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650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

参考
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关键词
5G

ETSI

650 Route des Lucioles F-06921
Sophia Antipolis Cedex - 法国

电话：+33 4 92 94 42 00 传真：+33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C 在格拉斯
分辖区注册的非营利协会 (06) N° 7803/88

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Contents

内容

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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

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[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: "NR; Service Data Protocol (SDAP) specification".

[10] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[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: "NR; User Equipment (UE) radio transmission and reception".

[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".

1 范围

本文档提供了 NG-RAN 的概述和整体描述，重点介绍了 NR 连接到 5GC 的无线接口协议架构（连接到 5GC 的 E-UTRA 包含在 36 系列中）。
无线接口协议的详细信息在 38 系列的配套规范中指定。

2 参考

下列文件中的条款通过本文的引用而构成本文件的条款。

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[1] 3GPP TR 21.905："3GPP 规范词汇"。

[2] 3GPP TS 36.300："演进的通用地面无线电接入（E-UTRA）和演进的通用地面无线电接入网络（E-UTRAN）；总体描述；第2阶段"。

[3] 3GPP TS 23.501："5G 系统的系统架构；第 2 阶段"。

[4] 3GPP TS 38.401："NG-RAN；架构描述"。

[5] 3GPP TS 33.501："5G 系统的安全架构和程序"。

[6] 3GPP TS 38.321："NR；媒体访问控制（MAC）协议规范"。

[7] 3GPP TS 38.322："NR；无线电链路控制（RLC）协议规范"。

[8] 3GPP TS 38.323："NR；分组数据汇聚协议（PDCP）规范"。

[9] 3GPP TS 37.324："NR；服务数据协议（SDAP）规范"。

[10] 3GPP TS 38.304："NR；空闲模式下的用户设备（UE）过程"。

[11] 3GPP TS 38.306："NR；用户设备（UE）无线接入能力"。

[12] 3GPP TS 38.331："NR；无线电资源控制（RRC）；协议规范"。

[13] 3GPP TS 38.133："NR；支持无线电资源管理的要求"。

[14] 3GPP TS 22.168："地震和海啸预警系统 (ETWS) 要求；第 1 阶段"。

[15] 3GPP TS 22.268："公共警告系统（PWS）要求"。

[16] 3GPP TS 38.410："NG-RAN；NG 一般方面和原则"。

[17] 3GPP TS 38.420："NG-RAN；Xn 一般方面和原则"。

[18] 3GPP TS 38.101："NR；用户设备（UE）无线电传输和接收"。

[19] 3GPP TS 22.261："下一代新服务和市场的服务要求"。

[20] 3GPP TS 38.202："NR；物理层提供的物理层服务"

[21] 3GPP TS 37.340："NR；多重连接；总体描述；第 2 阶段"。

[22] 3GPP TS 23.502："5G 系统程序；第 2 阶段"。

[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)".

3 Abbreviations and Definitions

3.1 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1], in 3GPP 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 3GPP TR 21.905 [1] and 3GPP 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
GFBR	Guaranteed Flow Bit Rate
I-RNTI	Inactive RNTI
INT-RNTI	Interruption RNTI
LDPC	Low Density Parity Check
MDBV	Maximum Data Burst Volume
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

[23] IETF RFC 4960 (2007-09)："流控制传输协议"。

[24] 3GPP TS 26.114："技术规范组服务和系统方面；IP 多媒体子系统 (IMS)；多媒体电话；媒体处理和交互"。

[25] 空白。

[26] 3GPP TS 38.413："NG-RAN；NG 应用协议（NGAP）"。

3 缩写和定义

3.1 缩写

出于本文档的目的，3GPP TR 21.905 [1]、3GPP TS 36.300 [2] 中给出的缩写以及以下内容适用。
本文档中定义的缩写优先于 3GPP TR 21.905 [1] 和 3GPP TS 36.300 [2] 中相同缩写的定义（如果有）。

5GC	5G核心网
5QI	5G 服务质量标识符
CSI	非周期CSI
AKA	身份验证和密钥协商
AMBR	聚合最大比特率
AMC	自适应调制和编码
AMF	访问和移动管理功能
ARP	分配和保留优先级
BA	带宽适配
BCH	广播频道
BPSK	二进制相移键控
RNTI	小区RNTI
CBRA	基于竞争的随机接入
CCE	控制通道元件
单边带CD	单元定义单边带
CFRA	无争用随机访问
CMAS	商业移动警报服务
核心集	控制资源集
DFT	离散傅里叶变换
DCI	下行控制信息
下行同步通道	下行共享信道
DMRS	解调参考信号
DRX	不连续接收
ETWS	地震和海啸警报系统
GFBR	保证流量比特率
RNTI	不活动的 RNTI
INT-RNTI	中断RNTI
LDPC	低密度奇偶校验
MDBV	最大数据突发量
MICO	仅移动发起的连接
MFBR	最大流量比特率
蒙泰尔	多媒体电话
MNO	移动网络运营商
多用户多输入多输出	多用户MIMO
NCGI	NR 小区全局标识符
NCR	邻区关系
NCRT	邻区关系表
NGAP	NG应用协议
NR	NR 无线电接入
RNTI	成为RNTI
PCH	寻呼通道
PCI	物理小区标识符
物理下行控制信道	物理下行控制信道
物理共享信道	物理下行共享信道

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
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
SRS	Sounding Reference Signal
SS	Synchronization Signal
SSB	Synchronization Signal and 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 3GPP TR 21.905 [1], in 3GPP 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 3GPP TR 21.905 [1] and 3GPP TS 36.300 [2].

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

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

MSG1: preamble transmission of the random access procedure.

PO 寻呼场合
普拉奇 物理随机接入信道
PRB 物理资源块
PRG 预编码资源块组
PSS 主同步信号
公共信道信道 物理上行控制信道
推 物理上行链路共享信道
PWS 公共警报系统
QAM 正交幅度调制
QFI QoS 流 ID
QPSK 正交相移键控
RA-RNTI 随机接入RNTI
RACH 随机接入信道
背包 基于 RAN 的通知区号
REG 资源元素组
RMSI 剩余最小 SI
RNA 基于 RAN 的通知区域
RNAU 基于 RAN 的通知区域更新
RNTI 无线网络临时标识符
RQA 反射 QoS 属性
RQoS 反射服务质量 RS 参考信号 RSRP 参考信号接收功率 RSRQ 参考信号接收质量 SD 切片微分器 SDAP 服务数据适配协议 SFI-RNTI 时隙格式指示 RNTI SI-RNTI 系统信息 RNTI SLA 服务级别协议 SMC 安全模式命令 SMF 会话管理功能 S-NSSAI 单网络切片选择辅助信息 SPS 半持久调度 SRS 探测参考信号 SS 同步信号 SSB 同步信号和 PBCH 块 SSS 辅助同步信号 SST 切片/服务类型 SU-MIMO 单用户 MIMO SUL 补充上行链路 TA 定时提前 TPC发射功率控制 UCI 上行链路控制信息 UL-SCH 上行链路共享信道 UPF 用户平面功能 URLLC 超可靠低延迟通信 Xn-C Xn-控制平面 Xn-U Xn-用户平面 XnAP Xn 应用协议

3.2 定义

出于本文档的目的，3GPP TR 21.905 [1]、3GPP TS 36.300 [2] 中给出的术语和定义以及以下内容适用。本文档中定义的术语优先于 3GPP TR 21.905 [1] 和 3GPP TS 36.300 [2] 中相同术语（如果有）的定义。

小区定义的 SSB：与 RMSI 相关联的 SSB。

gNB：向 UE 提供 NR 用户平面和控制平面协议终端的节点，并通过 NG 接口连接到 5GC。

MSG1：随机接入过程的前导码传输。

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 3GPP TS 23.501 [3]).

NOTE: The architecture and the F1 interface for a functional split are defined in 3GPP TS 38.401 [4].

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

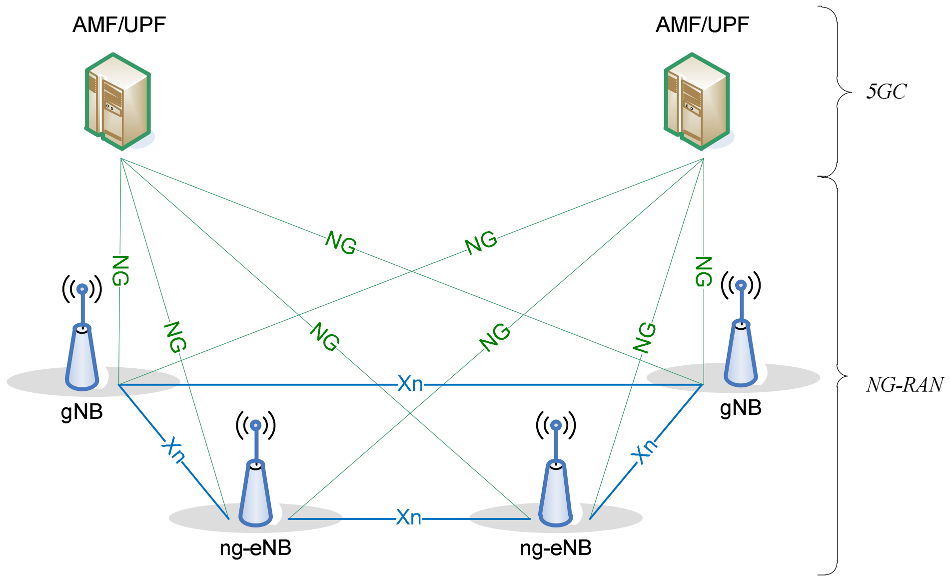


Figure 4.1-1: Overall Architecture

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);

MSG3：随机接入过程的第一次调度传输。

ng-eNB：向 UE 提供 E-UTRA 用户平面和控制平面协议终端的节点，并通过 NG 接口连接到 5GC。

NG-C：NG-RAN 和 5GC 之间的控制平面接口。

NG-U：NG-RAN和5GC之间的用户平面接口。

NG-RAN 节点：gNB 或 ng-eNB。

Numerology：对应于频域中的一个子载波间隔。通过将参考子载波间隔缩放整数N，可以定义不同的数字。

Xn：NG-RAN 节点之间的网络接口。

4 整体架构及功能拆分

4.1 整体架构

NG-RAN 节点是：

- gNB，向UE提供NR用户平面和控制平面协议终止；或者
- ng-eNB，向 UE 提供 E-UTRA 用户平面和控制平面协议终止。

gNB和ng-eNB通过Xn接口相互互连。
gNB 和 ng-eNB 还通过 NG 接口连接到 5GC，更具体地说，通过 NG-C 接口连接到 AMF（接入和移动管理功能），并通过以下方式连接到 UPF（用户平面功能）： NG-U 接口（参见 3GPP TS 23.501 [3]）。

