. MBMS parameters);
- Secondary NAS parameters.

C.2.3 Information whose location is FFS

The location of the following information is FFS:

- System Frame Number: SFN might be needed very fast i.e. for HO purposes. SFN might be needed also for decoding scheduling block parameters, but on the other hand it might be requested not to send often changing information on the static part in order to be able to make time soft combining. Further investigation on the SFN broadcasting is thus needed.

C.2.4 Dedicated part

The dedicated part is embedded in the RRC message that is meant for sending System Information Elements in unicast mode e.g. for HO purposes, positioning purposes The UE needs some information for the neighbouring cell to access it, this is needed to limit the interruption times caused by HO execution. When a UE receives a HO COMMAND it needs at least following information from the target cell:

- All information in the static part (see sub-clause C.2.1): may be received by the UE by itself;
- Most of the information from the access parameters (see sub-clause C.2.2): is favourably delivered by dedicated manner via the source cell, because the UE might not have time to get all the necessary secondary SI from the target cell;
- System Frame Number is needed to minimize the interruption times during the HO procedure. Most probably the UE needs to receive (at least confirm) the SFN directly by the neighbour cell SI reading, because giving the SFN via source cell may cause some inaccuracy to the SFN.

Annex D (informative): MBMS

D.1 MBMS control & 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 EPS bearer control.

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

D.2 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;
 - No support for unicast data transfer in the cell;
 - 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 MBSFN operation on the MCH of the MBSFN area is semi-statically configured e.g. by O&M.
 - Single-cell p-t-m transmission is possible.
- When a cell does not belong to a frequency layer dedicated to MBMS transmissions (MBMS/Unicast-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+DL-SCH (FFS);
 - The possible MBSFN operation on the MCH of the MBSFN area is semi-statically configured e.g. by O&M; or the SFN area is dynamic and may be based on counting mechanisms (FFS).
 - Counting is possible (FFS);

- P-t-p transmission on DL-SCH is FFS.

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

- Single-cell transmission (no MBSFN 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);
 - 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).
- Multi-cell transmission (MBSFN operation):
 - The MBMS service (MTCH and MCCH) is transmitted on MCH;
 - Combining is supported with SFN;
 - Synchronous transmission.

The BCCH indicates where the MCCH(s) are:

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

D.3 Deployment Scenarios

In terms of deployment scenarios of MBMS in E-UTRAN, the following alternatives can be listed:

- Carrier type: dedicated vs. mixed carrier;
- MBSFN transmission: multi-cell vs. single-cell transmission;
- Radio bearer type: p-t-m vs. p-t-p;
- Counting: yes or no;
- Audience measurement: yes or no;
- ON/OFF control of MBMS service delivery: yes or no;
- PTP / PTM radio bearer switching: yes or no;

Table D.3-1 below lists the combinations of the above alternatives that are specifically supported in E-UTRAN:

Table D.3-1: MBMS Deployment Scenarios

#	Carrier	Transmission	RB	Counting	Comments
1	dedicated	multi-cell	p-t-m	no	From 1 to n cells Audience measurement (FFS)
2	mixed	multi-cell	p-t-m	no	Audience measurement (FFS)
3	mixed	single-cell	p-t-m	yes	

D.4 MCCH Information

The following information types are proposed as candidates for inclusion on MCCH. Stage 3 work may group certain information into, for example, modified services information and unmodified services information, and to avoid duplication and reduce transmission size, group parameter sets into, for example, indexed common services information. It is FFS whether the information of the same type will map to the same IE. The information types described here are linked to the following use cases:

1. UE camping in a cell monitoring for session start(s).
2. UE powering up, entering a cell or on activation of a service, seeking to detect whether a service that it requires is ongoing in the cell.
3. UE commencing to receive a service or required to change parameters following reconfiguration.
4. UE receiving an MBMS service and monitoring for session stop, recounting indication, reconfiguration indication and revised parameters. Possibly also dynamic scheduling.
5. UE performing a cell reselection seeking information that aids service continuity.

