TS 5G.300 v1.1 (2016-06)

Technical Specification

KT PyeongChang 5G Special Interest Group (KT 5G-SIG);
KT 5th Generation Radio Access;
Overall Description;
(Release 1)

Ericsson, Intel Corp., Nokia, Qualcomm Technologies Inc., Samsung Electronics & KT

Document History

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0.1	2016-02-17	First Draft Version
1.1	2016-07-13	Final Version
1.2	2016-08-31	Correction in Appendix A4

Contents

Foreword

This Technical Specification has been produced by the KT PyeongChang 5G Special Interest Group (KT 5G-SIG)

1 Scope

The present document provides an overview and overall description of the radio interface protocol architecture for the PyeongChang 5G trial (P5G). Details of the radio interface protocols are specified in companion specifications of the TS 5G series.

2 References

[1] TS 5G.211: "5G Radio Access (5G RA); Physical channels and modulation".

[2] TS 5G.212: "5G Radio Access (5G RA); Multiplexing and channel coding".

[3] TS 5G.213: "5G Radio Access (5G RA); Physical layer procedures".

[4] TS 5G.214: "5G Radio Access (5G RA); Physical layer – Measurements".

[5] TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

3 Definitions, symbols and abbreviations

3.1 Definitions

KT PLMN ID: the PLMN ID used in the KT LTE network (MCC: 450, MNC: 08).

LTE area: tracking areas where only EPS services can be provided.

LTE UE: normal LTE UE that is not participating the PyeongChang 5G trial.

Non-P5G cell: LTE cell broadcasting the KT PLMN ID but not the P5G Trial PLMN ID.

P5G cell: LTE cell broadcasting both the KT PLMN ID and the P5G Trial PLMN ID.

P5G Trial PLMN ID: PLMN ID different from the KT PLMN ID (MCC: 450, MNC: TBD).

NOTE: P5G Trial MNC value is to be confirmed by Korean regulatory body.

P5G UE: enhanced UE that can support the extensions needed to participate the PyeongChang 5G trial.

P5G area: tracking areas where 5G trial services can be provided.

3.2 Abbreviations

BPSK	Binary Phase Shift Keying
CP	Cyclic Prefix
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSI	Channel State Information
ePLMN	Equivalent PLMN
5G Node	5G Node
5G RA	5G Radio Access
HARQ	Hybrid Automatic Repeat Request
LTE	Long Term Evolution
MAC	Medium Access Control
MBSFN	Multicast/Broadcast over Single Frequency Network
MIMO	Multiple Input Multiple Output
MCC	Mobile Country Code
MNC	Mobile Network Code
OFDM	Orthogonal Frequency Division Multiplexing
P5G	PyeongChang 5G

PLMN	Public Land Mobile Network
PLMN ID	PLMN Identity (MCC + MNC)
RPLMN	Registered PLMN
xPBCH	5G Physical Broadcast Channel
xPDSCH	5G Physical Downlink Shared Channel
xPDCCH	5G Physical Downlink Control Channel
xPRACH	5G Physical Random Access Channel
xPUCCH	5G Physical Uplink Control Channel
xPUSCH	5G Physical Uplink Shared Channel
QAM	Quadrature Amplitude Modulation
QPP	Quadratic Permutation Polynomial
QPSK	Quadrature Phase Shift Keying
RLC	Radio Link Control
RRC	Radio Resource Control
RSSI	Received Signal Strength Indicator
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
SAP	Service Access Point
TDD	Time Division Duplex
TX Diversity	Transmit Diversity
UE	User Equipment

4 Overall architecture

The E-UTRAN for the P5G trial consists of eNBs and 5G Nodes, providing the user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other by means of the X2 interface. The eNBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), more specifically to the MME (Mobility Management Entity) by means of the S1-MME and to the Serving Gateway (S-GW) by means of the S1-U. The 5G Nodes are connected by means of the S1-U interface to the S-GW, but are not connected to the MME via S1-MME. A 5G Node and an eNB are interconnected by means of the X2 interface, see clause 18.

The interface interconnecting the 5G Nodes is FFS.

The corresponding architecture is illustrated on Figure 4-1 below.

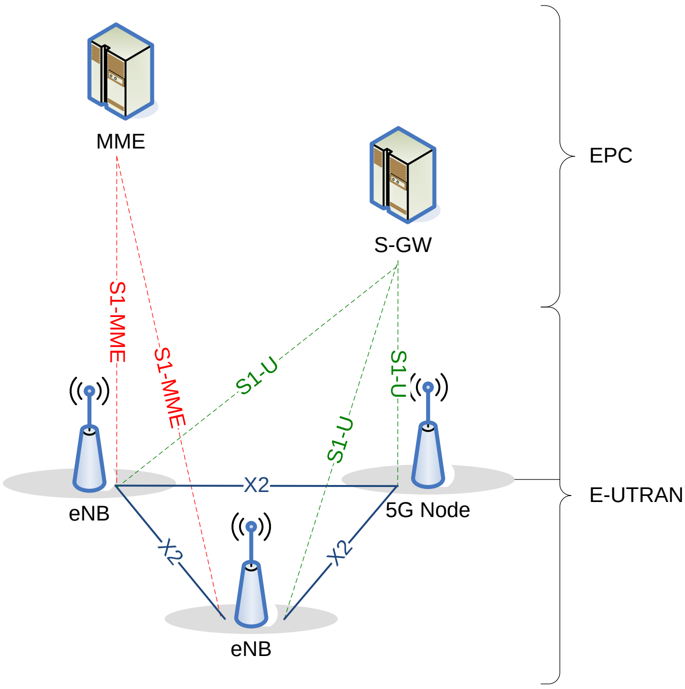

Figure 4-1: Overall Architecture

4.1 Functional Split

The eNB, MME, S-GW and PDN Gateway (P-GW) hosts the same functions as in LTE (see 3GPP TS 36.300 and TS 23.401). The 5G Node hosts the following functions:

- Functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling);
- Encryption of user data stream;
- Routing of User Plane data towards Serving Gateway;
- Transmission of system information;
- Measurement and measurement reporting configuration for mobility and scheduling.

4.2 Radio Protocol architecture

4.2.1 User plane

The figure 4.2.1-1 below shows the protocol stack for the user-plane, assuming dual connectivity between LTE and 5G. On the LTE side, the PDCP, RLC and MAC sublayers perform the same functions as in LTE listed in 3GPP TS 36.300 [5]. On the 5G side, the SWI/SPL, PDCP, RLC and MAC sublayers perform the functions listed in subclause 6.

