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Contents

Foreword

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1 Scope

The present document provides an overview and overall description of the NG-RAN and focuses on the radio interface protocol architecture of NR connected to 5GC (E-UTRA connected to 5GC is covered in the 36 series). Details of the radio interface protocols are specified in companion specifications of the 38 series.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[3] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[4] 3GPP TS 38.401: "NG-RAN; Architecture description".

[5] 3GPP TS 33.501: "Security Architecture and Procedures for 5G System".

[6] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[7] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".

[8] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[9] 3GPP TS 37.324: " E-UTRA and NR; Service Data Protocol (SDAP) specification".

[10] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state".

[11] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".

[12] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[13] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[14] 3GPP TS 22.168: "Earthquake and Tsunami Warning System (ETWS) requirements; Stage 1".

[15] 3GPP TS 22.268: "Public Warning System (PWS) Requirements".

[16] 3GPP TS 38.410: "NG-RAN; NG general aspects and principles".

[17] 3GPP TS 38.420: "NG-RAN; Xn general aspects and principles".

[18] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[19] 3GPP TS 22.261: "Service requirements for next generation new services and markets".

[20] 3GPP TS 38.202: "NR; Physical layer services provided by the physical layer"

[21] 3GPP TS 37.340: "NR; Multi-connectivity; Overall description; Stage-2".

[22] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[23] IETF RFC 4960 (2007-09): "Stream Control Transmission Protocol".

[24] 3GPP TS 26.114: "Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".

[25] Void.

[26] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[27] IETF RFC 3168 (09/2001): "The Addition of Explicit Congestion Notification (ECN) to IP".

[28] 3GPP TS 24.501: "NR; Non-Access-Stratum (NAS) protocol for 5G System (5GS)".

[29] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[30] 3GPP TS 38.415: "NG-RAN; PDU Session User Plane Protocol".

3 Abbreviations and Definitions

3.1 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1], in TS 36.300 [2] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1] and TS 36.300 [2].

5GC	5G Core Network
5QI	5G QoS Identifier
A-CSI	Aperiodic CSI
AKA	Authentication and Key Agreement
AMBR	Aggregate Maximum Bit Rate
AMC	Adaptive Modulation and Coding
AMF	Access and Mobility Management Function
ARP	Allocation and Retention Priority
BA	Bandwidth Adaptation
BCH	Broadcast Channel
BPSK	Binary Phase Shift Keying
C-RNTI	Cell RNTI
CBRA	Contention Based Random Access
CCE	Control Channel Element
CD-SSB	Cell Defining SSB
CFRA	Contention Free Random Access
CMAS	Commercial Mobile Alert Service
CORESET	Control Resource Set
DFT	Discrete Fourier Transform
DCI	Downlink Control Information
DL-SCH	Downlink Shared Channel
DMRS	Demodulation Reference Signal
DRX	Discontinuous Reception
ETWS	Earthquake and Tsunami Warning System
FS	Feature Set
GFBR	Guaranteed Flow Bit Rate
I-RNTI	Inactive RNTI
INT-RNTI	Interruption RNTI
KPAS	Korean Public Alarm System
LDPC	Low Density Parity Check
MDBV	Maximum Data Burst Volume
MIB	Master Information Block
MICO	Mobile Initiated Connection Only

MFBR	Maximum Flow Bit Rate
MMTEL	Multimedia telephony
MNO	Mobile Network Operator
MU-MIMO	Multi User MIMO
NCGI	NR Cell Global Identifier
NCR	Neighbour Cell Relation
NCRT	Neighbour Cell Relation Table
NGAP	NG Application Protocol
NR	NR Radio Access
P-RNTI	Paging RNTI
PCH	Paging Channel
PCI	Physical Cell Identifier
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PO	Paging Occasion
PRACH	Physical Random Access Channel
PRB	Physical Resource Block
PRG	Precoding Resource block Group
PSS	Primary Synchronisation Signal
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
PWS	Public Warning System
QAM	Quadrature Amplitude Modulation
QFI	QoS Flow ID
QPSK	Quadrature Phase Shift Keying
RA-RNTI	Random Access RNTI
RACH	Random Access Channel
RANAC	RAN-based Notification Area Code
REG	Resource Element Group
RMSI	Remaining Minimum SI
RNA	RAN-based Notification Area
RNAU	RAN-based Notification Area Update
RNTI	Radio Network Temporary Identifier
RQA	Reflective QoS Attribute
RQoS	Reflective Quality of Service
RS	Reference Signal
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
SD	Slice Differentiator
SDAP	Service Data Adaptation Protocol
SFI-RNTI	Slot Format Indication RNTI
SIB	System Information Block
SI-RNTI	System Information RNTI
SLA	Service Level Agreement
SMC	Security Mode Command
SMF	Session Management Function
S-NSSAI	Single Network Slice Selection Assistance Information
SPS	Semi-Persistent Scheduling
SR	Scheduling Request
SRS	Sounding Reference Signal
SS	Synchronization Signal
SSB	SS/PBCH block
SSS	Secondary Synchronisation Signal
SST	Slice/Service Type
SU-MIMO	Single User MIMO
SUL	Supplementary Uplink
TA	Timing Advance
TPC	Transmit Power Control
UCI	Uplink Control Information
UL-SCH	Uplink Shared Channel
UPF	User Plane Function
URLLC	Ultra-Reliable and Low Latency Communications

Xn-C	Xn-Control plane
Xn-U	Xn-User plane
XnAP	Xn Application Protocol

3.2 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1], in TS 36.300 [2] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1] and TS 36.300 [2].