Table D.4-1: Potential MCCH Information Types

Information Type	Use Case
Service and session identities	
Session start – own layer	1
Session start – another (mixed or dedicated) layer (FFS)	1
Ongoing or by request (FFS) – own layer	2
Ongoing or by request – another (mixed or dedicated) layer (FFS)	2, 5 ³
Short identities indexing service identities	2,3,4,5
Service parameters – radio bearer information, physical channel configuration information, scheduling information (Note 1)	
For services (MTCH) transmitted on DL-SCH	3, 4, 5
For services (MTCH) transmitted on MCH	3, 4, 5
Required action – whilst receiving a service	
Session stop indication	4
Reconfiguration indication	4
Recounting indication (FFS)	4
Change state (FFS)	4 ² , 5 ²
Required action – service access	
Make service request (FFS)	3
Change state (FFS)	3 ²
Counting control information:	
For services transmitted on DL-SCH	3, 4
For services transmitted on MCH (FFS)	3, 4
Single-cell MTCH feedback control (FFS)	3, 4
Indication of the existence of other layers (dedicated, mixed) (FFS)	1, 2, 5 ³
Other frequency layer parameters (FFS)	1, 2, 5 ³
Neighbour cell information e.g. service existence, MTCH or MCCH parameters (FFS)	5
MBSFN area edge cell indication or identity (FFS)	5
Parameters that identify how to receive scheduling information(FFS)	3, 4, 5
S-MCCH parameters and scheduling (on P-MCCH)	2, 4, 3, 5
MCCH modification indication (FFS)	1, 4

Note 1: Scheduling information may take two forms, e.g. semi-static scheduling of the TTIs in which MCH transmissions can take place and short-term scheduling which indicates whether transmissions take place within these TTI, e.g. for DRX (FFS).
Note 2: The case represented here is the FFS scenario where an eNB requires a UE to enter RRC Connected state in order to receive a service. This relates to a single-cell transmission e.g. to perform feedback. A UE might be required to do this on taking up the service, on transferring into a cell whilst receiving the service or whilst receiving the service when in a cell.
Note 3: The use case represents case 2 of the service continuity requirements as described in section 15.4.

Annex E (informative): Drivers for Mobility Control

Table E-1 lists the drivers, limitations, and their applicability to intra-frequency, inter-frequency, and inter-RAT scenarios. Each driver and limitation is described in Section E.1 and E.2, respectively. For inter-frequency and inter-RAT scenarios, the applicable drivers are shown in detail for IDLE/ACTIVE modes and their transitions in Section E.3.

Table E-1: Drivers and limitations for mobility control and applicability to mobility scenarios.

	#	Drivers/limitations	Intra-frequency	Inter-frequency	Inter-RAT
Drivers	1	Best radio condition	X	X	X
	2	Camp load balancing		X	X
	3	Traffic load balancing		X	X
	4	UE capability		X	X
	5	Hierarchical cell structures		X	X
	6	Network sharing		X	X
	7	Private networks/home cells		X	X
	8	Subscription based mobility control		X	X
	9	Service based mobility control		X	X
	10	MBMS		X	X
Limitations	11	UE battery saving	X	X	X
	12	Network signalling/processing load	X	X	X
	13	U-plane interruption and data loss	X	X	X
	14	OAM complexity	X	X	X

As shown in Table E.1, the applicable drivers depend on the mobility scenario, i.e., intra-frequency, inter-frequency, and inter-RAT:

- **Intra-frequency mobility:** intra-frequency mobility is the most fundamental, indispensable, and frequent scenario. With the frequency reuse being one in E-UTRAN, applying any driver other than the “best radio condition” to intra-frequency mobility control incur increased interference and hence degraded performance. As such, only the “best radio condition” driver is applicable to intra-frequency mobility. Note that the exact definition of “intra-frequency mobility” is yet unclear, and shall be clarified with RAN1.
- **Inter-frequency mobility:** as in UTRAN, an operator may have multiple carriers/bands for E-UTRAN working in parallel. The use of these frequency layers may be diverse. For example, some of these frequency layers may utilise the same eNB sites and antenna locations (i.e., co-located configuration), whereas some may be used to form a hierarchical cell structure (HCS), or even be used for private networks. Some frequency layers may provide MBMS services, while some may not. Moreover, E-UTRAN carriers/bands may be extended in the future to increase capacity. For example, as E-UTRAN gains popularity, an operator may decide to convert existing UTRAN carriers into E-UTRAN ones. The operator may also acquire additional carriers/bands, that are not necessarily contiguous. As a consequence, different UE band capabilities may coexist and different carriers/bands may operate at different areas within a network. The E-UTRAN standard should readily support such carrier/band extensions and diverse network configurations, providing flexibility and efficiency. Therefore, a number of drivers apply to inter-frequency mobility control, in addition to the “best radio condition” driver.
- **Inter-RAT mobility:** the aspects that need to be considered for inter-RAT are similar to those for inter-frequency. For mobility solutions to be complete with the inter-RAT drivers, relevant updates would be necessary on the legacy (UTRAN/GERAN) specifications. This will add to the limitations, which are evidently

more effective in inter-RAT. Although the drivers/limitations need to be assessed per objective RAT (UTRAN/GERAN), the solutions should be made common as much as possible to reduce any complexity.