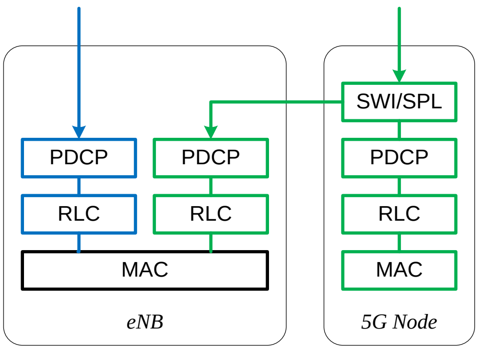

Figure 4.3.1-1: Radio Protocol Architecture for Dual Connectivity between LTE and 5G

4.2.2 Control plane

The figure below shows the protocol stack for the control-plane, where:

- At the eNB, PDCP, RLC and MAC sublayers perform the same functions as listed in 3GPP TS 36.300 [5];
- LTE RRC (terminated in eNB on the network side) performs the same functions as listed in 3GPP TS 36.300 [5];
- 5G RRC signalling always uses LTE radio resources to be transmitted and uses a specific DRB for that purpose;
- 5G RRC performs the functions listed in subclause 7, e.g.:
    - 5G RRC connection management;
    - 5G mobility;
    - 5G security control.

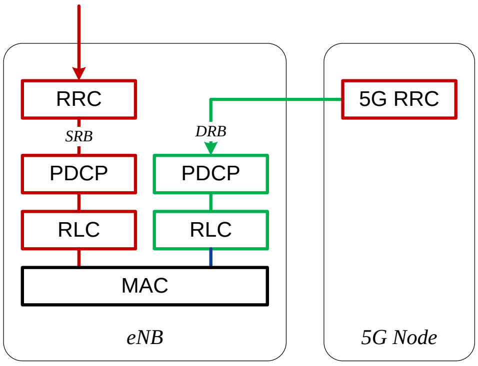

Figure 4.2.2-1: Control-plane protocol stack

5 Physical Layer for 5G

Physical layer requirements are specified in TS 5G.211, "5G Radio Access (5G RA); Physical channels and modulation", TS 5G.212, "5G Radio Access (5G RA); Multiplexing and channel coding", and TS 5G.213, "5G Radio Access (5G RA); Physical layer procedures".

6 Layer 2

On the 5G side, Layer 2 is split into the SWI/SPL, PDCP, RLC and MAC sublayers. This subclause gives a high level description of the Layer 2 sub-layers on the 5G side in terms of services and functions, focusing on the differences with the Layer 2 of LTE.

6.1 MAC Sublayer

This subclause provides an overview on services and functions provided by the MAC sublayer on the 5G side.

6.1.1 Services and Functions

Compared to LTE, the main services and functions of the MAC sublayer on the 5G side also include:

- Concatenation of multiple MAC SDUs belonging to one logical channel into transport block (TB)

6.1.2 Logical Channels

6.1.2.1 Control Channels

Control channels are used for transfer of control plane information only.

The control channels offered by MAC are:

- **Broadcast Control Channel (BCCH)**

  A downlink channel for broadcasting system control information.

6.1.2.2 Traffic Channels

Traffic channels are used for the transfer of user plane information only.

The traffic channels offered by MAC are:

- **Dedicated Traffic Channel (DTCH)**

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

6.1.3.1 Mapping in Uplink

The figure below depicts the mapping between uplink logical channels and uplink transport channels:

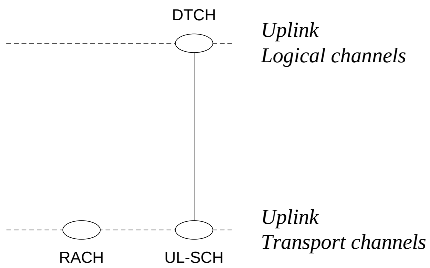

Figure 6.1.3.1-1: Mapping between uplink logical channels and uplink transport channels

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

- DTCH can be mapped to UL-SCH.

The figure below depicts the mapping between downlink logical channels and downlink transport channels:

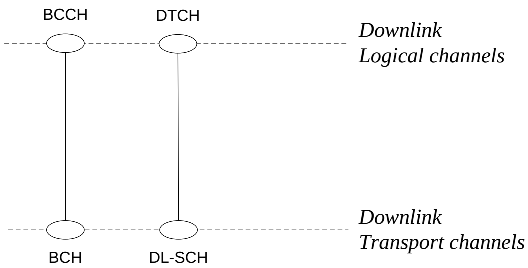

Figure 6.1.3.2-1: Mapping between downlink logical channels and downlink transport channels

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

- BCCH can be mapped to BCH;
- DTCH can be mapped to DL-SCH;

6.1.3 PDU Structure

The MAC PDU structure supports MAC subheader with LCID length of 5 bits and 16 bit length field for indicating length of MAC SDU.

6.2 RLC Sublayer

This subclause provides an overview on services and functions provided by the RLC sublayer on the 5G side.

6.2.1 Services and Functions

Compared to LTE, the RLC sublayer does not include the concatenation of upper layer PDUs.

6.2.2 PDU Structure

Figure 6.2.2-1 below depicts the RLC PDU structure where:

- The PDU sequence number carried by the RLC header is independent of the SDU sequence number (i.e. PDCP sequence number);
- A red dotted line indicates the occurrence of segmentation;

- Because RLC does not support concatenation and segmentation only occurs when needed the content of an RLC PDU can generally be described by the following relations:
  - 1 complete SDU_i; or
  - 1 segment of SDU_i .

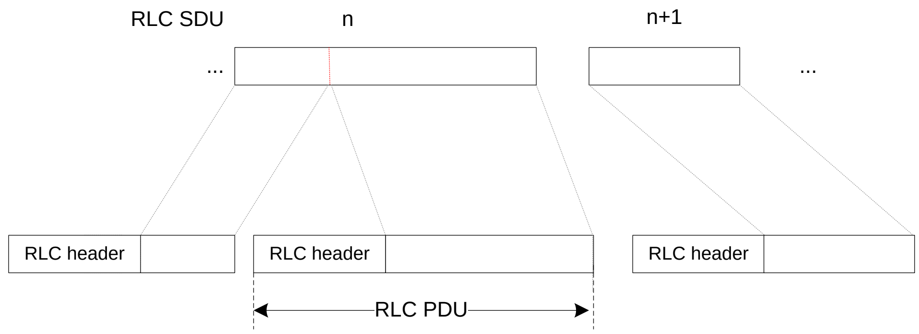

Figure 6.2.2-1: RLC PDU Structure

6.3 PDCP Sublayer

This subclause provides an overview on services and functions provided by the PDCP sublayer on the 5G side.

6.3.1 Services and Functions

Compared to LTE, the main services and functions of the PDCP sublayer for the user plane include on the 5G side also include:

- Retransmission of PDCP SDUs at handover between 5G cell for RLC AM;

6.3.2 PDU Structure

Figure 6.3.2-1 below depicts the PDCP PDU structure for user plane data, where:

- PDCP PDU and PDCP header are octet-aligned;
- PDCP header is 3 bytes long including 18bit PDCP SN.

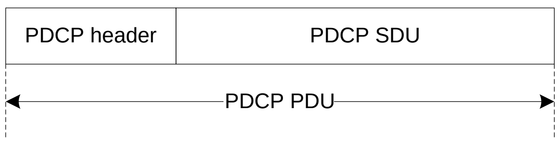

Figure 6.3.2-1: PDCP PDU Structure

6.4 SWI/SPL Sublayer

6.4.1 Services and Functions

The main services and functions of the SWI/SPL sublayer include:

- PDCP PDU routing for transmission between LTE and 5G;
- Support of lossless switch from LTE to 5G by sending an end marker in UL as last PDCP SDU delivered on the LTE path. The format for the end marker packet is specified in Annex C.