笔记： 功能分割的架构和 F1 接口在 3GPP TS 38.401 [4] 中定义。

NG-RAN架构如下图4.1-1所示。

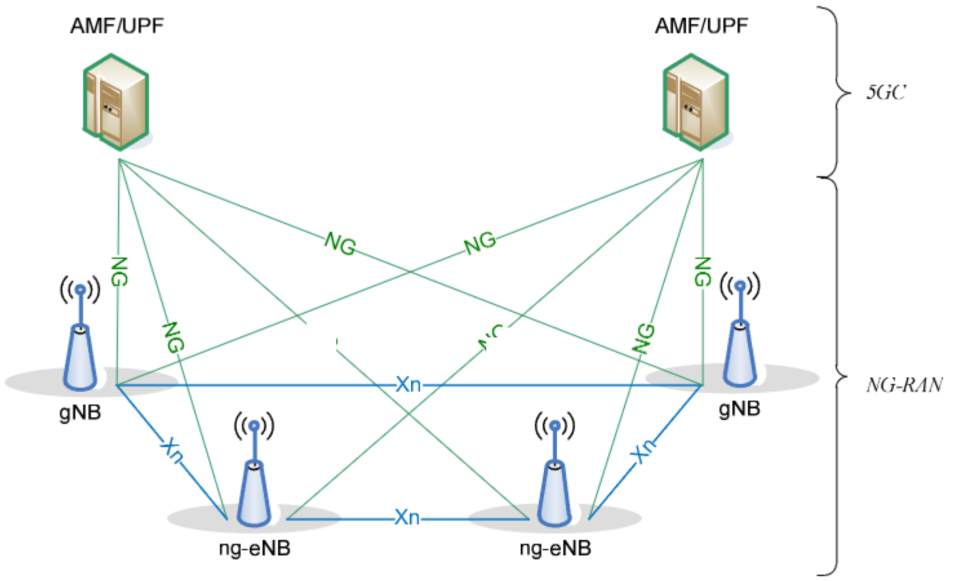


图4.1-1： 整体架构

4.2 功能分割

gNB 和 ng-eNB 具有以下功能：

- 无线资源管理功能：无线承载控制、无线准入控制、连接移动性控制、上下行链路资源动态分配给UE（调度）；

- 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 3GPP 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 3GPP 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;

- IP头压缩、数据加密和完整性保护；
- 当无法根据UE提供的信息确定到AMF的路由时，UE附着时AMF的选择；
- 将用户平面数据路由至 UPF；
- 将控制平面信息路由至 AMF；
- 连接建立和释放；
- 寻呼消息的调度和传输；
- 系统广播信息（源自AMF或OAM）的调度和传输；
- 用于移动性和调度的测量和测量报告配置；
- 上行链路中的传输级数据包标记；
- 会话管理；
- 支持网络切片；
- QoS 流管理和映射到数据无线承载；
- 支持RRC_INACTIVE状态下的UE；
- NAS消息分发功能；
- 无线接入网络共享；
- 双连接；
- NR 和 E-UTRA 之间的紧密互通。

AMF 具有以下主要功能（参见 3GPP TS 23.501 [3]）：

- NAS信令终止；
- NAS信令安全；
- AS 安全控制；
- 用于 3GPP 接入网络之间移动性的 CN 节点间信令；
- 空闲模式UE Reachability（包括寻呼重传的控制和执行）；
- 登记区管理；
- 支持系统内和系统间移动性；
- 接入认证；
- 接入授权，包括检查漫游权；
- 移动管理控制（订阅和策略）；
- 支持网络切片；
- 单模光纤选择。

UPF 具有以下主要功能（参见 3GPP TS 23.501 [3]）：

- RAT 内/RAT 间移动性的锚点（如果适用）；
- 与数据网络互连的外部 PDU 会话点；
- 数据包路由和转发；

- 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 3GPP 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.

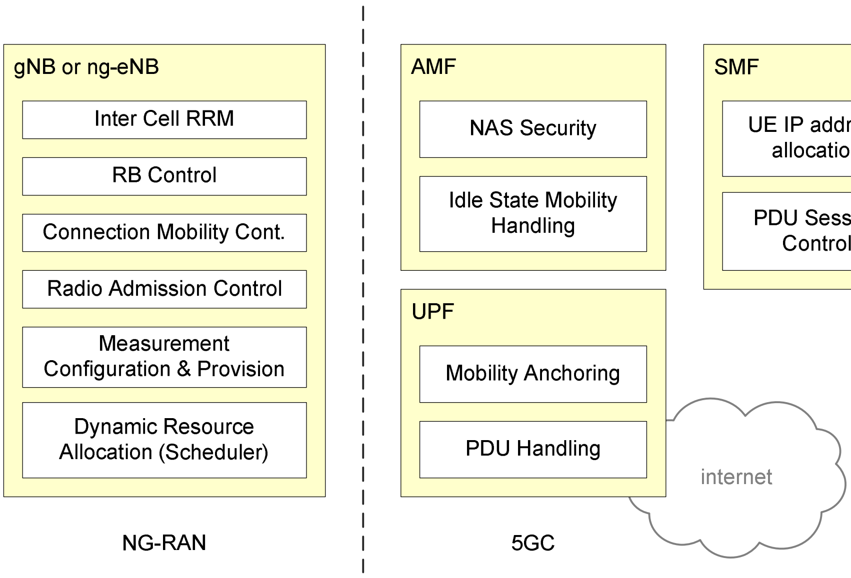


Figure 4.2-1: Functional Split between NG-RAN and 5GC

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.

- 策略规则执行的数据包检查和用户平面部分;
- 流量使用报告;
- 上行链路分类器支持将流量路由至数据网络;
- 支持多宿主 PDU 会话的分支点;
- 用户平面的 QoS 处理，例如数据包过滤、门控、UL/DL 速率强制;
- 上行链路流量验证（SDF 到 QoS 流映射）;
- 下行报文缓冲和下行数据通知触发。

会话管理功能 (SMF) 具有以下主要功能（请参阅 3GPP TS 23.501 [3]）:

- 会话管理;
- UE IP地址分配和管理;
- UP功能的选择和控制;
- 在 UPF 上配置流量转向，将流量路由到正确的目的地;
- 策略执行和QoS的控制部分;
- 下行数据通知。

下图对此进行了总结，其中黄色框表示逻辑节点，白色框表示主要功能。

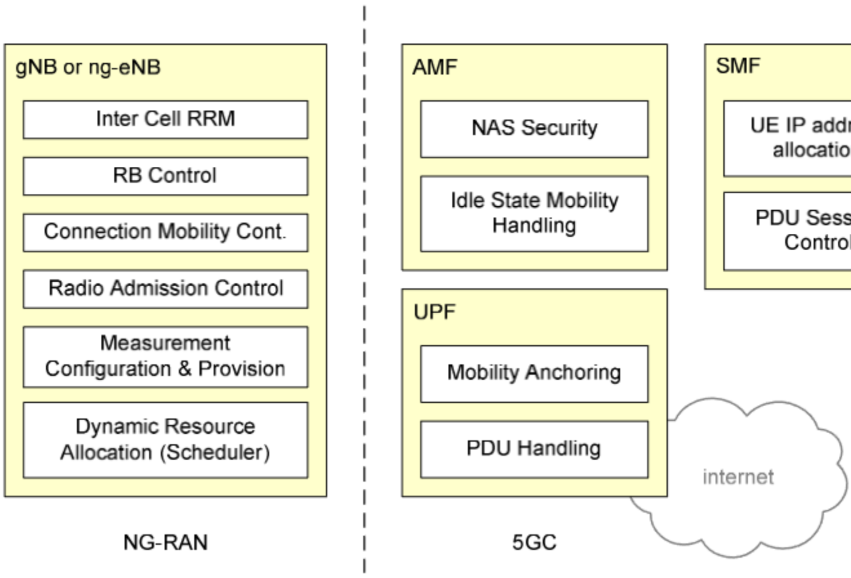


图 4.2-1：NG-RAN 和 5GC 之间的功能划分

4.3 网络接口

4.3.1 OF接口

4.3.1.1 OF 用户平面

NG 用户平面接口 (NG-U) 在 NG-RAN 节点和 UPF 之间定义。 NG接口的用户面协议栈如图4.3.1.1-1所示。传输网络层构建在 IP 传输之上，GTP-U 用于在 UDP/IP 之上承载 NG-RAN 节点和 UPF 之间的用户平面 PDU。

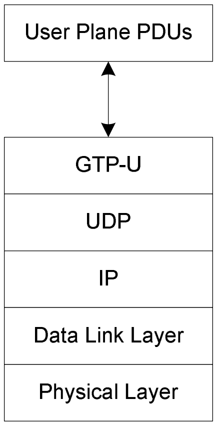


Figure 4.3.1.1-1: NG-U Protocol Stack

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 3GPP 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.

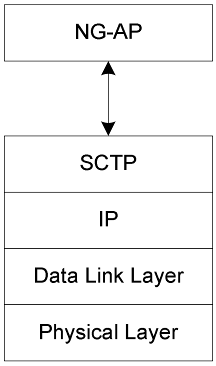


Figure 4.3.1.2-1: NG-C Protocol Stack

NG-C provides the following functions:

- NG interface management;
- UE context management;
- UE mobility management;
- Transport of NAS messages;
- Paging;
- PDU Session Management;
- Configuration Transfer;
- Warning Message Transmission.

Further details of NG-C can be found in 3GPP TS 38.410 [16].