E.1 Drivers

The drivers for mobility control are described in the following sections.

E.1.1 Best radio condition

The primary purpose of cell reselection, regardless of intra-frequency, inter-frequency, or inter-RAT, is to ensure that the UE camps on/connects to the best cell in terms of radio condition, e.g., path loss, received reference symbol power, or received reference symbol E_s/I_0 . The UE should support measurements to suffice this aspect. For E-UTRAN cells, the frequency domain scheduling and channel/symbol mapping may have some implications to designing the measurements and reselection/reporting criteria. The UE would also have to check that the selected cell falls within the accessible range (in terms of signal strength and possibly also in terms of propagation delay, i.e., check if it falls within the dynamic range of timing advance, FFS).

E-UTRAN should support good mobility even when the radio environment changes suddenly, e.g., when the UE enters a tunnel or in a Manhattan-like street cell scenario. It should be discussed whether a special mechanism is needed to cope with such sudden changes in radio environment or it can be handled with good radio network planning practices. In either case, the system design should minimise any side effects of counteracting the sudden changes in the radio environment (e.g., ping-pongs).

For inter-frequency/RAT mobility, the UE needs idle gaps to perform measurements on other frequency layers/RATs. In addition, for inter-RAT, E-UTRAN measurements while the UE is in another RAT (UTRAN/GERAN) need to be supported. It should be discussed whether in certain cases (e.g., co-located E-UTRAN cells within the same frequency band) the measurements can be omitted.

E.1.2 Camp load balancing

This is to distribute idle state UEs among the available bands/carriers/RATs, such that upon activation, the traffic loading of the bands/carriers/RATs would be balanced. At least the path loss difference between different bands should be compensated to avoid UEs concentrating to a certain frequency layer (e.g., lower frequency bands due to the propagation nature). A deliberate mechanism would be necessary to avoid UEs concentrating to a certain RAT (e.g., E-UTRAN). Various solutions have been presented including the use of Qoffset and an approach of limiting the frequency layers for camping.

For inter-RAT, this driver also includes the aspect of balancing the loading of core network nodes of different RATs. Nevertheless, for intra- E-UTRAN, the core network load aspect is out of scope, since MME/Serving Gateway relocation by itself should not cause any radio mobility procedure (but only NAS procedures like NAS ID and security updates).

E.1.3 Traffic load balancing

This is to balance the loading of active state UEs, using redirection for example. In E-UTRAN, traffic load balancing is essential because of the shared channel nature. That is, the user throughput decreases as the number of active UEs in the cell increases, and the loading directly impacts on the user perception. A solution is desired that causes minimum impact on the user perception. This implies that inter-layer transitions are preferably done during data inactivity (e.g., DRX) or transition to the idle state. Although this driver is also applicable to inter-RAT, for inter-RAT, the “service dependent control” driver may be more dominant than the load balancing aspect.

E.1.4 UE capability

As E-UTRAN bands/carriers may be extended in the future, UEs having different band capabilities may coexist within a network. It is also likely that roaming UEs have different band capabilities. Overlaying different RATs adds to this variety. The mobility solution should cope with the coexistence of various UE capabilities in an efficient manner.

E.1.5 Hierarchical cell structures

As in UTRAN, hierarchical cell structures (HCS) may be utilised in E-UTRAN to cover for example, indoors and hot spots efficiently. It is possible that E-UTRAN is initially deployed only at hot spots, in which case this driver becomes essential for inter-RAT, not just for inter-frequency. Another use case would be to deploy a large umbrella cell to cover a vast area without having to deploy a number of regular cells, while providing capacity by the regular cells on another frequency. While HCS can be seen as a solution to reduce measurement and signalling loads, to optimise HCS usage, mobility control should take into account the UE mobility (e.g., speed). This however implies that sufficient mobility detection is also required. Although HCS is not addressed as a mobility driver for intra-frequency mobility, intra-frequency HCS deployment should not be restricted.