6.4.2 PDU Structure

The SWI/SPL does not include any header to the SWI/SPL SDU, thus SWI/SPL PDU is identical to SWI/SPL SDU.

7 RRC

7.1 Services and Functions

On LTE side, RRC performs the same functions as in LTE (see 3GPP TS 36.300 and TS 36.331). On 5G side, the main services and functions of the 5G RRC sublayer include:

- Establishment, maintenance and release of an 5G RRC connection between the UE and E-UTRAN;
- Security functions including key management;
- Establishment, configuration, maintenance and release of point to point Radio Bearers;
- Mobility functions including 5G cell addition/release, UE measurement reporting and control of the reporting;
- QoS management functions.

7.2 RRC protocol states & state transitions

On LTE side, no changes are brought to the RRC states and state transitions.

On 5G side, 5G RRC state machine consists of two states:

- 5G RRC_IDLE:
  - No PDN connection established for 5G RRC.
- 5G RRC_CONNECTED:
  - There is a PDN connection for 5G RRC;
  - Transfer of unicast data to/from UE;
  - At lower layers, the UE may be configured with a UE specific connected mode DRX;
  - For UEs supporting CA, use of one or more SCells, aggregated with the PCell, for increased bandwidth;
  - Network controlled mobility, i.e. 5G cell addition, 5G cell change, 5G cell release, 5G Node-B handover;
  - The UE:
    - Monitors control channels associated with the shared data channel to determine if data is scheduled for it;
    - Provides channel quality and feedback information;
    - Perform beam management;
    - Performs neighbouring cell measurements and measurement reporting;
    - Acquires system information.

7.3 Transport of NAS messages

The transport of NAS messages relies on existing mechanisms defined for LTE.

7.4 System Information

System information on LTE side remains untouched i.e. there are no 5G related SIB broadcast by the eNB. On 5G side, only the MIB is broadcast, SIBs are not.

7.5 Transport of 5G RRC messages

As shown on Figure 4.3.2-1 above, 5G RRC messages are always carried as user plane data over LTE in a separate DRB, which uses a specific QCI. The PDCP SDUs for that DRB are regular IP packets with IP headers.

8 5G Radio identities

The following 5G related UE identities are used at cell level:

- C-RNTI: unique identification used for identifying 5G-RRC Connection and scheduling;
- Temporary C-RNTI: identification used for the 5G random access procedure;
- Random value for contention resolution: during some transient states, the UE is temporarily identified with a random value used for contention resolution purposes.

NOTE: E-UTRAN identities defined in TS 36.300 [5] apply to LTE.

9 ARQ and HARQ

5G provides ARQ and HARQ functionalities. The ARQ functionality provides error correction by retransmissions in acknowledged mode at Layer 2. The HARQ functionality ensures delivery between peer entities at Layer 1.

9.1 HARQ principles

The HARQ within the 5G MAC sublayer has the following characteristics:

- N-process Stop-And-Wait;
- HARQ transmits and retransmits transport blocks;
- In the downlink:
  - Asynchronous adaptive HARQ;

NOTE: in CC mode the adaptive only applies to the frequency allocation as specified in 5G.213.

  - Uplink ACK/NAKs in response to downlink (re)transmissions are sent on xPUCCH or xPUSCH, which is configured by 5G RRC;
  - xPDCCH signals the HARQ process number and if it is a transmission or retransmission (NDI is commonly applied to both codewords);
  - UL feedback time on xPUCCH is configurable by an timing information signalled by xPDCCH , which is depended on UE capability associated with the minimum HARQ feedback processing time on UE side;
  - The length of HARQ feedback reporting information is configurable by 5G RRC signalling by 5G Node;
  - Retransmissions are always scheduled through xPDCCH.
- In the uplink:
  - Asynchronous adaptive HARQ;

NOTE: in CC mode the adaptive only applies to the frequency allocation as specified in 5G.213.

  - Maximum number of retransmissions configured per UE (as opposed to per radio bearer);
  - Downlink ACK/NAKs in response to uplink (re)transmissions are identified at UE with NDI and HARQ process number signalled by xPDCCH i.e. there is no explicit ACK/NACK information;
  - xPDCCH signals the HARQ process number and if it is a transmission or retransmission (NDI is commonly applied to both codewords);

- Retransmissions are always scheduled through xPDCCH.

9.2 ARQ principles

The ARQ within the 5G-RLC sublayer has the following characteristics:

- ARQ retransmits 5G-RLC PDUs or 5G-RLC PDU segments based on 5G-RLC status reports;
- Polling for 5G-RLC status report is used when needed by 5G-RLC;
- 5G-RLC receiver can also trigger 5G-RLC status report after detecting a missing 5G-RLC PDU or 5G-RLC PDU segment.

10 Mobility

For the trial, 5G cells belong to the EPC and mobility management relies on the procedures defined for LTE.

10.1 Intra E-UTRAN

10.1.1 Mobility Management in ECM-IDLE

10.1.1.1 General principles

The idle mode roaming principles are based on standard UE idle mode procedures specified by 3GPP. There are impacts on the mobility management UE procedures in ECM-IDLE i.e. the UE can only select LTE cells following existing mechanisms. The roaming of LTE UE and P5G UE is based on the availability of the HPLMN cells for both LTE UE and P5G UE. This allows LTE service for both LTE UE and P5G UE in LTE cells and P5G cells.

The P5G area of the network is identified by a specific PLMN ID, the P5G Trial PLMN ID (see Annex A). The idle mode roaming principle of both LTE UE and P5G UE is based on normal UE idle mode procedures for UE that is registered to HPLMN (KT PLMN ID) and performs re-selections between suitable cells as specified in 3GPP TS 36.304, clause 4.3. The LTE cells in the P5G area broadcast both the P5G Trial PLMN ID, and the KT PLMN ID. KT PLMN ID is broadcast in order to make all cells suitable cells for LTE UE and P5G UE. These LTE cells in 5G coverage area are referred to as P5G cells. The LTE cells outside of the P5G area broadcast the KT PLMN ID but not the P5G Trial PLMN ID. They are referred to as non-P5G cells.

There are no Tracking Areas with mixture of LTE cells and P5G cells, hence all UEs perform TAU upon entering or leaving the P5G area. When initiating TAU Request, all UEs indicate KT PLMN ID as their selected PLMN ID in the RRC Connection Establishment.

10.1.1.2 LTE UE roaming between LTE and P5G area

Whether the LTE UE is attaching to a P5G or a non-P5G cell, the LTE UE performs a normal attach. From then onwards, idle mode mobility is controlled by the LTE UE selecting suitable cells (3GPP TS 36.304) of the Registered PLMN, i.e. the KT PLMN.

Mobility from non-P5G to P5G cell is enabled, as the LTE UE considers the P5G cells suitable cells for its cell re-selection (the network is indicating its RPLMN as one of the two network sharing PLMNs that are available via that P5G cell).