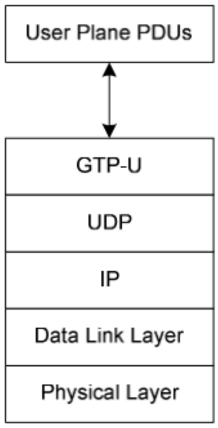


图 4.3.1.1-1：NG-U 协议栈

NG-U 在 NG-RAN 节点和 UPF 之间提供无保证的用户平面 PDU 传送。

NG-U 的更多细节可以在 3GPP TS 38.410 [16] 中找到。

4.3.1.2 OF控制平面

NG 控制平面接口 (NG-C) 在 NG-RAN 节点和 AMF 之间定义。 NG接口的控制面协议栈如图4.3.1.2-1所示。传输网络层建立在IP传输之上。
为了信令消息的可靠传输，在IP之上添加了SCTP。应用层信令协议称为NGAP（NG应用协议）。 SCTP 层提供应用层消息的有保证的传递。
在传输中，IP层点对点传输用于传送信令PDU。

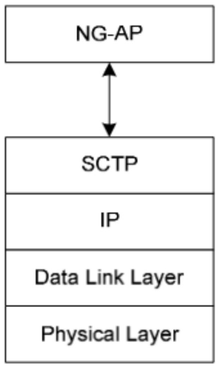


图 4.3.1.2-1：NG-C 协议栈

NG-C提供以下功能：

- NG接口管理；
- UE上下文管理；
- UE移动性管理；
- NAS消息的传输；
- 寻呼；
- PDU 会话管理；
- 配置传输；
- 警告消息传输。

NG-C 的更多细节可以在 3GPP TS 38.410 [16] 中找到。

4.3.2 Xn Interface

4.3.2.1 Xn User Plane

The Xn User plane (Xn-U) interface is defined between two NG-RAN nodes. The user plane protocol stack on the Xn interface is shown in Figure 4.3.2.1-1. 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.

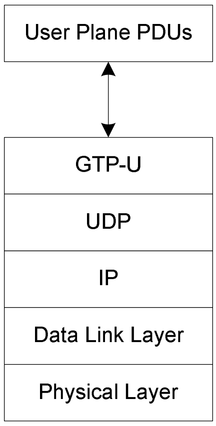


Figure 4.3.2.1-1: Xn-U Protocol Stack

Xn-U provides non-guaranteed delivery of user plane PDUs and supports the following functions:

- Data forwarding;
- Flow control.

Further details of Xn-U can be found in 3GPP TS 38.420 [17].

4.3.2.2 Xn Control Plane

The Xn control plane interface (Xn-C) is defined between two NG-RAN nodes. The control plane protocol stack of the Xn interface is shown on Figure 4.3.2.2-1. The transport network layer is built on SCTP on top of IP. The application layer signalling protocol is referred to as XnAP (Xn Application Protocol). 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.

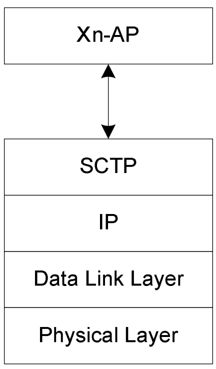


Figure 4.3.2.2-1: Xn-C Protocol Stack

The Xn-C interface supports the following functions:

- Xn interface management;
- UE mobility management, including context transfer and RAN paging:
- Dual connectivity.

4.3.2 Xn接口

4.3.2.1 Xn 用户平面

Xn 用户平面 (Xn-U) 接口在两个 NG-RAN 节点之间定义。 Xn接口的用户面协议栈如图4.3.2.1-1所示。传输网络层建立在IP传输之上，GTP-U在UDP/IP之上使用来承载用户平面PDU。

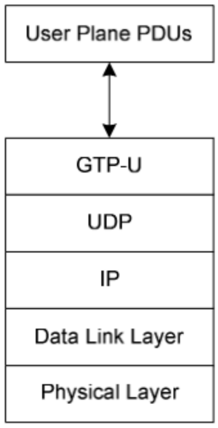


图 4.3.2.1-1：Xn-U 协议栈

Xn-U提供用户面PDU的无保证交付，并支持以下功能：

- 数据转发；
- 流量控制。

Xn-U 的更多细节可以在 3GPP TS 38.420 [17] 中找到。

4.3.2.2 Xn控制平面

Xn 控制平面接口 (Xn-C) 在两个 NG-RAN 节点之间定义。 Xn接口的控制面协议栈如图4.3.2.2-1所示。传输网络层建立在IP之上的SCTP之上。
应用层信令协议称为XnAP（Xn应用协议）。 SCTP 层提供应用层消息的有保证的传递。在传输中，IP 层使用点对点传输来传送信令 PDU。

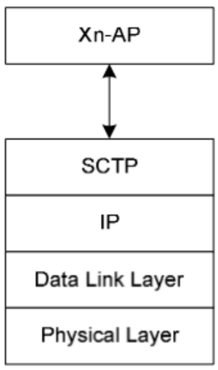


图 4.3.2.2-1：Xn-C 协议栈

Xn-C接口支持以下功能：

- Xn接口管理；
- UE移动性管理，包括上下文传输和RAN寻呼：
- 双连接。

Further details of Xn-C can be found in 3GPP TS 38.420 [17].

4.4 Radio Protocol Architecture

4.4.1 User Plane

The figure below shows the protocol stack for the user plane, where SDAP, PDCP, RLC and MAC sublayers (terminated in gNB on the network side) perform the functions listed in subclause 6.

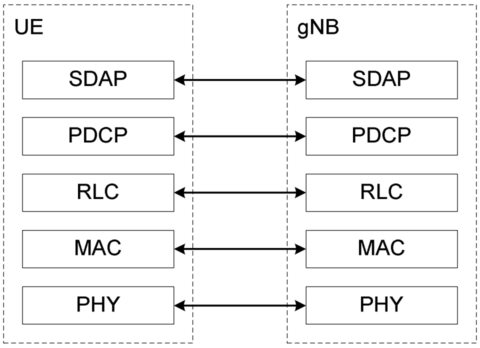


Figure 4.4.1-1: User Plane Protocol Stack

4.4.2 Control Plane

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

- PDCP, RLC and MAC sublayers (terminated in gNB on the network side) perform the functions listed in subclause 6;
- RRC (terminated in gNB on the network side) performs the functions listed in subclause 7;
- NAS control protocol (terminated in AMF on the network side) performs the functions listed in 3GPP TS 23.501 [3]), for instance: authentication, mobility management, security control…

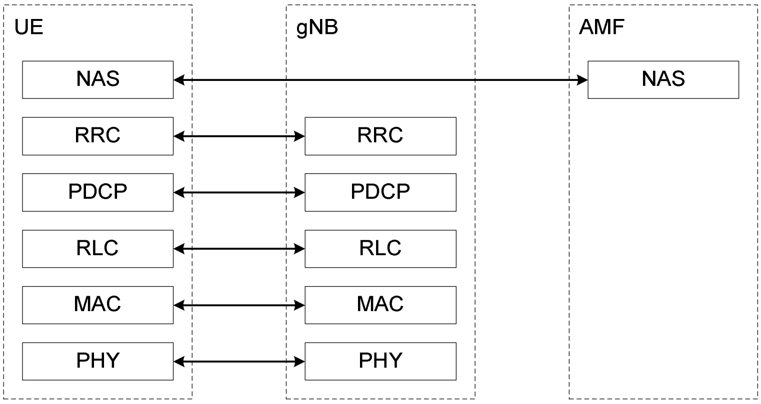


Figure 4.4.2-1: Control Plane Protocol Stack

4.5 Multi-RAT Dual Connectivity

NG-RAN supports Multi-RAT Dual Connectivity (MR-DC) operation whereby a UE in RRC_CONNECTED is configured to utilise radio resources provided by two distinct schedulers, located in two different NG-RAN nodes connected via a non-ideal backhaul and providing either E-UTRA (i.e. if the node is an ng-eNB) or NR access (i.e. if the node is a gNB). Further details of MR-DC operation can be found in 3GPP TS 37.340 [21].

Xn-C 的更多细节可以在 3GPP TS 38.420 [17] 中找到。

4.4 无线协议架构

4.4.1 用户平面

下图显示了用户平面的协议栈，其中SDAP、PDCP、RLC和MAC子层（终止于网络侧的gNB）执行子条款6中列出的功能。

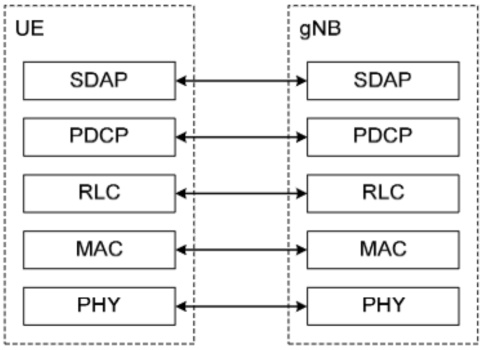


图 4.4.1-1：用户面协议栈

4.4.2 控制平面

下图展示了控制平面的协议栈，其中：

- PDCP、RLC和MAC子层（终止于网络侧的gNB）执行子条款6中列出的功能；
- RRC（终止于网络侧的gNB）执行子条款7中列出的功能；
- NAS控制协议（在网络侧终止于AMF）执行3GPP TS 23.501 [3]）中列出的功能，例如：身份验证、移动性管理、安全控制……

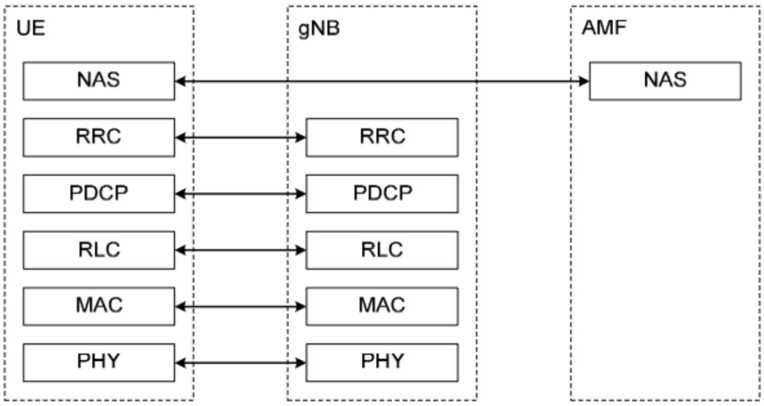


图 4.4.2-1：控制平面协议栈

4.5 多 RAT 双连接

NG-RAN 支持多 RAT 双连接 (MR-DC) 操作，其中 RRC_CONNECTED 中的 UE 配置为利用两个不同调度器提供的无线电资源，这两个调度器位于通过非理想回程连接的两个不同 NG-RAN 节点中，并提供E-UTRA（即如果节点是 ng-eNB）或 NR 接入（即如果节点是 gNB）。 MR-DC 操作的更多细节可以在 3GPP TS 37.340 [21] 中找到。

5 Physical Layer

5.1 Waveform, numerology and frame structure

The downlink transmission waveform is conventional OFDM using a cyclic prefix. The uplink transmission waveform is conventional OFDM using a cyclic prefix with a transform precoding function performing DFT spreading that can be disabled or enabled.