E.1.6 Network sharing

At the edge of a shared portion of a network, it will be necessary to direct UEs belonging to different PLMNs to different target cells. The mobility solutions in both idle and active states should therefore support differentiation between UEs of different operators.

E.1.7 Private networks/home cells

Cells that are part of a sub-network should prioritise the camping on that sub-network. UEs that do not belong to private sub-networks should not attempt to camp or access them. Although this could be resolved by the use of forbidden TAs as in UTRAN, a more deliberate mechanism may be needed as some of these sub-networks could be very small, e.g., one home.

E.1.8 Subscription based mobility control

This mobility driver aims to limit the inter-RAT mobility for certain UEs, e.g., based on subscription or other operator policies. The system should provide means to disallow access on certain RATs (including E-UTRAN) as done with "LA reject" in legacy systems. It should be possible for the operator to trigger a subsequent UE action such as a cell or PLMN selection.

E.1.9 Service based mobility control

An operator may have different policies in allocating frequencies to certain services. For example, the operator may concentrate VoIP UEs to a certain frequency layer or RAT (e.g., UTRAN or GERAN), if evaluations prove this effective. UEs requiring higher data rates may better be served on a frequency layer or RAT (e.g., E-UTRAN) having a larger bandwidth. The operator may also want to accommodate premium services on a certain frequency layer or RAT, that has better coverage or larger bandwidth.

This driver is essential for inter-RAT, due to the different QoS levels provided by different RATs. The nature of the service being requested (e.g., QoS and traffic behaviour) should be considered in controlling mobility, so that services are accommodated in the best suitable RAT. Note that such service dependent control shall only be based on network decisions and not on UE decisions (i.e., no UE based service dependent cell reselection), except for MBMS scenarios.

E.1.10 MBMS

As MBMS services may be provided only in certain frequency layers, it may be beneficial/necessary to control inter-frequency/RAT mobility depending on whether the UE receives a particular MBMS service or not. For MBMS scenarios only, UE based service dependent cell reselection might be considered acceptable. This aspect also depends on the UE capability for simultaneous reception of MBMS and unicast.

E.2 Limitations for mobility control

While the issues mentioned above drive E-UTRAN towards "aggressive" mobility control, the limiting factors also have to be considered. The factors listed below apply to all intra-frequency, inter-frequency, and inter-RAT mobility scenarios.

E.2.1 UE battery saving

The mobility solution should not consume excessive UE battery, e.g., due to measurements, measurement reporting, BCH reception, or TA update signalling. This could be achieved for example by setting appropriate measurement rules such as S-criteria, hysteresis, and time-to-trigger. Adaptive control of some measurement/mobility parameters (e.g., based on DRX, cell size, or mobility) may also be considered as a countermeasure. To reduce TA update signalling, TA allocations can be differentiated depending on the UE speed or the mobility vector, on top of appropriate TA planning. Effects on additional delays (e.g., paging) should also be investigated if means such as “long DRX” are used to achieve these savings.

It should be investigated together with RAN4 if a coupling between measurements accuracy and DRX (as in UTRAN) is also acceptable for E-UTRAN.

E.2.2 Network signalling/processing load

The mobility solution should not cause excessive network signalling/processing load. This includes over-the-air signalling, S1/X2 signalling, and processing load at network nodes. Unnecessary handovers and cell reselections should be avoided, and PCH and BCH signalling, as well as dedicated signalings, should be limited. This could be achieved by similar countermeasures as for UE battery saving.

E.2.3 U-plane interruption and data loss

U-plane interruption and data loss caused by the mobility solution should be limited. The required QoS should be satisfied in any case.

E.2.4 OAM complexity

The mobility solution should not demand excessive efforts in operating/maintaining a network. For example, when a new eNB is added or an existing eNB fails, the mobility solution should not incur excessive efforts to set up or modify the parameters. Means should be studied to integrate the mobility solutions in the concept of “self-optimisation” to minimise manual processes. Reducing the neighbour list information in E-UTRAN would also be a countermeasure to this requirement.