Since the LTE UE is camping on its HPLMN cell (RPLMN = HPLMN) in P5G network, it is also free to re-select to standalone LTE network cell.

NOTE: Since P5G cells indicate network sharing by broadcasting both KT PLMN ID and P5G Trial PLMN ID, no equivalent PLMN ID indication from the CN is needed for the LTE UEs.

10.1.1.3 P5G UE roaming between LTE and P5G area

P5G UEs consider KT PLMN ID are their HPLMN. This enables cell re-selection between P5G to non-P5G cells.

P5G UE uses the availability of P5G Trial PLMN ID as an indication of availability of 5G service. P5G UE triggers the establishment of PDN Connection for 5G signalling based on PLMN ID after having detected based on the advertised

P5G Trial PLMN ID that it has entered the P5Garea. If P5G UE detects that the selected cell does not broadcast P5G Trial PLMN ID, then the UE shall release the PDN connection for 5G signalling.

10.1.2 Mobility Management in ECM-CONNECTED

The measurements of 5G cells is configured by 5G RRC and are transparent to the eNB. The transitions from RRC_IDLE to RRC_CONNECTED are not affected by 5G RRC and rely on LTE procedures.

10.1.2.1 Initial 5G RRC connection establishment

The initial 5G RRC connection establishment procedure is initiated by the UE via LTE to establish a DRB for 5G RRC signalling between the UE and the 5G Node. Figure 10.1.2.8.1-1 shows the initial 5G RRC connection establishment:

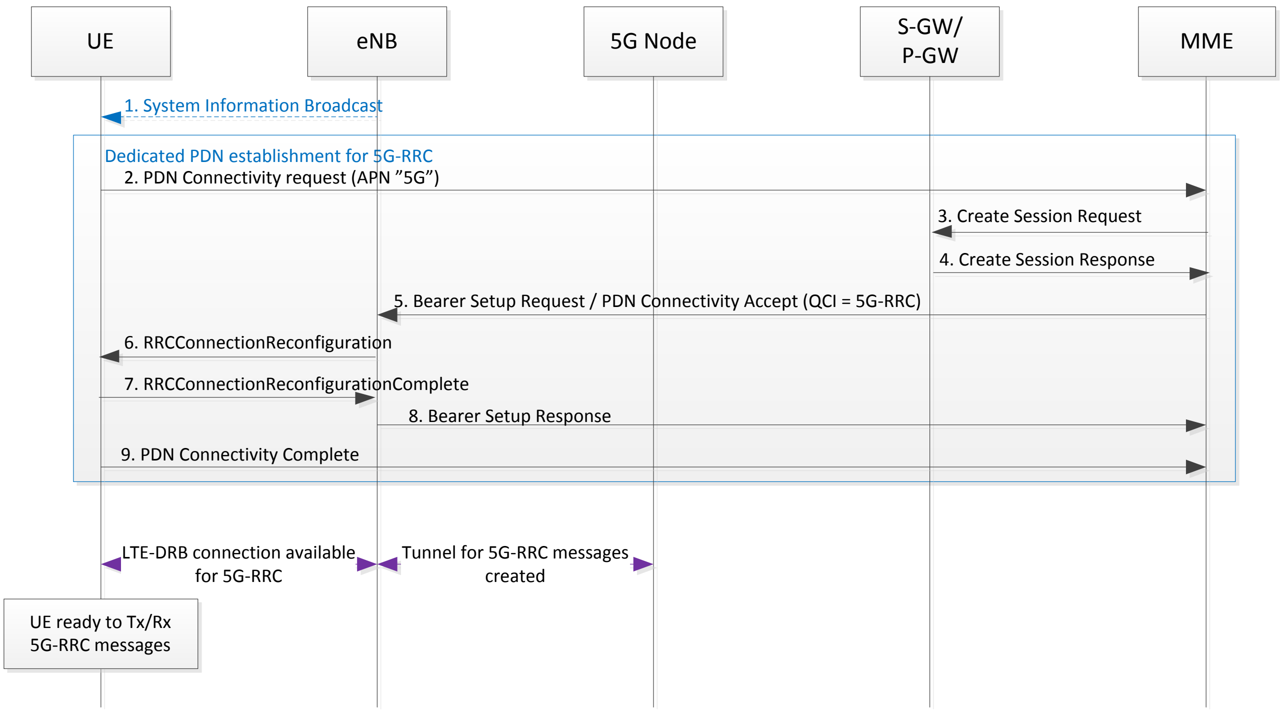

Figure 10.1.2.1-1: Initial 5G RRC connection establishment

1. The eNB provides SIB(s) via broadcast to the UE indicating the availability of P5G Trial PLMN ID.
2. Based on the 5G PLMN ID availability, the UE initiates a PDN Connectivity Request (APN, PDN Type, Protocol Configuration Options, Request Type) message (see 3GPP TS 23.401, section 5.10.2). If the UE was in ECM-IDLE mode, this NAS message is preceded by the Service Request procedure. UE shall indicate APN "5G APN" when it requests a PDN connection for 5G RRC connection.
3. If the UE is authorized for 5G RRC connection (according to the user subscription), the MME allocates a Bearer Id, and sends a Create Session Request message to the Serving GW (see 3GPP TS 23.401, section 5.10.2).
4. The Serving GW returns a Create Session Response message to the MME (see 3GPP TS 23.401, section 5.10.2).
5. The MME sends PDN Connectivity Accept (APN, PDN Type, PDN Address, EPS Bearer Id, Session Management Request, Protocol Configuration Options) message to the UE. This message is contained in an S1_MME control message Bearer Setup Request (EPS Bearer QoS, UE-AMBR, PDN Connectivity Accept, S1-TEID) to the eNB.

NOTE: A specific QCI is assigned for EPS Bearer QoS to identify the 5G RRC connection bearer.

6. The eNB sends RRC Connection Reconfiguration to the UE including the PDN Connectivity Accept message.
7. The UE sends the RRC Connection Reconfiguration Complete to the eNB.

8. The eNB send an S1-AP Bearer Setup Response to the MME. The S1-AP message includes the TEID of the eNB and the address of the eNB used for downlink traffic on the S1_U reference point.

9. The UE NAS layer builds a PDN Connectivity Complete message including EPS Bearer Identity. The UE then sends a PDN Connectivity Complete to the MME.

NOTE: Once the UE has obtained a PDN Address Information (signalled in the PDN Connectivity Accept message), the UE can send uplink packets (5G RRC messages) towards the eNB which will then be tunnelled to the 5G Node.

10.1.2.2 5G Cell Addition

The 5G cell addition is initiated by the 5G Node and is used to provide radio resources from the 5G Node to the UE. This procedure is used to add at least the first 5G cell. Figure 10.1.2.8.2-1 shows the 5G cell addition:

Figure 10.1.2.2-1: 5G cell addition

1. After the initial 5G RRC connection establishment procedure according to clause 10.1.2.1, or after a subsequent RRC connection establishment where a DRB for 5G RRC signalling is automatically configured, the 5G Node should send *UE-5GCapabilityEnquiry* message via LTE DRB requesting UE capabilities for 5G RAT.