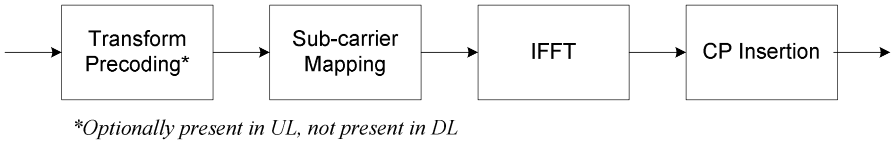


Figure 5.1-1: Transmitter block diagram for CP-OFDM with optional DFT-spreading

The numerology is based on exponentially scalable sub-carrier spacing $\Delta f = 2^{\mu} \times 15$ kHz with μ={0,1,3,4} for PSS, SSS and PBCH and μ={0,1,2,3} for other channels. Normal CP is supported for all sub-carrier spacings, Extended CP is supported for μ=2. 12 consecutive sub-carriers form a Physical Resource Block (PRB). Up to 275 PRBs are supported on a carrier.

Table 5.1-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15[\text{kHz}]$	Cyclic prefix	Supported for data	Supported for synch
0	15	Normal	Yes	Yes
1	30	Normal	Yes	Yes
2	60	Normal, Extended	Yes	No
3	120	Normal	Yes	Yes
4	240	Normal	No	Yes

The UE may be configured with one or more bandwidth parts on a given component carrier, of which only one can be active at a time, as described in subclauses 7.8 and 6.10 respectively. The active bandwidth part defines the UE's operating bandwidth within the cell's operating bandwidth. For initial access, and until the UE's configuration in a cell is received, initial bandwidth part detected from system information is used.

Downlink and uplink transmissions are organized into frames with 10 ms duration, consisting of ten 1 ms subframes. Each frame is divided into two equally-sized half-frames of five subframes each. The slot duration is 14 symbols with Normal CP and 12 symbols with Extended CP, and scales in time as a function of the used sub-carrier spacing so that there is always an integer number of slots in a subframe.

Timing Advance *TA* is used to adjust the uplink frame timing relative to the downlink frame timing.

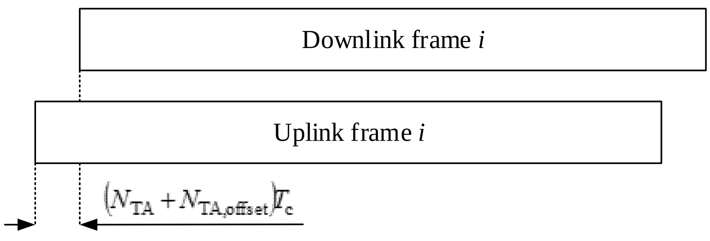


Figure 5.1-2: Uplink-downlink timing relation

Operation on both paired and unpaired spectrum is supported.

5 物理层

5.1 波形、数字和帧结构

下行链路传输波形是使用循环前缀的传统OFDM。上行链路传输波形是使用循环前缀的传统 OFDM，其具有执行可以禁用或启用的 DFT 扩展的变换预编码功能。

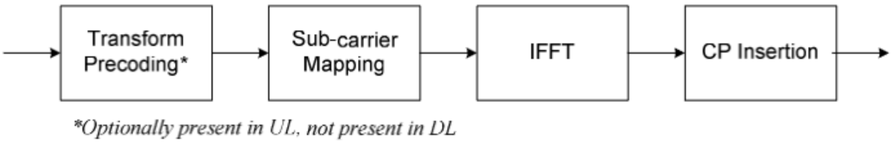


图 5.1-1：具有可选 DFT 扩展的 CP-OFDM 发射机框图

该参数集基于指数可扩展的子载波间隔Δf = 2× 15 kHz，其中 PSS、SSS 和 PBCH 的 μ={0,1,3,4}，其他信道的 μ={0,1,2,3}。所有子载波间隔均支持普通 CP， μ=2 时支持扩展 CP。 12个连续的子载波形成物理资源块(PRB)。
一个运营商最多支持275个PRB。

表 5.1-1：支持的传输参数。

μ	Δf = $2^{μ}$.15［千赫］	循环前缀	支持数据	支持同步
0	15	普通的	Yes	Yes
1	30	普通的	Yes	Yes
2	60	正常、扩展	Yes	No
3	120	普通的	Yes	Yes
4	240	普通的	No	Yes

UE可以在给定分量载波上配置有一个或多个带宽部分，其中一次只有一个可以是活动的，如分别在子条款7.8和6.10中所描述的。
活动带宽部分定义了小区工作带宽内UE的工作带宽。对于初始接入，并且直到接收到小区中的UE的配置为止，使用从系统信息检测到的初始带宽部分。

下行链路和上行链路传输被组织成持续时间为 10 ms 的帧，由 10 个 1 ms 子帧组成。每个帧被分成两个大小相等的半帧，每个半帧有五个子帧。
时隙持续时间对于正常 CP 为 14 个符号，对于扩展 CP 为 12 个符号，并且在时间上根据所使用的子载波间隔进行缩放，以便子帧中始终存在整数个时隙。

定时提前TA用于调整相对于下行链路帧定时的上行链路帧定时。

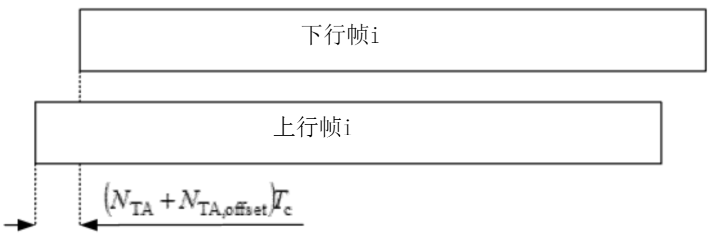


图5.1-2：上下行时序关系

支持在配对和不配对频谱上运行。

5.2 Downlink

5.2.1 Downlink transmission scheme

A closed loop Demodulation Reference Signal (DMRS) based spatial multiplexing is supported for Physical Downlink Shared Channel (PDSCH). Up to 8 and 12 orthogonal DL DMRS ports are supported for type 1 and type 2 DMRS respectively. Up to 8 orthogonal DL DMRS ports per UE are supported for SU-MIMO and up to 4 orthogonal DL DMRS ports per UE are supported for MU-MIMO. The number of SU-MIMO code words is one for 1-4 layer transmissions and two for 5-8 layer transmissions.

The DMRS and corresponding PDSCH are transmitted using the same precoding matrix and the UE does not need to know the precoding matrix to demodulate the transmission. The transmitter may use different precoder matrix for different parts of the transmission bandwidth, resulting in frequency selective precoding. The UE may also assume that the same precoding matrix is used across a set of Physical Resource Blocks (PRBs) denoted Precoding Resource Block Group (PRG).

Transmission durations from 2 to 14 symbols in a slot is supported.

Aggregation of multiple slots with Transport Block (TB) repetition is supported.

5.2.2 Physical-layer processing for physical downlink shared channel

The downlink physical-layer processing of transport channels consists of the following steps:

- Transport block CRC attachment;
- Code block segmentation and code block CRC attachment;
- Channel coding: LDPC coding;
- Physical-layer hybrid-ARQ processing;
- Rate matching;
- Scrambling;
- Modulation: QPSK, 16QAM, 64QAM and 256QAM;
- Layer mapping;
- Mapping to assigned resources and antenna ports.

The UE may assume that at least one symbol with demodulation reference signal is present on each layer in which PDSCH is transmitted to a UE, and up to 3 additional DMRS can be configured by higher layers.

Phase Tracking RS may be transmitted on additional symbols to aid receiver phase tracking.

The DL-SCH physical layer model is described in 3GPP TS 38.202 [20].

5.2.3 Physical downlink control channels

The Physical Downlink Control Channel (PDCCH) can be used to schedule DL transmissions on PDSCH and UL transmissions on PUSCH, where the Downlink Control Information (DCI) on PDCCH includes:

- Downlink assignments containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to DL-SCH;
- Uplink scheduling grants containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to UL-SCH.

In addition to scheduling, PDCCH can be used to for

- Activation and deactivation of configured PUSCH transmission with configured grant;
- Activation and deactivation of PDSCH semi-persistent transmission;

5.2 下行

5.2.1 下行传输方案

物理下行链路共享信道（PDSCH）支持基于闭环解调参考信号（DMRS）的空间复用。类型 1 和类型 2 DMRS 分别支持最多 8 个和 12 个正交 DL DMRS 端口。
SU-MIMO 支持每个 UE 最多 8 个正交 DL DMRS 端口，MU-MIMO 支持每个 UE 最多 4 个正交 DL DMRS 端口。 SU-MIMO码字的数量对于1-4层传输为1个，对于5-8层传输为2个。

DMRS和相应的PDSCH使用相同的预编码矩阵来发送，并且UE不需要知道预编码矩阵来解调传输。
发射机可以针对传输带宽的不同部分使用不同的预编码器矩阵，从而产生频率选择性预编码。
UE还可以假定在表示为预编码资源块组（PRG）的一组物理资源块（PRB）上使用相同的预编码矩阵。

支持一个时隙中 2 到 14 个符号的传输持续时间。

支持具有传输块 (TB) 重复的多个时隙的聚合。

5.2.2 物理下行共享信道的物理层处理

传输信道的下行物理层处理包括以下步骤：

- 传输块CRC附件；
- 码块分割和码块CRC附加；
- 信道编码：LDPC编码；
- 物理层混合ARQ处理；
- 费率匹配；
- 扰乱；
- 调制方式：QPSK、16QAM、64QAM、256QAM；
- 图层映射；
- 映射到分配的资源和天线端口。

UE可以假设具有解调参考信号的至少一个符号存在于向UE发送PDSCH的每一层上，并且高层可以配置多达3个附加DMRS。

相位跟踪RS可以在附加符号上发送以帮助接收器相位跟踪。

3GPP TS 38.202 [20] 中描述了 DL-SCH 物理层模型。

5.2.3 物理下行控制信道

物理下行控制信道（PDCCH）可用于调度PDSCH上的DL传输和PUSCH上的UL传输，其中PDCCH上的下行控制信息（DCI）包括：

- 下行链路分配至少包含与DL-SCH相关的调制和编码格式、资源分配和混合ARQ信息；

- 上行链路调度授权至少包含调制和编码格式、资源分配以及与UL-SCH相关的混合ARQ信息。

除了调度之外，PDCCH还可以用于

- 使用配置的授权激活和停用配置的 PUSCH 传输；
- PDSCH半持续传输的激活和去激活；

- Notifying one or more UEs of the slot format;
- Notifying one or more UEs of the PRB(s) and OFDM symbol(s) where the UE may assume no transmission is intended for the UE;
- Transmission of TPC commands for PUCCH and PUSCH;
- Transmission of one or more TPC commands for SRS transmissions by one or more UEs;
- Switching a UE's active bandwidth part;
- Initiating a random access procedure.