E.3 Inter-frequency/RAT drivers

E.3.1 Mobility control during IDLE mode

This is to control the mobility of UEs during IDLE mode, i.e., cell reselection. Table E.3.1-1 summarises applicability of the drivers for different inter-frequency/RAT scenarios and necessary features to support the drivers. Note that in Tables E.3.1-1, E.3.2-1, E.3.3-1, E.3.4-1, an “X” in the table indicates that the driver is essential, whereas an “(X)” indicates that the driver may be reduced in support depending on the complexity incurred. Furthermore in Tables E.3.1-1, E.3.2-1, E.3.3-1, E.3.4-1, the following abbreviations are used:

- L→L: LTE to LTE inter-frequency mobility;
- L→U: LTE to UTRAN inter-RAT mobility;
- U→L: UTRAN to LTE inter-RAT mobility;
- L→G: LTE to GERAN inter-RAT mobility;
- G→L: GERAN to LTE inter-RAT mobility.

Table E.3.1-1: Mobility control during IDLE (cell reselection).

#	Drivers	Applicability					Necessary features to support drivers
		L→L	L→U	U→L	L→G	G→L	
1	Radio condition	X	X	X	X	X	Inter-frequency/RAT measurements (solutions to

							mitigate measurement load should be considered, e.g., S-criteria); Cell reselection and reselection criteria.
2	Camp load balancing	X	X	X	(X)	(X)	Mechanism to prioritise cell reselection to certain layer/RAT, depending on the loading of layers/RATs; Load information exchange (not needed if balancing is inadapative, i.e., only based on subscriber penetration on each band/RAT.).
3	Traffic load balancing						N/A
4	UE capability	(X)	X	X	X	X	Mechanism to prioritise cell reselection to certain layer/RAT, depending on the UE capability.
5	HCS	(X)	(X)	(X)	(X)	(X)	Mobility detection (e.g., number of crossed cells); Mechanism to prioritise cell reselection to certain layer/RAT, depending on the UE speed (e.g., HCS mechanism as in UTRAN).
6	Network sharing	X	X	X	X	(X)	Mechanism to direct the UE to the appropriate PLMN at a network sharing border; Mechanism to restrict UE measurements and reselection to cells that are entitled to access.
7	Private networks / home cells	X	(X)	X		(X)	Mechanism to prioritise reselection to private/home cells that are entitled to access; Mechanism to restrict UE measurements and reselection to cells that are entitled to access; Other unidentified features, FFS.
8	Subscription / Policy based mobility control	X	X	X	(X)	(X)	Mechanism to prioritise cell reselection to certain layer/RAT, depending on the subscription information or any other operator policy (e.g., for L→L there may be cases where an operator has policy in allocating UEs to certain frequencies due to different carrier bandwidths).
9	Service based mobility control						N/A
10	MBMS	X	(X)	X			Mechanism to prioritise cell reselection to the layer/RAT, depending on whether the UE requires reception of a certain MBMS transmission.

E.3.2 Mobility control upon IDLE to ACTIVE transition

This is to control the mobility of UEs upon IDLE to ACTIVE transition, i.e., redirection upon RRC or U-plane establishment. Table E.3.2-1 summarises applicability of the drivers for different inter-frequency/RAT scenarios and necessary features to support the drivers.

**Table E.3.2-1: Mobility control upon IDLE to ACTIVE transition
(redirection upon RRC/U-plane establishment)**

#	Drivers	Applicability					Necessary features to support drivers
		L→L	L→U	U→L	L→G	G→L	
1	Radio condition	(X)	(X)				Inter-frequency/RAT measurements (during IDLE mode or upon IDLE to ACTIVE transition) and measurement reporting upon RRC establishment (it should be investigated whether measurements can be omitted in some or all cases, e.g., co-located cells).
2	Camp load balancing						N/A
3	Traffic load balancing	X	(X)	(X)	(X)		Redirection to a certain layer/RAT (cell) upon RRC establishment, depending on the loading of layers/RATs; Load information exchange (not needed if balancing is inadapative, i.e., only based on subscriber penetration on each band/RAT).

4	UE capability	X	(X)		(X)		Redirection to a certain layer/RAT (cell) upon RRC establishment, depending on the UE capability.
5	HCS						N/A
6	Network sharing	(X)	(X)	(X)	(X)		Redirection to a certain layer/RAT (cell) of the preferred PLMN, upon RRC establishment.
7	Private networks / home cells	(X)					Redirection from a certain private/home cell.
8	Subscription / Policy based mobility control	X	X	(X)	(X)	(X)	Redirection to a certain layer/RAT (cell) upon RRC establishment, depending on the subscription information (if available upon establishment) or any other operator policy.
9	Service based mobility control	X	X	(X)	(X)	(X)	Redirection to a certain layer/RAT (cell) upon RRC establishment, depending on the requested service (if the service information is available upon establishment).
10	MBMS						N/A

E.3.3 Mobility control during ACTIVE mode

This is to control the mobility of UEs during ACTIVE mode (ECM-CONNECTED or UTRAN RRC Connected), i.e., handover. Table E.3.3-1 summarises applicability of the drivers for different inter-frequency/RAT scenarios and necessary features to support the drivers.