Cell-Defining SSB: an SSB with an RMSI associated.

CORESET#0: the control resource set for at least SIB1 scheduling, can be configured either via MIB or via dedicated RRC signalling.

gNB: node providing NR user plane and control plane protocol terminations towards the UE, and connected via the NG interface to the 5GC.

Intra-system Handover: Handover that does not involve a CN change (EPC or 5GC).

Inter-system Handover: Handover that involves a CN change (EPC or 5GC).

MSG1: preamble transmission of the random access procedure.

MSG3: first scheduled transmission of the random access procedure.

ng-eNB: node providing E-UTRA user plane and control plane protocol terminations towards the UE, and connected via the NG interface to the 5GC.

NG-C: control plane interface between NG-RAN and 5GC.

NG-U: user plane interface between NG-RAN and 5GC.

NG-RAN node: either a gNB or an ng-eNB.

Numerology: corresponds to one subcarrier spacing in the frequency domain. By scaling a reference subcarrier spacing by an integer *N*, different numerologies can be defined.

Xn: network interface between NG-RAN nodes.

4 Overall Architecture and Functional Split

4.1 Overall Architecture

An NG-RAN node is either:

- a gNB, providing NR user plane and control plane protocol terminations towards the UE; or
- an ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards the UE.

The gNBs and ng-eNBs are interconnected with each other by means of the Xn interface. The gNBs and ng-eNBs are also connected by means of the NG interfaces to the 5GC, more specifically to the AMF (Access and Mobility Management Function) by means of the NG-C interface and to the UPF (User Plane Function) by means of the NG-U interface (see TS 23.501 [3]).

NOTE: The architecture and the F1 interface for a functional split are defined in TS 38.401 [4].

The NG-RAN architecture is illustrated in Figure 4.1-1 below.

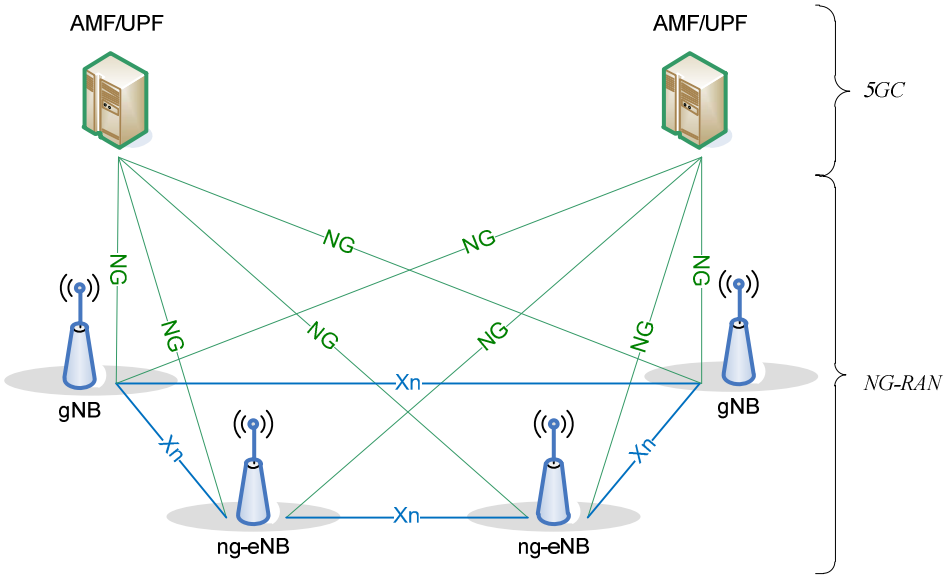

Figure 4.1-1: Overall Architecture

4.2 Functional Split

The **gNB** and ng-eNB host 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);
- IP header compression, encryption and integrity protection of data;
- Selection of an AMF at UE attachment when no routing to an AMF can be determined from the information provided by the UE;
- Routing of User Plane data towards UPF(s);
- Routing of Control Plane information towards AMF;
- Connection setup and release;
- Scheduling and transmission of paging messages;
- Scheduling and transmission of system broadcast information (originated from the AMF or OAM);
- Measurement and measurement reporting configuration for mobility and scheduling;
- Transport level packet marking in the uplink;
- Session Management;
- Support of Network Slicing;
- QoS Flow management and mapping to data radio bearers;
- Support of UEs in RRC_INACTIVE state;
- Distribution function for NAS messages;
- Radio access network sharing;
- Dual Connectivity;
- Tight interworking between NR and E-UTRA.