A UE monitors a set of PDCCH candidates in the configured monitoring occasions in one or more configured COntrol REsource SETs (CORESETs) according to the corresponding search space configurations.

A CORESET consists of a set of PRBs with a time duration of 1 to 3 OFDM symbols. The resource units Resource Element Groups (REGs) and Control Channel Elements (CCEs) are defined within a CORESET with each CCE consisting a set of REGs. Control channels are formed by aggregation of CCE. Different code rates for the control channels are realized by aggregating different number of CCE. Interleaved and non-interleaved CCE-to-REG mapping are supported in a CORESET.

Polar coding is used for PDCCH.

Each resource element group carrying PDCCH carries its own DMRS.

QPSK modulation is used for PDCCH.

5.2.4 Synchronization signal and PBCH

The Synchronization Signal and PBCH block (SSB) consists of primary and secondary synchronization signals (PSS, SSS), each occupying 1 symbol and 127 subcarriers, and PBCH spanning across 3 OFDM symbols and 240 subcarriers, but on one symbol leaving an unused part in the middle for SSS as show in figure 5.2.4-1. The periodicity of the SSB can be configured by the network and the time locations where SSB can be sent are determined by sub-carrier spacing.

Within the frequency span of a carrier, multiple SSBs can be transmitted. The PCIs of those SSBs do not have to be unique, i.e. different SSBs can have different PCIs. However, when an SSB is associated with an RMSI, the SSB corresponds to an individual cell, which has a unique NCGI (see subclause 8.2). Such an SSB is referred to as a Cell-Defining SSB (CD-SSB). A PCell is always associated to a CD-SSB located on the synchronization raster.

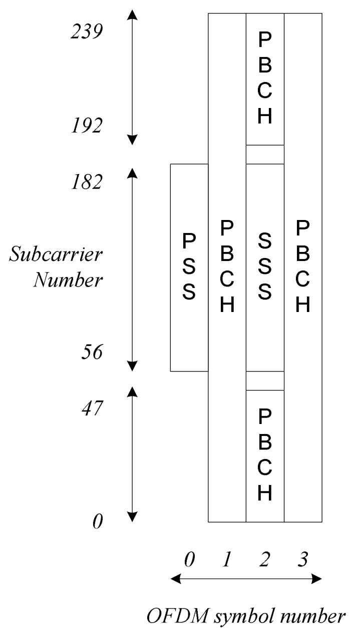


Figure 5.2.4-1: Time-frequency structure of SSB

- 向一个或多个UE通知时隙格式;
- 向一个或多个UE通知PRB和OFDM符号，其中UE可以假设没有传输打算给该UE;
- PUCCH和PUSCH的TPC命令的传输;
- 一个或多个UE传输用于SRS传输的一个或多个TPC命令;
- 切换UE的活动带宽部分;
- 启动随机接入过程。

UE根据相应的搜索空间配置，在一个或多个配置的控制资源集合(CORESET)中，在配置的监控时机中监控一组PDCCH候选。
CORESET 由一组持续时间为 1 到 3 个 OFDM 符号的 PRB 组成。资源单元资源元素组 (REG) 和控制信道元素 (CCE) 在 CORESET 内定义，每个 CCE 包含一组 REG。
控制信道由CCE聚合形成。通过聚合不同数量的CCE来实现控制信道的不同码率。 CORESET 支持交错和非交错 CCE 到 REG 映射。

极性编码用于PDCCH。

承载PDCCH的每个资源元素组承载其自己的DMRS。

PDCCH 使用 QPSK 调制。

5.2.4 同步信号和PBCH

同步信号和 PBCH 块 (SSB) 由主同步信号和辅同步信号 (PSS、SSS) 组成，每个同步信号占用 1 个符号和 127 个子载波，PBCH 跨越 3 个 OFDM 符号和 240 个子载波，但在一个符号上留下未使用的部分中间为SSS，如图5.2.4-1所示。 SSB的周期可以由网络配置，发送SSB的时间位置由子载波间隔决定。

在一个载波的频率范围内，可以传输多个SSB。这些 SSB 的 PCI 不必是唯一的，即不同的 SSB 可以具有不同的 PCI。
然而，当SSB与RMSI相关联时，SSB对应于具有唯一NCGI的单个小区（参见子条款8.2）。这样的SSB被称为单元定义SSB(CD-SSB)。 PCell 始终与位于同步光栅上的 CD-SSB 相关联。

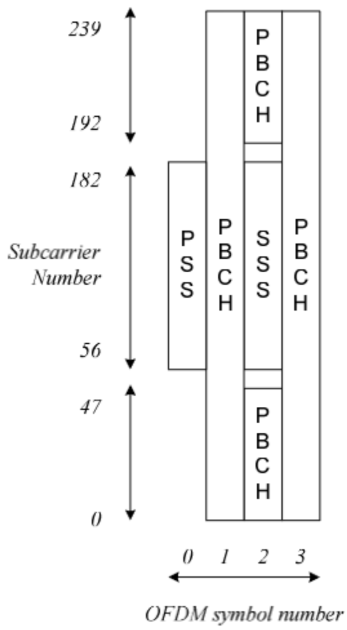


图5.2.4-1：单边带时频结构

Polar coding is used for PBCH.

The UE may assume a band-specific sub-carrier spacing for the SSB unless a network has configured the UE to assume a different sub-carrier spacing.

PBCH symbols carry its own frequency-multiplexed DMRS.

QPSK modulation is used for PBCH.

The PBCH physical layer model is described in 3GPP TS 38.202 [20].

5.2.5 Physical layer procedures

5.2.5.1 Link adaptation

Link adaptation (AMC: adaptive modulation and coding) with various modulation schemes and channel coding rates is applied to the PDSCH. The same coding and modulation is applied to all groups of resource blocks belonging to the same L2 PDU scheduled to one user within one TTI and within a MIMO codeword.

For channel state estimation purposes, the UE may be configured to measure CSI-RS and estimate the downlink channel state based on the CSI-RS measurements. The UE feeds the estimated channel state back to the gNB to be used in link adaptation.

5.2.5.2 Power Control

Downlink power control can be used.

5.2.5.3 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the Cell ID of that cell. NR cell search is based on the primary and secondary synchronization signals, and PBCH DMRS, located on the synchronization raster.

5.2.5.4 HARQ

Asynchronous Incremental Redundancy Hybrid ARQ is supported. The gNB provides the UE with the HARQ-ACK feedback timing either dynamically in the DCI or semi-statically in an RRC configuration.

The UE may be configured to receive code block group based transmissions where retransmissions may be scheduled to carry a sub-set of all the code blocks of a TB.

5.2.5.5 Reception of SIB1

MIB on PBCH provides the UE with parameters for monitoring of PDCCH for scheduling PDSCH that carries the SIB1. PBCH may also indicate that there is no associated SIB1, in which case the UE may be pointed to another frequency from where to search for an SSB that is associated with a SIB1 as well as a frequency range where the UE may assume no SSB associated with SIB1 is present. The indicated frequency range is confined within a contiguous spectrum allocation of the same operator in which SSB is detected.

5.3 Uplink

5.3.1 Uplink transmission scheme

Two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission.

For codebook based transmission, the gNB provides the UE with a transmit precoding matrix indication in the DCI. The UE uses the indication to select the PUSCH transmit precoder from the codebook. For non-codebook based transmission, the UE determines its PUSCH precoder based on wideband SRI field from the DCI.

A closed loop DMRS based spatial multiplexing is supported for PUSCH. For a given UE, up to 4 layer transmissions are supported. The number of code words is one. When transform precoding is used, only a single MIMO layer transmission is supported.

PBCH 使用极性编码。

UE可以假设用于SSB的频带特定子载波间隔，除非网络已将UE配置为假设不同的子载波间隔。

PBCH 符号携带其自己的频率复用 DMRS。

PBCH 使用 QPSK 调制。

3GPP TS 38.202 [20] 中描述了 PBCH 物理层模型。

5.2.5 物理层流程

5.2.5.1 链接适配

具有各种调制方案和信道编码率的链路自适应（AMC：自适应调制和编码）被应用于PDSCH。
相同的编码和调制应用于属于同一L2 PDU的所有资源块组，该L2 PDU被调度到一个TTI内和MIMO码字内的一个用户。

为了信道状态估计的目的，UE可以被配置为测量CSI-RS并且基于CSI-RS测量来估计下行链路信道状态。 UE将估计的信道状态反馈给gNB以用于链路自适应。

5.2.5.2 功率控制

可以使用下行链路功率控制。

5.2.5.3 小区搜索

小区搜索是 UE 获取与小区的时间和频率同步并检测该小区的小区 ID 的过程。 NR 小区搜索基于主同步信号和辅同步信号以及位于同步光栅上的 PBCH DMRS。

5.2.5.4 HARQ

支持异步增量冗余混合ARQ。 gNB 在 DCI 中动态地或在 RRC 配置中半静态地向 UE 提供 HARQ-ACK 反馈定时。

UE可以被配置为接收基于码块组的传输，其中可以调度重传以携带TB的所有码块的子集。

5.2.5.5 SIB1 的接收

PBCH上的MIB向UE提供用于监视PDCCH的参数，以用于调度承载SIB1的PDSCH。 PBCH还可以指示不存在关联的SIB1，在这种情况下，UE可以被指向从中搜索与SIB1关联的SSB的另一个频率以及UE可以假设没有与SIB1关联的SSB的频率范围。 SIB1 存在。
指示的频率范围被限制在检测到单边带的同一运营商的连续频谱分配内。

5.3 上行链路

5.3.1 上行传输方案

PUSCH支持两种传输方案：基于码本的传输和基于非码本的传输。

对于基于码本的传输，gNB 在 DCI 中向 UE 提供传输预编码矩阵指示。 UE使用该指示从码本中选择PUSCH发送预编码器。
对于基于非码本的传输，UE 基于来自 DCI 的宽带 SRI 字段确定其 PUSCH 预编码器。

PUSCH 支持基于闭环 DMRS 的空间复用。对于给定的 UE，最多支持 4 层传输。码字数为1。当使用变换预编码时，仅支持单MIMO层传输。

Transmission durations from 1 to 14 symbols in a slot is supported.

Aggregation of multiple slots with TB repetition is supported.

Two types of frequency hopping are supported, intra-slot frequency hopping, and in case of slot aggregation, inter-slot frequency hopping.