Table E.3.3-1: Mobility control during ACTIVE (handover)

#	Drivers	Applicability					Necessary features to support drivers
		L→L	L→U	U→L	L→G	G→L	
1	Radio condition	X	X	X	X	(X)	Gap assisted inter-frequency/RAT measurements (network controlled); Measurement reporting and reporting criteria; Inter-frequency/RAT handover (UE assisted network controlled).
2	Camp load balancing						N/A
3	Traffic load balancing	X	(X)	(X)	(X)		Inter-frequency/RAT handover (network controlled); Load information exchange (not needed if balancing is inadapative, i.e., only based on subscriber penetration on each band/RAT).
4	UE capability	(X)	(X)	(X)	(X)		Inter-frequency/RAT handover (network controlled), depending on the UE capability.
5	HCS	(X)	(X)	(X)			Mobility detection (e.g., number of crossed cells); Inter-frequency/RAT handover (network controlled), depending on the UE speed.
6	Network sharing	X	X	X	X		Inter-frequency/RAT handover (network controlled) to a cell of the appropriate PLMN at network sharing border; Mechanism to restrict UE measurements to cells that are entitled to access.
7	Private networks /home cells	X	X	X	X	X	Inter-frequency/RAT handover (network controlled) to a private/home cell on another layer/RAT, where the UE is entitled to access; Mechanism to restrict UE measurements and reselection to cells that are entitled to access; Other unidentified features, FFS.
8	Subscription / Policy based mobility control	(X)	X	X	X	X	Inter-frequency/RAT handover (network controlled), depending on the subscription information or any other operator policy.
9	Service based mobility control	(X)	X	X	X	X	Inter-frequency/RAT handover (network controlled), depending on the service or combination of services being used or requested.
10	MBMS	X	X	X			Inter-frequency/RAT handover (network

							controlled), depending on whether the UE requires reception of a certain MBMS transmission.
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E.3.4 Mobility control upon ACTIVE to IDLE transition

This is to control the mobility of UEs upon ACTIVE to IDLE transition, i.e., redirection upon RRC or U-plane release. Table E.3.4-1 summarises applicability of the drivers for different inter-frequency/RAT scenarios and necessary features to support the drivers.

Table E.3.4-1: Mobility control upon ACTIVE to IDLE transition (redirection upon RRC/U-plane release)

#	Drivers	Applicability					Necessary features to support the driver
		L→L	L→U	U→L	L→G	G→L	
1	Radio condition	X	X	X	X	X	Gap assisted inter-frequency/RAT measurements (it should be investigated whether measurements can be omitted in some or all cases, e.g., co-located cells), OR Cell search upon redirection.
2	Camp load balancing	X	X	X	(X)	(X)	Redirection to a certain layer/RAT upon RRC release, depending on the loading of layers/RATs; Load information exchange (not needed if balancing is inadaptive, i.e., only based on subscriber penetration on each band/RAT).
3	Traffic load balancing						N/A
4	UE capability	X	X	X	(X)	(X)	Redirection to a certain layer/RAT upon RRC release, depending on the UE capability.
5	HCS						N/A
6	Network sharing	X	X	X	X		Redirection to a certain layer/RAT of the preferred PLMN, upon RRC release.
7	Private networks / home cells						N/A
8	Subscription / Policy based mobility control	X	X	X	(X)	(X)	Redirection to a certain layer/RAT upon RRC release, depending on the subscription information or any other operator policy.
9	Service based mobility control	(X)	(X)		(X)		Redirection (or maintaining) to a certain layer/RAT upon RRC release, depending on the service that has been used (predicting that the UE uses the same service in the future).
10	MBMS	(X)	(X)		(X)		Redirection to a certain layer/RAT upon stop of an MBMS service reception.

Annex F (informative): Mobility and Access Control Requirements associated with Closed Subscriber Group (CSG) Cells

F.1 Access Control

The following description is provided from the perspective of the Home cell deployment, and is used as an example to understand the general requirements of Closed Subscriber Group (CSG) Cells.