The **AMF** hosts the following main functions (see TS 23.501 [3]):

- NAS signalling termination;
- NAS signalling security;
- AS Security control;
- Inter CN node signalling for mobility between 3GPP access networks;
- Idle mode UE Reachability (including control and execution of paging retransmission);
- Registration Area management;
- Support of intra-system and inter-system mobility;
- Access Authentication;
- Access Authorization including check of roaming rights;
- Mobility management control (subscription and policies);
- Support of Network Slicing;
- SMF selection.

The **UPF** hosts the following main functions (see TS 23.501 [3]):

- Anchor point for Intra-/Inter-RAT mobility (when applicable);
- External PDU session point of interconnect to Data Network;
- Packet routing & forwarding;
- Packet inspection and User plane part of Policy rule enforcement;
- Traffic usage reporting;
- Uplink classifier to support routing traffic flows to a data network;
- Branching point to support multi-homed PDU session;
- QoS handling for user plane, e.g. packet filtering, gating, UL/DL rate enforcement;
- Uplink Traffic verification (SDF to QoS flow mapping);
- Downlink packet buffering and downlink data notification triggering.

The Session Management function (**SMF**) hosts the following main functions (see TS 23.501 [3]):

- Session Management;
- UE IP address allocation and management;
- Selection and control of UP function;
- Configures traffic steering at UPF to route traffic to proper destination;
- Control part of policy enforcement and QoS;
- Downlink Data Notification.

This is summarized on the figure below where yellow boxes depict the logical nodes and white boxes depict the main functions.

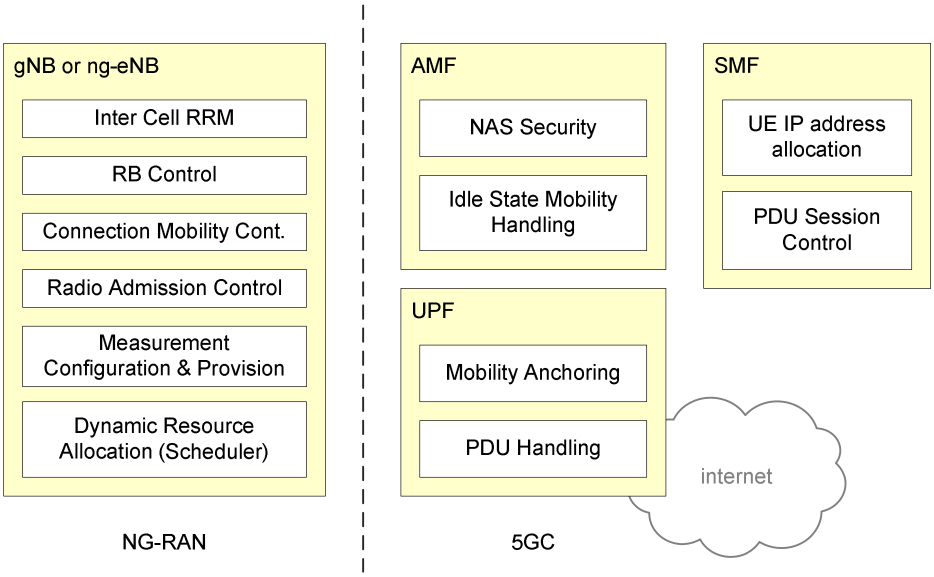

Figure 4.2-1: Functional Split between NG-RAN and 5GC

4.3 Network Interfaces

4.3.1 NG Interface

4.3.1.1 NG User Plane

The NG user plane interface (NG-U) is defined between the NG-RAN node and the UPF. The user plane protocol stack of the NG interface is shown on Figure 4.3.1.1-1. 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 NG-RAN node and the UPF.

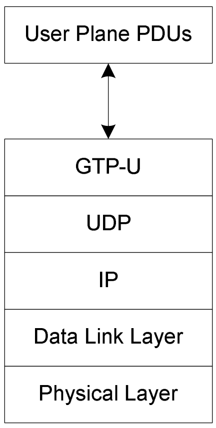

Figure 4.3.1.1-1: NG-U Protocol Stack

NG-U provides non-guaranteed delivery of user plane PDUs between the NG-RAN node and the UPF.

Further details of NG-U can be found in TS 38.410 [16].

4.3.1.2 NG Control Plane

The NG control plane interface (NG-C) is defined between the NG-RAN node and the AMF. The control plane protocol stack of the NG interface is shown on Figure 4.3.1.2-1. The transport network layer is built on IP transport. For the reliable transport of signalling messages, SCTP is added on top of IP. The application layer signalling protocol is referred to as NGAP (NG Application Protocol). The SCTP layer provides guaranteed delivery of application layer messages. In the transport, IP layer point-to-point transmission is used to deliver the signalling PDUs.