PUSCH may be scheduled with DCI on PDCCH, or a semi-static configured grant may be provided over RRC, where two types of operation are supported:

- The first PUSCH is triggered with a DCI, with subsequent PUSCH transmissions following the RRC configuration and scheduling received on the DCI, or
- The PUSCH is triggered by data arrival to the UE's transmit buffer and the PUSCH transmissions follow the RRC configuration.

5.3.2 Physical-layer processing for physical uplink shared channel

The uplink physical-layer processing of transport channels consists of the following steps:

- Transport Block CRC attachment;
- Code block segmentation and Code Block CRC attachment;
- Channel coding: LDPC coding;
- Physical-layer hybrid-ARQ processing;
- Rate matching;
- Scrambling;
- Modulation: π/2 BPSK (with transform precoding only), QPSK, 16QAM, 64QAM and 256QAM;
- Layer mapping, transform precoding (enabled/disabled by configuration), and pre-coding;
- Mapping to assigned resources and antenna ports.

The UE transmits at least one symbol with demodulation reference signal on each layer on each frequency hop in which the PUSCH is transmitted, and up to 3 additional DMRS can be configured by higher layers.

Phase Tracking RS may be transmitted on additional symbols to aid receiver phase tracking.

The UL-SCH physical layer model is described in 3GPP TS 38.202 [20].

5.3.3 Physical uplink control channel

Physical uplink control channel (PUCCH) carries the Uplink Control Information (UCI) from the UE to the gNB. Five formats of PUCCH exist, depending on the duration of PUCCH and the UCI payload size.

- Format #0: Short PUCCH of 1 or 2 symbols with small UCI payloads of up to two bits with UE multiplexing capacity of up to 6 UEs with 1-bit payload in the same PRB;
- Format #1: Long PUCCH of 4-14 symbols with small UCI payloads of up to two bits with UE multiplexing capacity of up to 84 UEs without frequency hopping and 36 UEs with frequency hopping in the same PRB;
- Format #2: Short PUCCH of 1 or 2 symbols with large UCI payloads of more than two bits with no UE multiplexing capability in the same PRBs;
- Format #3: Long PUCCH of 4-14 symbols with large UCI payloads with no UE multiplexing capability in the same PRBs;
- Format #4: Long PUCCH of 4-14 symbols with moderate UCI payloads with multiplexing capacity of up to 4 UEs in the same PRBs.

The short PUCCH format of up to two UCI bits is based on sequence selection, while the short PUCCH format of more than two UCI bits frequency multiplexes UCI and DMRS. The long PUCCH formats time-multiplex the UCI and

支持一个时隙中 1 到 14 个符号的传输持续时间。

支持 TB 重复的多个时隙聚合。

支持两种类型的跳频：时隙内跳频，以及时隙聚合情况下的时隙间跳频。

PUSCH 可以通过 PDCCH 上的 DCI 进行调度，或者可以通过 RRC 提供半静态配置的授权，其中支持两种类型的操作：

- 第一个 PUSCH 由 DCI 触发，后续 PUSCH 传输遵循在 DCI 上接收到的 RRC 配置和调度，或者

- PUSCH 由数据到达 UE 的发送缓冲区触发，并且 PUSCH 传输遵循 RRC 配置。

5.3.2 物理上行链路共享信道的物理层处理

传输信道的上行链路物理层处理包括以下步骤：

- 传输块 CRC 附件；
- 代码块分割和代码块CRC附加；
- 信道编码：LDPC编码；
- 物理层混合ARQ处理；
- 费率匹配；
- 扰乱；
- 调制：/2 BPSK（仅具有变换预编码）、QPSK、16QAM、64QAM 和 256QAM；
- 层映射、变换预编码（通过配置启用/禁用）和预编码；
- 映射到分配的资源和天线端口。

UE在发送PUSCH的每个跳频上的每一层上发送至少一个带有解调参考信号的符号，并且高层可以配置最多3个附加DMRS。

相位跟踪RS可以在附加符号上发送以帮助接收器相位跟踪。

UL-SCH 物理层模型在 3GPP TS 38.202 [20] 中描述。

5.3.3 物理上行控制信道

物理上行链路控制信道（PUCCH）承载从UE到gNB的上行链路控制信息（UCI）。 PUCCH 存在五种格式，具体取决于 PUCCH 的持续时间和 UCI 有效负载大小。

- 格式 #0：1 或 2 个符号的短 PUCCH，具有最多 2 位的小 UCI 有效负载，在同一 PRB 中具有最多 6 个具有 1 位有效负载的 UE 复用能力；
- 格式 #1：4-14 个符号的长 PUCCH，具有最多 2 位的小 UCI 有效负载，UE 复用容量在同一 PRB 中最多可容纳 84 个不带跳频的 UE 和 36 个带跳频的 UE；
- 格式#2：1或2个符号的短PUCCH，具有超过两个比特的大UCI有效负载，在相同的PRB中没有UE复用能力；
- 格式#3：4-14个符号的长PUCCH，具有大UCI有效负载，在相同PRB中没有UE复用能力；
- 格式#4：具有中等 UCI 有效负载的 4-14 个符号的长 PUCCH，在相同 PRB 中具有最多 4 个 UE 的复用容量。

最多两个UCI比特的短PUCCH格式基于序列选择，而超过两个UCI比特的短PUCCH格式频率复用UCI和DMRS。长 PUCCH 格式时分复用 UCI 和

DMRS. Frequency hopping is supported for long PUCCH formats and for short PUCCH formats of duration of 2 symbols. Long PUCCH formats can be repeated over multiple slots.

UCI multiplexing in PUSCH is supported when UCI and PUSCH transmissions coincide in time, either due to transmission of a UL-SCH transport block or due to triggering of A-CSI transmission without UL-SCH transport block:

- UCI carrying HARQ-ACK feedback with 1 or 2 bits is multiplexed by puncturing PUSCH;
- In all other cases UCI is multiplexed by rate matching PUSCH.

UCI consists of the following information:

- CSI;
- ACK/NAK;
- Scheduling request.

QPSK and π/2 BPSK modulation can be used for long PUCCH with more than 2 bits of information, QPSK is used for short PUCCH with more than 2 bits of information and BPSK and QPSK modulation can be used for long PUCCH with up to 2 information bits.

Transform precoding is applied to long PUCCH.

Channel coding used for uplink control information is described in table 5.3.3-1.

Table 5.3.3-1: Channel coding for uplink control information

Uplink Control Information size including CRC, if present	Channel code
1	Repetition code
2	Simplex code
3-11	Reed Muller code
>11	Polar code

5.3.4 Random access

Random access preamble sequences, of two different lengths are supported. Long sequence length 839 is applied with subcarrier spacings of 1.25 and 5 kHz and short sequence length 139 is applied with sub-carrier spacings 15, 30, 60 and 120 kHz. Long sequences support unrestricted sets and restricted sets of Type A and Type B, while short sequences support unrestricted sets only.

Multiple PRACH preamble formats are defined with one or more PRACH OFDM symbols, and different cyclic prefix and guard time. The PRACH preamble configuration to use is provided to the UE in the system information.

The UE calculates the PRACH transmit power for the retransmission of the preamble based on the most recent estimate pathloss and power ramping counter. If the UE conducts beam switching, the counter of power ramping remains unchanged.

The system information provides information for the UE to determine the association between the SSB and the RACH resources. The RSRP threshold for SSB selection for RACH resource association is configurable by network.

5.3.5 Physical layer procedures

5.3.5.1 Link adaptation

Four types of link adaptation are supported as follows:

- Adaptive transmission bandwidth;
- Adaptive transmission duration;
- Transmission power control;
- Adaptive modulation and channel coding rate.

DMRS。长 PUCCH 格式和持续时间为 2 个符号的短 PUCCH 格式支持跳频。长PUCCH格式可以在多个时隙上重复。

当 UCI 和 PUSCH 传输在时间上一致时（由于 UL-SCH 传输块的传输或由于在没有 UL-SCH 传输块的情况下触发 A-CSI 传输），支持 PUSCH 中的 UCI 复用：

- 通过打孔PUSCH复用承载1或2比特HARQ-ACK反馈的UCI；
- 在所有其他情况下，UCI 通过速率匹配 PUSCH 进行复用。

UCI 由以下信息组成：

- CSI；
- 确认/否认；
- 调度请求。

QPSK和/2 BPSK调制可用于具有超过2比特信息的长PUCCH，QPSK用于具有超过2比特信息的短PUCCH，BPSK和QPSK调制可用于具有最多2比特信息的长PUCCH 。

变换预编码应用于长PUCCH。

用于上行链路控制信息的信道编码如表5.3.3-1所示。

表5.3.3-1：上行控制信息的信道编码

上行链路控制信息大小，包括 CRC（如果存在）	频道代码
1	重复代码
2	单工码
3-11	里德穆勒码
>11	极地码

5.3.4 随机访问

支持两种不同长度的随机接入前导序列。长序列长度839与1.25和5kHz的子载波间隔一起应用，并且短序列长度139与15、30、60和120kHz的子载波间隔一起应用。
长序列支持A类和B类的非限制集和限制集，而短序列仅支持非限制集。

多种PRACH前导码格式由一个或多个PRACH OFDM符号以及不同的循环前缀和保护时间来定义。要使用的 PRACH 前导码配置在系统信息中提供给 UE。

UE基于最近估计的路径损耗和功率斜坡计数器来计算用于前导码重传的PRACH发射功率。如果UE进行波束切换，则功率斜坡计数器保持不变。

系统信息为UE提供确定SSB和RACH资源之间的关联的信息。用于RACH资源关联的SSB选择的RSRP阈值可由网络配置。

5.3.5 物理层流程

5.3.5.1 链接适配

支持四种类型的链路适配：

- 自适应传输带宽；
- 自适应传输时长；
- 发射功率控制；
- 自适应调制和信道编码率。

For channel state estimation purposes, the UE may be configured to transmit SRS that the gNB may use to estimate the uplink channel state and use the estimate in link adaptation.

5.3.5.2 Uplink Power control

The gNB determines the desired uplink transmit power and provides uplink transmit power control commands to the UE. The UE uses the provided uplink transmit power control commands to adjust its transmit power.

5.3.5.3 Uplink timing control

The gNB determines the desired Timing Advance setting and provides that to the UE. The UE uses the provided TA to determine its uplink transmit timing relative to the UE's observed downlink receive timing.

5.3.5.4 HARQ

Asynchronous Incremental Redundancy Hybrid ARQ is supported. The gNB schedules each uplink transmission and retransmission using the uplink grant on DCI.