If an operator uses the 2G or 3G systems for a deployment in a home, there are some limitations imposed by mandating that only a UE from a specific User Group can access the cell. This access restriction is needed because some backhaul links for this type of deployment are not considered to provide adequate QoS to support a large numbers of UEs, or there may be regulatory issues with sharing the backhaul link/eNB access in that location, and additionally the backhaul maybe owned by the subscriber and they may not be happy to share the link with other subscribers.

In 3G, the Access Control would work based on the Location Updating or Routing Area Updating Reject for the LA or RA which is being signalled on the cell. Each unique User Group would require its Location Area ID, however the LAC of the LA ID is only 2 octets, which needs to be shared with the normal LAs of the PLMN.

There is an additional drawback with this solution in 3G, which is that all terminals would attempt to perform the Location Updating procedure on a cell advertising a LA not on the list of forbidden LAs in the UE. The network would reject the location updating procedure of those UEs which are not in the User Group associated with the LA. This would lead to the scenario in a densely populated area, where a UE moving down the street could attempt to access a home cell at each house, before being rejected causing a wastage of battery in the terminal, and unnecessary signalling/processing load in the core network.

- 1. A UE should not camp on or access a CSG Cell if it is not part of the User Group which is allowed to access that CSG Cell.**

It shall be possible to update the User Group associated with a specific Home-eNB, e.g. based on request by the registered owner of the Home-eNB, under the supervision of the network operator. When a subscriber is added to the User Group for the Home-eNB, the UE of the newly added subscriber should be able to (almost) immediately camp on the cell(s) of Home-eNB and then may acquire service through the Home-eNB. This is especially important in the deployment scenario where this subscriber has no other means to access the network, i.e. there is no Macro-layer coverage available. For this it might be necessary to update the list of allowed CSG cells for a particular UE by network signalling or other means.

- 2. The subscriber registered as the owner of a CSG Cell or group of Cells, under supervision of the operator, shall be able to control/modify quickly which other subscribers form part of the User Group associated with its CSG Cell(s).**

F.2 Mobility

The Home-eNB/CSG cells should form part of the network of the operator, and therefore the design needs to support mobility of UEs between the Macro-Layer network and the Home-eNB/CSG cells. In the following text, what is called Macro layer encompasses all the cells which are not from the CSG being considered i.e. it is not about their size/coverage but the fact that they are not closed.

- 3. The system shall support bidirectional handover between CSG Cells and any eNodeB (E-UTRAN) or RNC (UTRAN) or BSS (GERAN) or with another CSG Cell of the same or different CSG.**

The Home-eNBs will be deployed to improve network coverage, improve network capacity as well as offer differential billing models. As the User billing could be dependent on whether the UE is using the Home-eNB, it is important that the UE when it is range of the Home-eNB automatically camps on the Home-eNB.

- 4. It shall be possible to allow UEs which are allowed to access a given CSG cell, to prioritise their camping towards the CSG Cells when in coverage of the CSG cells. To achieve this it should be possible either to set the reselection parameters accordingly or other means should allow this.**

It is important that UEs camped on the Home-eNB do not cause excessive signalling load or processing load if/when the UE moves frequently between the Macro-Layer network and the Home-eNB.

- 5. The system shall avoid excessive signalling and processing load from a UE frequently reselecting in LTE Idle between the CSG Cells and the non-CSG cells of eNodeB (E-UTRAN) or RNC (UTRAN) or BSS (GERAN).**

As discussed above, the Home-eNBs will have an associated User Group describing which UEs can access the Home-eNB. The handover procedures needs to take the User Group of the Target Home-eNB into account when deciding whether to handover a UE to a specific Home-eNB. The solution for the mobility to/from the Home-eNB should avoid unnecessary signalling between the RAN nodes.

- 6. The handover procedures shall take into account whether a UE is part of the User Group of the target CSG Cell. The mobility procedures should allow for prioritisation of the CSG Cells in ECM-CONNECTED when the UE enters coverage of a CSG Cell and the UE is part of the User Group of this cell.**

As the number of Home-eNBs in the network will become large, the proportion of measurements made by a UE which could be wasted may become large, to the point where it affects the mobility performance of the UE/system, as well as draining the battery of the UE. It is therefore necessary for the UE to be able to avoid unnecessary measurements of Home-eNBs where the UE does not belong to the User Group of the Home-eNB.