   The 5G Node shall use UE's 5G RRC PDN connection IP address as destination address for all 5G RRC messages but for *UE-5GCapabilityEnquiry* message for which the 5G Node shall use a predefined IP address as specified in Annex B. The 5G Node uses another predefined IP address as source address as specified in Annex B. The 5G Node encapsulates a 5G RRC message in a UDP/IP header. The 5G Node shall use UDP port number as specified in Annex B.

2. Upon receiving the *UE-5GCapabilityEnquiry* message from the network, the UE shall send *UE-5GCapabilityInformation* message and the entire UE 5G capabilities to 5G Node via LTE DRB.

   For *UE-5GCapabilityInformation* and for all subsequent 5G RRC messages, the UE shall use a predefined IP address as destination address as well as its 5G RRC PDN connection IP address as source address, as specified in Annex B. The UE encapsulates 5G RRC message in a UDP/IP header. The UE shall use UDP port number as specified in AnnexB.

NOTE: If the 5G Node does not intend to configure 5G measurements, then it can release any possibly existing old 5G configuration by sending an additional *RRCConnectionReconfiguration* with *ConfigRelease*.

3. The 5G Node may initiate the 5G RRC connection reconfiguration procedure for configuring 5G frequency layer measurements to the UE.

4. The UE applies the new configuration and replies with *5GRRCConnectionReconfigurationComplete* message.

5. UE reports 5G measurement results to the 5G Node in *5GmeasurementReport* according to the measurement configuration provided in *5GRRCConnectionReconfiguration*.

6. If the RRM entity in the 5G Node determines it is able to admit resources for the UE, it allocates respective radio resources and respective transport network resources. The 5G Node triggers Random Access so that synchronisation towards the 5G Node radio resource configuration can be performed. The 5G Node sends the new radio configuration to the UE in *5GRRCConnectionReconfiguration* message.

   If this is the first configuration of a 5G cell, then ciphering configuration shall be present.

7. The UE applies the new configuration and replies with 5GRRCConnectionReconfigurationComplete message. In case the UE is unable to comply with (part of) the configuration included in the *5GRRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

8. The UE performs synchronisation towards the 5G cell.

10.1.2.3 5G Cell Change

The 5G cell change is initiated by the 5G Node and is used to change the/a 5G Cell. Figure 10.1.2.8.3-1 shows the 5G cell change:

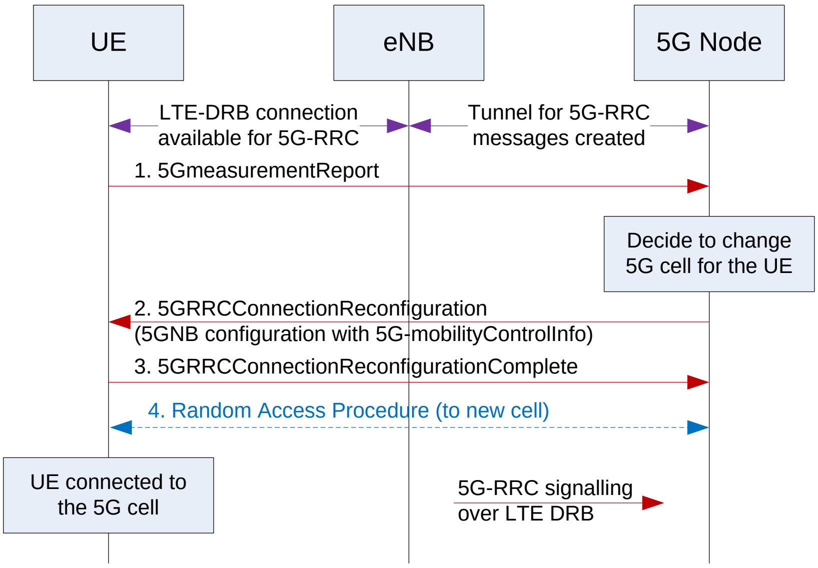

Figure 10.1.2.3-1: 5G cell change

1. UE reports 5G measurement results to the 5G Node in *5GmeasurementReport* according to the measurement configuration provided in *5GRRCConnectionReconfiguration*..

2. 5G Node generates a new radio resource configuration for the 5G cell change and sends *the 5GRRCConnectionReconfiguration* message to the UE.

3. The UE applies the new configuration and replies with *5GRRCConnectionReconfigurationComplete* message.

4. If instructed, the UE performs synchronisation towards the 5G Cell. Otherwise, the UE may perform UL transmission after having applied the new configuration.

10.1.2.4 5G Cell Release

The 5G cell release is initiated by the 5G Node and is used to remove the/a 5G Cell. Figure 10.1.2.8.4-1 shows the 5G cell change:

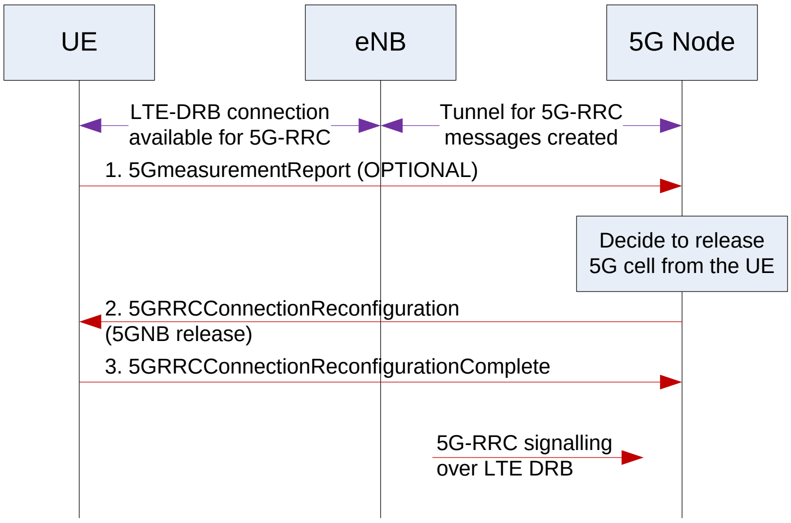

Figure 10.1.2.4-1: 5G cell release

1. UE reports the 5G measurement results to the 5G Node according to the measurement configuration provided in *5GmeasurementReport*.

NOTE: 5G link loss (a.k.a. RLF) event in the UE may also serve as a trigger for informing the 5G Node of the need to release the 5G cell. Furthermore, the release of a 5G cell can also be initiated by the 5G Node directly, without any indication coming form the UE (for instance due to load reason).

2. The 5G Node indicates in the *5GRRCConnectionReconfiguration* message towards the UE that the UE shall release the 5G cell.

3. The UE applies the new configuration and replies with *5GRRCConnectionReconfigurationComplete* message.

10.1.3. 5G Measurements

The UE reports measurement information in accordance with the measurement configuration as provided by the 5G Node. 5G RRC provides the measurement configuration applicable for a UE in 5GRRC_CONNECTED by means of dedicated signalling, i.e. using the *RRCConnectionReconfiguration* message.