The UE may be configured to transmit code block group based transmissions where retransmissions may be scheduled to carry a sub-set of all the code blocks of a transport block.

5.4 Carrier aggregation

5.4.1 Carrier aggregation

In Carrier Aggregation (CA), two or more Component Carriers (CCs) are aggregated. A UE may simultaneously receive or transmit on one or multiple CCs depending on its capabilities. CA is supported for both contiguous and non-contiguous CCs. When CA is deployed frame timing and SFN are aligned across cells that can be aggregated. The maximum number of configured CCs for a UE is 16 for DL and 16 for UL.

5.4.2 Supplementary Uplink

In conjunction with a UL/DL carrier pair (FDD band) or a bidirectional carrier (TDD band), a UE may be configured with additional, Supplementary Uplink (SUL). SUL differs from the aggregated uplink in that the UE may be scheduled to transmit either on the supplementary uplink or on the uplink of the carrier being supplemented, but not on both at the same time.

5.5 Transport Channels

The physical layer offers information transfer services to MAC and higher layers. The physical layer transport services are described by *how* and with what characteristics data are transferred over the radio interface. An adequate term for this is "Transport Channel". This should be clearly separated from the classification of *what* is transported, which relates to the concept of logical channels at MAC sublayer.

Downlink transport channel types are:

1. **Broadcast Channel (BCH)** characterised by:
   - fixed, pre-defined transport format;
   - requirement to be broadcast in the entire coverage area of the cell, either as a single message or by beamforming different BCH instances.
2. **Downlink Shared Channel (DL-SCH)** characterised by:
   - support for HARQ;
   - support for dynamic link adaptation by varying the modulation, coding and transmit power;
   - possibility to be broadcast in the entire cell;
   - possibility to use beamforming;
   - support for both dynamic and semi-static resource allocation;

出于信道状态估计的目的，UE可以被配置为发送gNB可以用来估计上行链路信道状态的SRS并且在链路自适应中使用该估计。

5.3.5.2 上行功率控制

gNB确定所需的上行链路发射功率并向UE提供上行链路发射功率控制命令。 UE使用所提供的上行链路发射功率控制命令来调整其发射功率。

5.3.5.3 上行时序控制

gNB 确定所需的定时提前设置并将其提供给 UE。 UE使用所提供的TA来确定其相对于UE观察到的下行链路接收定时的上行链路发送定时。

5.3.5.4 HARQ

支持异步增量冗余混合ARQ。 gNB 使用 DCI 上的上行链路授权来调度每个上行链路传输和重传。

UE可以被配置为传送基于码块组的传输，其中可以调度重传以携带传输块的所有码块的子集。

5.4 载波聚合

5.4.1 载波聚合

在载波聚合（CA）中，两个或多个分量载波（CC）被聚合。 UE可以根据其能力在一个或多个CC上同时接收或发送。连续和非连续 CC 均支持 CA。
当部署 CA 时，帧定时和 SFN 在可聚合的小区之间对齐。为 UE 配置的 CC 的最大数量对于 DL 是 16，对于 UL 是 16。

5.4.2 补充上行链路

结合UL/DL载波对（FDD频带）或双向载波（TDD频带），UE可以配置有附加的补充上行链路（SUL）。
SUL 与聚合上行链路的不同之处在于，UE 可以被调度在补充上行链路或正在补充的载波的上行链路上进行传输，但不能同时在两者上进行传输。

5.5 运输渠道

物理层向MAC层和更高层提供信息传输服务。物理层传输服务通过数据通过无线电接口传输的方式和特征来描述。对此的适当术语是“传输通道”。
这应该与传输内容的分类清楚地分开，后者涉及 MAC 子层逻辑信道的概念。

下行传输信道类型有：

1. 广播信道 (BCH) 的特点是:
   - 固定的、预定义的传输格式;
   - 要求在小区的整个覆盖区域中广播，无论是作为单个消息还是通过波束成形不同的 BCH 实例。

2. 下行链路共享信道 (DL-SCH) 的特点是:
   - 支持HARQ;
   - 通过改变调制、编码和发射功率来支持动态链路自适应;
   - 可以在整个小区内广播;
   - 使用波束成形的可能性;
   - 支持动态和半静态资源分配;

  - support for UE discontinuous reception (DRX) to enable UE power saving;

3. **Paging Channel (PCH)** characterised by:
   - support for UE discontinuous reception (DRX) to enable UE power saving (DRX cycle is indicated by the network to the UE);
   - requirement to be broadcast in the entire coverage area of the cell, either as a single message or by beamforming different BCH instances;
   - mapped to physical resources which can be used dynamically also for traffic/other control channels.

Uplink transport channel types are:

1. **Uplink Shared Channel (UL-SCH)** characterised by:
   - possibility to use beamforming;
   - support for dynamic link adaptation by varying the transmit power and potentially modulation and coding;
   - support for HARQ;
   - support for both dynamic and semi-static resource allocation.
2. **Random Access Channel(s) (RACH)** characterised by:
   - limited control information;
   - collision risk.

Association of transport channels to physical channels is described in 3GPP TS 38.202 [20].

6 Layer 2

6.1 Overview

The layer 2 of NR is split into the following sublayers: Medium Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP) and Service Data Adaptation Protocol (SDAP). The two figures below depict the Layer 2 architecture for downlink and uplink, where:

- The physical layer offers to the MAC sublayer transport channels;
- The MAC sublayer offers to the RLC sublayer logical channels;
- The RLC sublayer offers to the PDCP sublayer RLC channels;
- The PDCP sublayer offers to the SDAP sublayer radio bearers;
- The SDAP sublayer offers to 5GC QoS flows;
- *Comp.* refers to header compression and *segm.* to segmentation;
- Control channels (BCCH, PCCH are not depicted for clarity).

NOTE: The gNB may not be able to guarantee that a L2 buffer overflow will never occur. If such overflow occurs, the UE may discard packets in the L2 buffer.

- 支持UE非连续接收（DRX）以实现UE省电；

3. 寻呼信道 (PCH) 的特点是：

- 支持UE非连续接收（DRX）以实现UE省电（DRX周期由网络向UE指示）；
- 要求在小区的整个覆盖区域中广播，无论是作为单个消息还是通过波束成形不同的 BCH 实例；
- 映射到也可以动态地用于业务/其他控制信道的物理资源。

上行链路传输信道类型有：

1. 上行链路共享信道 (UL-SCH) 的特点是：
   - 使用波束成形的可能性；
   - 通过改变发射功率和潜在的调制和编码来支持动态链路自适应；
   - 支持HARQ；
   - 支持动态和半静态资源分配。
2. 随机接入信道 (RACH) 的特点是：
   - 有限的控制信息；
   - 碰撞风险。

3GPP TS 38.202 [20] 中描述了传输信道与物理信道的关联。

6 第2层

6.1 概述

NR 第 2 层分为以下子层：媒体访问控制 (MAC)、无线链路控制 (RLC)、分组数据汇聚协议 (PDCP) 和服务数据适配协议 (SDAP)。
下面两图描述了下行链路和上行链路的第 2 层架构，其中：

- 物理层向MAC子层提供传输通道；
- MAC子层向RLC子层提供逻辑信道；
- RLC子层向PDCP子层提供RLC信道；
- PDCP子层向SDAP子层提供无线承载；
- SDAP子层向5GC提供QoS流；
- 比较。指的是头压缩和segm。进行细分；
- 控制信道（为了清楚起见，未描绘BCCH、PCCH）。