- 7. It shall be possible to minimise the quantity of measurements which UEs perform on CSG Cells, if the UE does not belong to the User Group of a specific CSG Cell.**

Due to the high number of Home-eNBs and the nature of their deployment, it would not be practical to change the configuration for the mobility procedures (measurements, handover, etc.) in the macro layer nodes when a Home-eNB is deployed/dismissed.

- 8. The mobility procedures shall allow a large number of (small) CSG Cells to be deployed within the coverage of e-UTRAN, UTRAN and GERAN macro-layer cells. Deployment of (additional) CSG Cells shall not require reconfiguration of other eNodeB (E-UTRAN) or RNC (UTRAN) or BSS (GERAN).**

In order to minimise the impact on UEs not allowed to use CSG cells or not allowed to use a particular CSG cell, means shall be provided which allow the UE to either identify prior to cell reselection that the configured neighbour cell is a CSG cell or means shall be provided which do not impact the UEs on the macro cells.

- 9. The mobility procedures for moving UEs to CSG cells shall minimise impact to other UEs on the same macro cells not entitled to use CSG cells or a given CSG cell.**

Annex G (informative): Guideline for E-UTRAN UE capabilities

Each radio access technology has defined specific “classes” of terminals in terms of radio capabilities. E.g. in GPRS the “multislot classes” are defined, in UMTS R’99 different dedicated bearer classes are defined and for HSDPA and HSUPA 12 respectively 6 physical layer categories are defined. The definition of UMTS R’99 UE classes lead to 7 DL classes and 7 UL classes for FDD out of which only 2 DL and 3 UL classes were commercially realized. Furthermore the lower end classes (e.g. 64 UL and 64 DL) disappeared from the market with commercialization of the UMTS networks quite soon. Besides these class definitions a huge number of possible parameter combinations (to achieve certain data rates) exist with UMTS R’99 which lead to the huge number of RAB and RB combinations defined. Further activities in the early phase of UMTS standardization aimed to reduce the number of possible combinations significantly.

For HSDPA two “simple” DL categories (11 & 12) with lowered complexity were defined with the intent to speed up commercialization of HSDPA. Originally those categories should have been removed for Rel-6. Out of the 12 defined categories only approx. 4 will be realized in commercial HSDPA platform products. A similar situation is likely for HSUPA as well as for the combinations of HSDPA/HSUPA.

Generally the aim to mandate certain essential functions/requirements can help to simplify the system definition as well as the realization options (e.g. mandating 20 MHz of DL reception as well as 20 MHz UL transmission bandwidth significantly reduced the E-UTRAN system complexity). Especially mandating certain terminal functions could be useful for the system design if a defined subset of parameter combinations are also supported by the systems, e.g. the eNB scheduler. However, there is also a risk that not all the defined E-UTRA features are deployed in the networks at the time when terminals are made commercially available on the market place. Some features are likely to be rather large and complex, which further increases the risk of interoperability problems unless these features have undergone sufficient interoperability testing (IOT) on real network equipment, and preferably with more than one network in order to improve the confidence of the UE implementation. Thus, avoiding unnecessary UE mandatory features but instead defining a limited set of UE radio classes allows simplification for the interoperability testing.

Given the discussion above, it seems beneficial for the introduction of E-UTRAN to limit the combination of radio capabilities to a clearly defined subset and ensure that a given set of parameters is supported by certain UE classes as well as networks for rapid E-UTRAN deployment. It seems unrealistic to mandate only one single UE class which always mandates the maximum capability.

In order to address the different market requirements (low end, medium and high end), the definition of the following UE classes are proposed:

Table G-1: E-UTRAN UE Classes

Class	UL	DL
A	[50] Mbps	[100] Mbps
B	[25] Mbps	[50] Mbps
C	[2] Mbps	[2] Mbps

NOTE: For simplification reasons, the table only depict the UE capabilities in terms of uplink and downlink peak data rates supported. However, it should be noted that further discussion on other features is expected once the work progresses.

It may require further discussion whether there be a need for an additional terminal class between 2 Mbps and 50 Mbps classes. It might make sense, since up to 5 MHz band allocations may be rather common in real deployments for several years. This would point to bit rate class of 25 Mbps in DL and 10 Mbps in UL.

The above given data rates are indicative and should be subject for further discussions in 3GPP RAN working groups. Depending on the different solutions to reach those data rates, the target should be to define [3..4] UE classes in different data rate ranges, and other parameters affecting device complexity and cost. The definition of the required parameters/features is for further study for each of the classes. For instance, half-duplex UEs form a specific category that may be frequency band specific.