The measurement configuration includes the following parameters:

1. **Measurement objects:** the objects on which the UE shall perform the measurements.
   - A measurement object is a single 5G carrier frequency.
2. **Reporting configurations**: a list of reporting configurations where each reporting configuration consists of the following:
   - Reporting criterion: the criterion that triggers the UE to send a measurement report. This can either be periodical or a single event description. Four events are used:
     - Serving 5G cell becomes better than threshold;
     - Serving 5G cell becomes worse than threshold;
     - Neighbour 5G cell becomes offset better than serving 5G cell;
     - Neighbour 5G cell becomes better than threshold.

NOTE: Layer 3 filtering is used.

3. **Quantity:** the measurement quantity for 5G carrier frequencies is RSRP.

5G RRC only configures a single measurement object for a given 5G frequency, i.e. it is not possible to configure two or more measurement objects for the same frequency with different associated parameters. Multiple instances of the same event can be configured though e.g. by configuring two reporting configurations with different thresholds.

10.1.4 Radio Link Failure in LTE

Editor's note: Placeholder to document the procedure for RLF in LTE.

10.1.5 Radio Link Failure in 5G

Only one phase governs the behaviour associated to 5G radio link failure as shown on Figure 10.1.5-1:

- 5G RLF handling procedure:
  - started upon radio problem detection which can be indicated from the lower layer by considering beam measurement results;
  - leads to radio link failure detection;
  - no UE-based mobility;
  - based on timer or other (e.g. counting) criteria (T_1).

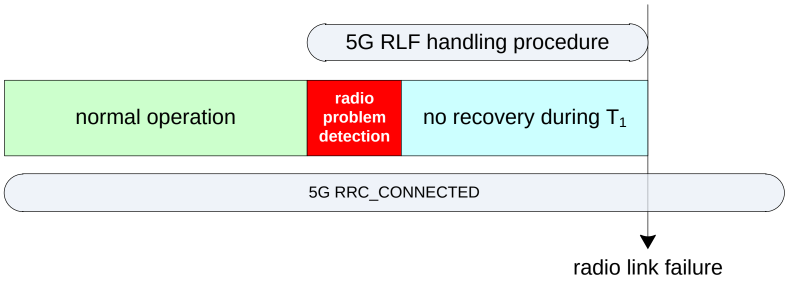

Figure 10.1.5-1: 5G Radio Link Failure

After declaring RLF, the UE sends the 5G Measurement Report to the 5G Node through eNB. Once 5G Node receives this MR message it can decide for 5G UE to release the 5G cell.

10.2 Inter RAT

Inter-RAT mobility is assumed to rely on existing LTE procedures, without any impacts.

11 Scheduling and Rate Control

In order to utilise the xSCH resources efficiently, a scheduling function is used in MAC. In this subclause, an overview of the scheduler for the transmission over 5G radio interface is given in terms of scheduler operation, signalling of scheduler decisions, and measurements to support scheduler operation. An overview of the scheduler defined in TS 36.300 [5] is applied for LTE radio interface.

Compared to LTE following features are not supported:

- Scheduling of SL-SCH;
- Cross-carrier scheduling when CA is configured;
- Carrier activation/deactivation when CA is configured. (Note: All configured CC are considered as active.);
- Prioritized bit rate;

- Explicit Congestion Notification.

If not otherwise defined in following subclauses, the subclause 11 in [5] applies for 5G scheduling operation.

11.1 Basic Scheduler Operation

MAC in 5G-Node 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 5G-Node 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.

When CA is configured, a UE may be scheduled over multiple serving cells simultaneously but at most one random access procedure shall be ongoing at any time.

A linking between UL and DL allows identifying the serving cell for which the DL assignment or UL grant applies as follows:

- DL assignment received on PCell corresponds to downlink transmission on PCell;
- UL grant received on PCell corresponds to uplink transmission on PCell;
- DL assignment received on $SCell_n$ corresponds to downlink transmission on $SCell_n$;
- UL grant received on $SCell_n$ corresponds to uplink transmission on $SCell_n$. If $SCell_n$ is not configured for uplink usage by the UE, the grant is ignored by the UE.

11.1.1 Downlink Scheduling

In the downlink, 5G-Node can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on xPDCCH(s). A UE always monitors the xPDCCH(s) in order to find possible allocation when its downlink reception is enabled (activity governed by DRX when configured). When CA is configured, the same C-RNTI applies to all serving cells.

Compared to LTE, semi-persistent scheduling is not supported in DL.

When required, retransmissions are explicitly signalled via the xPDCCH(s).

11.1.2 Uplink Scheduling

In the uplink, 5G-Node can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on xPDCCH(s). A UE always monitors the xPDCCH(s) in order to find possible allocation for uplink transmission when its downlink reception is enabled (activity governed by DRX when configured). When CA is configured, the same C-RNTI applies to all serving cells.

Compared to LTE, semi-persistent scheduling is not supported in UL.

When required, retransmissions are explicitly signalled via the xPDCCH(s).

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 UEs radio environment.

Compared to LTE single BSR format is supported in 5G.

11.4 Rate Control of GBR, MBR and UE-AMBR

11.4.1 Downlink

The 5G-Node guarantees the downlink GBR associated with a GBR bearer, enforces the downlink MBR 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.

Compared to LTE the prioritised bit rate (PBR) is not supported.

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

- All the radio bearer(s) in decreasing priority order for the remaining resources assigned by the grant.

NOTE: By limiting the total grant to the UE, the 5G-Node can ensure that the UE-AMBR plus the sum of MBRs is not exceeded.

NOTE: Provided the higher layers are responsive to congestion indications, the 5G-Node can enforce the MBR of an uplink radio bearer by triggering congestion indications towards higher layers and by shaping the data rate towards the S1 interface.

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

11.4.3 UE-AMBR for Dual Connectivity between LTE and 5G

In DC IW operation with LTE, the LTE eNB ensures that the UE-AMBR is not exceeded by:

1) limiting the resources it allocates to the UE in LTE cell(s); and

2) indicating to the 5G-Node a limit so that the 5G-Node can also in turn guarantee that this limit is not exceeded.

11.5 CSI reporting for Scheduling

The time and frequency resources used by the UE to report CSI are under the control of the 5G-Node. Compared to LTE only aperiodic CSI reporting is supported. A UE shall send the CSI report based on DCI format that indicates to include CSI report in UCI scheduled for uplink transmission. [3]

A UE is not expected to receive more than one CSI report request for a given subframe.

CSI reporting formats for 5G operation are defined in [3].

11.6 Explicit Congestion Notification

Compared to LTE explicit congestion notification is not supported in 5G.

12 DRX

There are no specific requirements on LTE DRX in P5G Trial. Normal 3GPP DRX requirements apply.

Due to the selected architecture, RRC Idle Mode DRX shall not be used in 5G in P5G Trial.

RRC Connected mode DRX specified for LTE in 3GPP TS 36.300 [5] may be used also in 5G in P5G Trial.

Extended DRX (eDRX) shall not be used in P5G Trial.

13 QoS

The same QoS framework as in LTE is used for the PyeongChang 5G trial.

On 5G side, a specific QCI is assigned to identify the radio bearer used for 5G RRC signalling.

14 Security

14.1 Overview and Principles

The following principles apply to 5G RAN security:

- The ciphering for 5G AS protection is a mandatory feature where only AES is considered as the ciphering algorithm (no integrity support for 5G AS protection).
- The 5G AS key (5G K_{eNB}) is derived at the 5G Node and delivered to the UE only via encrypted links (i.e., 4G DRB for 5G RRC signalling).
- The 5G K_{eNB} keys are cryptographically independent from the 4G K_{eNB} keys.
- Whenever a 5G cell change takes place, 5G K_{eNB} is derived at the target 5G cell and delivered to the UE.
- 5G K_{eNB} needs to be refreshed whenever PDCP COUNTs are about to wrap around.

The key derivation is depicted on Figure 14.1-1 below, where:

- 5G-RAND is a 256bits random value used as input into the 5G K_{eNB} derivations.
- 5G-C value is a 64 bit counter used as freshness input into the 5G K_{eNB} derivations.
- 5G K_{UPenc} is a key, which shall only be used for the protection of 5G UP traffic with a AES encryption algorithm. This key is derived by the UE and the 5G Node from 5G K_{eNB}, as well as an identifier for the encryption algorithm (UP-enc-alg, Alg-ID).

NOTE: 5G-RAND and 5G-C value are never delivered to the UE.

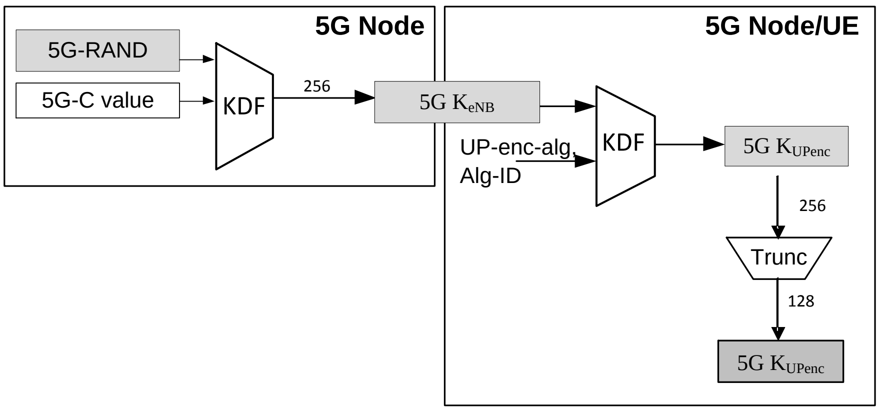

Figure 14.1-1: 5G Key Derivation

5G UP keys are refreshed when PDCP COUNTs are about to wrap around. 5G K_{eNB^*} is newly derived by 5G Node from the current "5G- C value" and delivered to UE via 5G RRC signalling. 5G K_{eNB^*} is then used as new 5G K_{eNB} for 5G UP traffic. When the UE goes into 5G RRC-IDLE all keys are deleted from the 5G Node.

5G UP keys are updated at 5G cell change by indicating in 5G RRC signalling to the UE the value of the new 5G K_{eNB} generated at new 5G cell.

14.2 Security termination points

The table below describes the security termination points.

Table 14.2-1 Security Termination Points

	Ciphering	Integrity Protection
5G U-Plane Data	Required and terminated in 5G Node	Not Required (NOTE)
NOTE: Integrity protection for 5G U-Plane is not required.		

14.3 5G Cell Removal

At 5G cell removal, the 5G cell shall delete the keys it stores. It is also assumed that 5G cell does no longer store state information about the corresponding UE and deletes the current keys from its memory. In particular, at 5G cell removal:

- The 5G cell and UE delete 5G K_{eNB} and 5G K_{UPenc}.

15 Radio Resource Management aspects

The main functions of, and high level guidelines for Radio Resource Management as described in 3GPP TS 36.300 also apply to the P5G trial system:

- **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, 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.

- **Radio Admission Control** (RAC): the task of radio admission control 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, 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).

- **Connection Mobility Control** (CMC): connection mobility control 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 LTE cell. Also, E-UTRAN parameters that configure the UE measurement and reporting procedures are broadcast. In connected mode, the mobility of radio connections has to be supported. LTE handover decisions may be based on UE and eNB measurements, and 5G cell addition, change and release decisions may be based on UE and 5G Node measurements. In addition, LTE handover decisions and 5G cell addition, change and release decisions may take other inputs, such as neighbour cell load, traffic distribution, transport and hardware resources and Operator defined policies into account.

- **Dynamic Resource Allocation** (DRA): the task of dynamic resource allocation is to allocate and de-allocate resources 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). DRA 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.

16 UE capabilities

The 5G RRC signalling carries the 5G capabilities. Compared to LTE, the UE 5G capability information is not stored in the MME. The UE provides the 5G capabilities including the IMEI-SV value of the 5G UE at the 5G RRC UE capability enquiry procedure.

Signalling of any other RAT capabilities in the 5G RRC is not supported.

The 5G Node may acquire the UE capabilities when necessary.

17 S1 Interface

There are no specific requirements on S1 in P5G Trial. 3GPP specification 3GPP TS 36.300 [5] and 3GPP TS 36.410 [x] apply also in P5G Trial.

S1 termination points are MME and LTE eNB.

NOTE: It is assumed that EPC core network is used for the Trial.

18 X2 Interface

X2 interface in P5G Trial follows standard 3GPP procedures as described in 3GPP TS 36.300 [5].

In order to support the agreed functionalities for P5G, X2 between an eNB and a 5G Node needs to be enhanced to support at least the following:

- 5G RRC DRB Establishment indication from eNB to 5G Node to trigger *UE-5GcapabilityEnquiry* (see section 10.1.2.2);
- Relay of the UE's end marker from eNB to 5G Node for in-sequence delivery in uplink during path switch from LTE to 5G;
- Indication of empty transmission buffers from eNB to 5G Node for in-sequence delivery in downlink during path switch from LTE to 5G.

Annex A (normative): Deployment, Assumptions and Requirements

This annex captures the high level requirements as well as the assumptions agreed for P5G.

A.1 Deployment Scenario

The basic deployment scenario assumed is depicted below, where a "4th LTE carrier" is used for interworking with the 5G carrier. Idle mode UEs with 5G capability need to have an RRC connection with an eNB operating on that 4th LTE carrier in order to initiate a 5G RRC connection.

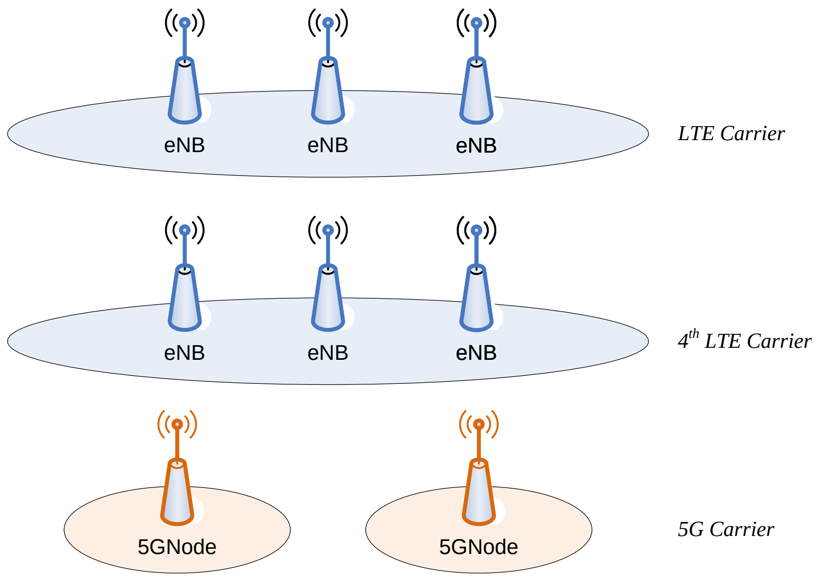

Figure A.1: 5G Trial Deployment Scenario

A.2 LTE Implementations

Requirements regarding possible impacts to existing implementations are:

- The addition and operation of 5G Nodes within E-UTRAN shall not impact NAS;
- Impacts to LTE (chipset and eNB) should be minimised;
- 18 bits PDCP SN is used;

Regarding the broadcast of system information and CN NAS configuration:

- No 5G radio related SIB broadcast in LTE;
- LTE cells broadcast the KT PLMN ID MCC=450 and MNC=08;
- P5G cells broadcast both KT PLMN ID MCC=450 and MNC=08 and P5G Trial PLMN ID with MCC=450 and MNC=P5G Trial MNC.

NOTE: P5G Trial MNC value is to be confirmed by Korean regulatory body, but value "02" is assumed

A.3 5G Implementations

The following assumptions are made regarding 5G implementations for P5G:

- Separate PLMN-ID is used for the trial network: it serves as an indication to the UE that a 5G RRC signalling connection can be requested. If not present, 5G RRC signalling connection shall not be requested by the UE.

- Usage of 5G resources by the UE requires LTE to be in RRC_CONNECTED in LTE.
- In terms of mobility, 5G cells may be released by the network before 4G handover and added after 4G handover.

The UE shall keep the 5G RRC connection in LTE handover, unless the network chooses to release 5G RRC connection

Concerning 5G Security, the following assumptions are made:

- Ciphering shall be implemented but can be turned off in 5G PDCP for high bit rates;
- AES algorithm is mandatory.
- No integrity protection of 5G RRC;
- Backhaul security involving 5G Nodes does not need to be assumed.

A.4 USIM configuration

This sub-clause identifies the specific changes that are needed for USIM configuration in PyeongChang 5G trial. Standard KT USIM configuration is assumed for all USIM resources where no exceptions specific to this trial are explicitly defined.

A.4.1 4G USIM

No requirements, i.e. USIM of subscriber who is not participating to PyeongChang 5G trial is not affected.

A.4.2 5G Trial USIM

The following applies to the Trial USIM

- MCC: 450 (Korea)
- MNC: the same as 08 used by KT outside of the 5G trial area

Annex B (normative): Higher layer aspects of 5G RRC

B.1 Protocol Stack for 5G RRC signalling

As shown on Figure B.1, the 5G RRC messages are encapsulated in UDP/IP header.

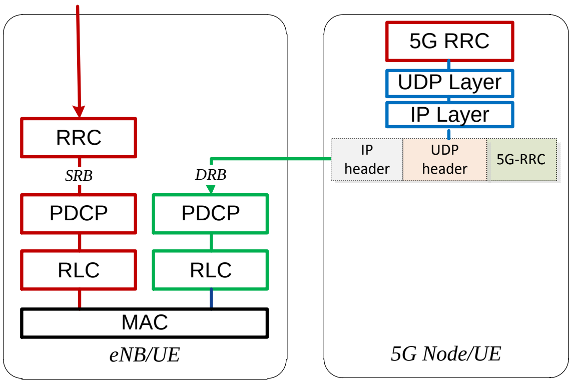

Figure B.1: Transport of 5G RRC messages

B.2 UDP port used for 5G RRC signalling

5G Node and UE use source and destination UDP port for 5G RRC messages according to Table B.2 below.

Table B.2: UDP Port for 5G RRC messages

	UE	5G Node
Source	xxx	yyy
Destination	yyy	xxx

Editor's note: UDP port number(s) should be defined.

B.3 IP addresses used for 5G RRC signalling

5G Node and UE use source and destination IP addresses for 5G RRC messages according to Table B.3 below.

Table B.3-: IP addresses for 5G RRC messages

	UE	5G Node
Source	UE's 5G RRC PDN connection IP address	xxx.xxx.xxx.x
Destination	xxx.xxx.xxx.x	255.255.255.255 or UE's 5G RRC PDN connection IP address

Editor's note: A predefined IP address for 5G Node (xxx.xxx.xxx.x) should be defined.

Annex C (normative): End marker packet in UL

C.1 Format of the end maker packet in UL

Figure C.1-1 below shows the end marker packet format. End Flag has 1-Byte length and is used to indicate the end marker packet.

IP Header	UDP Header	End Flag (1 Byte)

Figure C.1: Format for the end marker packet in UL

C.2 UDP port used for the end marker packet

UE uses source and destination UDP port for the end marker packet in UL according to Table C.2 below.

Table C.2: UDP Port for the end marker packet in UL

	UE
Source	xxx
Destination	yyy

Editor's note: UDP port number(s) should be defined.

C.3 IP addresses used for the end marker packet

UE uses source and destination IP addresses for the end marker packet in UL according to Table C.3 below.

Table C.3: IP addresses for the end marker packet in UL

	UE
Source	UE's PDN connection IP address
Destination	255.255.255.255

Note: The destination address is selected to ensure it passes TFT filtering in the UE

C.4 End Flag

UE uses End Flag for the end marker packet in UL according to Table C.4 below.

Table C.4: End flag for the end marker packet in UL

	UE
End Flag	1111 1111

Annex Z (informative): Change history

Change history (before approval)							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2015.01					First Skeleton and initial content		0.1.0
2015.02					Outcome of IWK Telco captured	0.1.0	0.2.0
2015.03					Outcome of IWK Meeting captured	0.2.0	0.3.0
2015.04					Outcome of IWK Telco captured	0.3.0	0.3.1
2015.04					Outcome of F2F meeting captured: - clarifications on RRC states and Measurements	0.3.1.	0.4.0
2015.05					Outcome of IWK Telco and Finalisation CRs captured	0.4.0	0.5.0
2015.05					Editorial clean-up	0.5.0	0.5.1
2015.05					Outcome of F2F meeting captured: - Annex on End Marker - Clarifications on HARQ - Placeholders for RLF	0.5.1	0.6.0
2015.06					Outcome of IWK Telco captured: - RLF for 5G captured - references to PHY specs added for section 5	0.6.0	1.0.0
2015.06					Outcome of F2F meeting captured: - distinction between inter-RAN node interfaces - 5G Cell Maintenance during LTE Handover - 5G RRC Reset	1.0.0	1.1.0