笔记： gNB 可能无法保证 L2 缓冲区溢出永远不会发生。如果发生这种溢出，UE可以丢弃L2缓冲器中的分组。

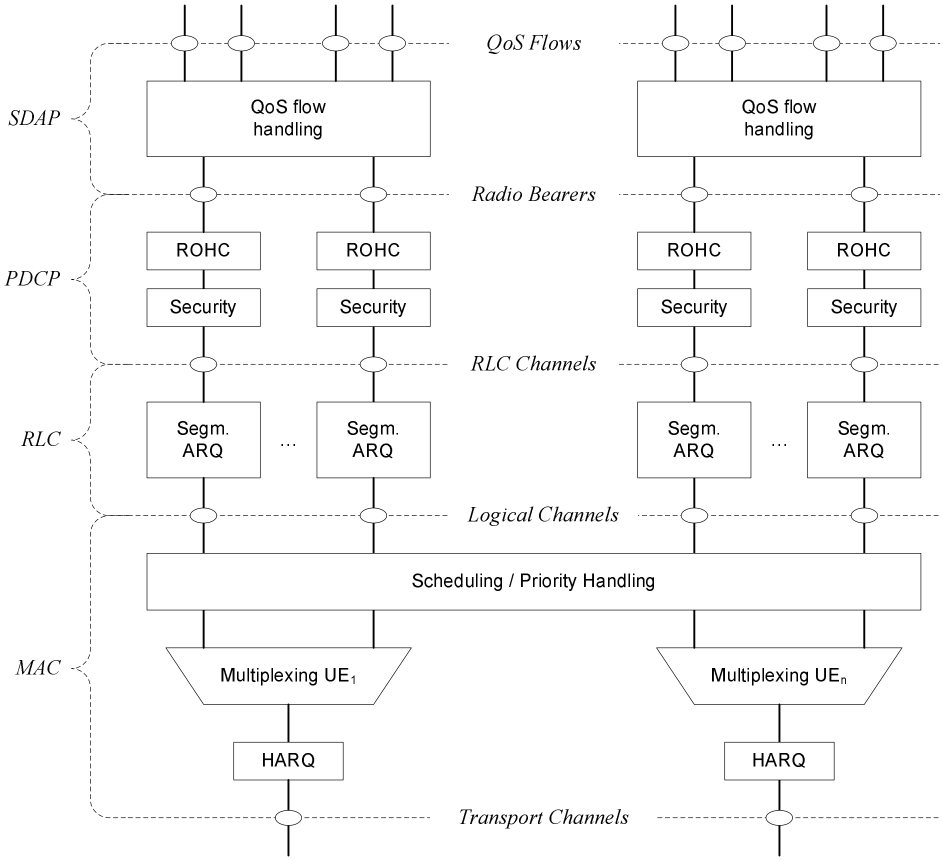


Figure 6.1-1: Downlink Layer 2 Structure

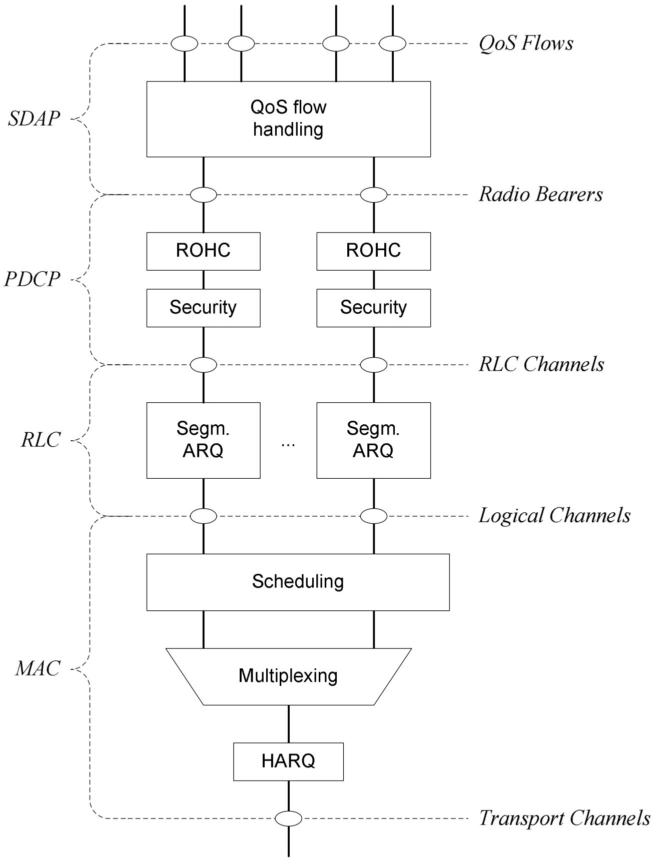


Figure 6.1-2: Uplink Layer 2 Structure

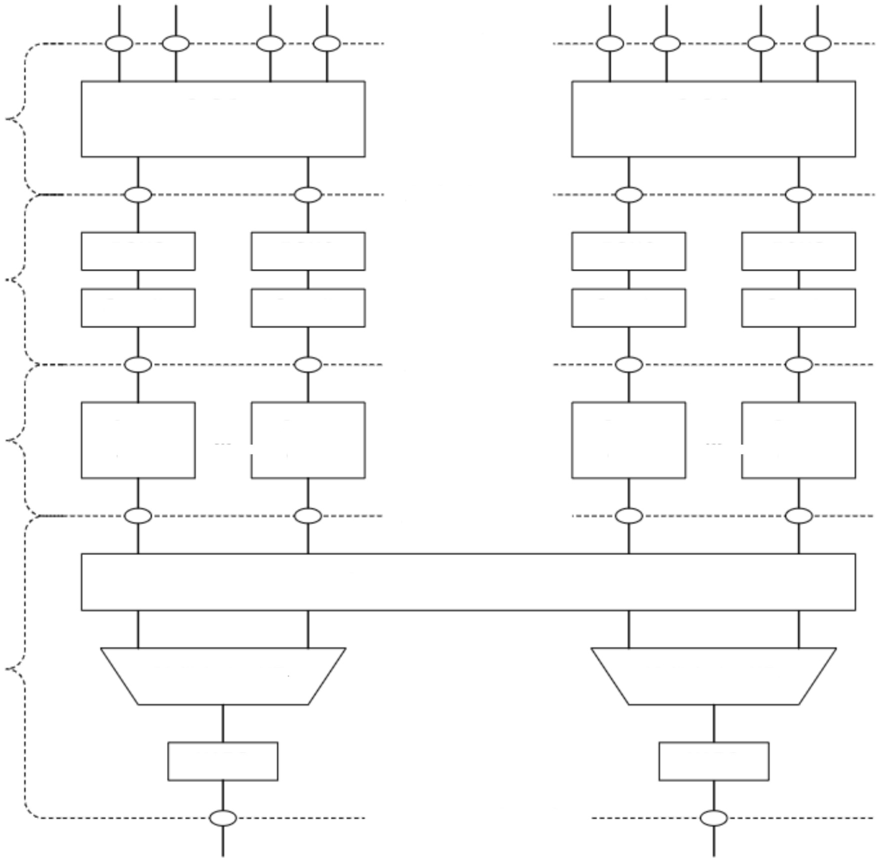


图 6.1-1：下行二层结构

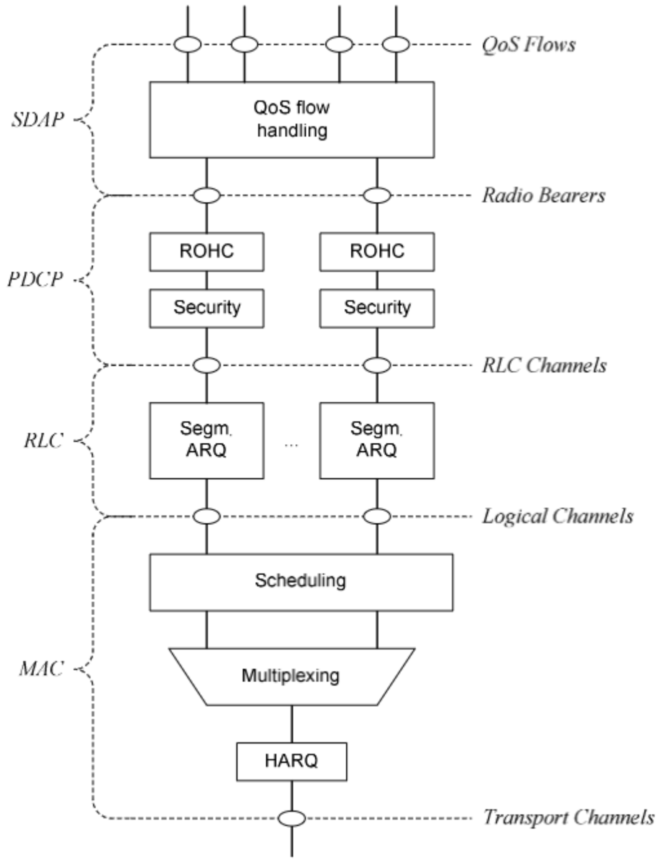


图 6.1-2：上行链路二层结构

Radio bearers are categorized into two groups: data radio bearers (DRB) for user plane data and signalling radio bearers (SRB) for control plane data.

6.2 MAC Sublayer

6.2.1 Services and Functions

The main services and functions of the MAC sublayer include:

- Mapping between logical channels and transport channels;
- Multiplexing/demultiplexing of MAC SDUs belonging to one or different logical channels into/from transport blocks (TB) delivered to/from the physical layer on transport channels;
- Scheduling information reporting;
- Error correction through HARQ (one HARQ entity per cell in case of CA);
- Priority handling between UEs by means of dynamic scheduling;
- Priority handling between logical channels of one UE by means of logical channel prioritisation;
- Padding.

A single MAC entity can support multiple numerologies, transmission timings and cells. Mapping restrictions in logical channel prioritisation control which numerology(ies), cell(s), and transmission timing(s) a logical channel can use (see subclause 16.1.2).

6.2.2 Logical Channels

Different kinds of data transfer services as offered by MAC. Each logical channel type is defined by what type of information is transferred. Logical channels are classified into two groups: Control Channels and Traffic Channels. Control channels are used for the transfer of control plane information only:

- Broadcast Control Channel (BCCH): a downlink channel for broadcasting system control information.
- Paging Control Channel (PCCH): a downlink channel that transfers paging information, system information change notifications and indications of ongoing PWS broadcasts.
- Common Control Channel (CCCH): channel for transmitting control information between UEs and network. This channel is used for UEs having no RRC connection with the network.
- Dedicated Control Channel (DCCH): a point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. Used by UEs having an RRC connection.

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

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

6.2.3 Mapping to Transport Channels

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

- BCCH can be mapped to BCH;
- BCCH can be mapped to DL-SCH;
- PCCH can be mapped to PCH;
- CCCH can be mapped to DL-SCH;
- DCCH can be mapped to DL-SCH;
- DTCH can be mapped to DL-SCH.

无线承载分为两组：用于用户平面数据的数据无线承载（DRB）和用于控制平面数据的信令无线承载（SRB）。

6.2 MAC子层

6.2.1 服务与功能

MAC子层的主要服务和功能包括：

- 逻辑信道和传输信道之间的映射；
- 将属于一个或不同逻辑信道的 MAC SDU 复用/解复用到传输信道上传送到物理层的传输块 (TB) 或从传输块 (TB) 中解复用；
- 调度信息上报；
- 通过 HARQ 纠错（在 CA 情况下每个小区一个 HARQ 实体）；
- UE之间通过动态调度进行优先级处理；
- 通过逻辑信道优先级来处理一个UE的逻辑信道之间的优先级；
- 填充。

单个 MAC 实体可以支持多个数字、传输定时和单元。逻辑信道优先级中的映射限制控制逻辑信道可以使用哪些数字、单元和传输定时（参见子条款16.1.2）。

6.2.2 逻辑通道

MAC 提供的不同类型的数据传输服务。每个逻辑信道类型由传输的信息类型来定义。逻辑信道分为两组：控制信道和业务信道。
控制通道仅用于传输控制平面信息：

- 广播控制信道(BCCH)：用于广播系统控制信息的下行信道。
- 寻呼控制信道 (PCCH)：传输寻呼信息、系统信息更改通知和正在进行的 PWS 广播指示的下行链路信道。
- 公共控制信道(CCCH)：用于在UE和网络之间传输控制信息的信道。
该信道用于与网络没有RRC连接的UE。
- 专用控制信道(DCCH)：在UE和网络之间传输专用控制信息的点对点双向信道。由具有 RRC 连接的 UE 使用。

业务信道仅用于传输用户平面信息：

- 专用业务信道（DTCH）：点对点信道，专用于一个UE，用于传输用户信息。 DTCH可以存在于上行链路和下行链路中。

6.2.3 映射到传输通道

在下行链路中，逻辑信道和传输信道之间存在以下连接：

- BCCH可以映射到BCH；
- BCCH可以映射到DL-SCH；
- PCCH可以映射到PCH；
- CCCH可以映射到DL-SCH；
- DCCH可以映射到DL-SCH；
- DTCH可以映射到DL-SCH。

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

- CCCH can be mapped to UL-SCH;
- DCCH can be mapped to UL- SCH;
- DTCH can be mapped to UL-SCH.

6.2.4 HARQ

The HARQ functionality ensures delivery between peer entities at Layer 1. A single HARQ process supports one TB when the physical layer is not configured for downlink/uplink spatial multiplexing, and when the physical layer is configured for downlink/uplink spatial multiplexing, a single HARQ process supports one or multiple TBs.

6.3 RLC Sublayer

6.3.1 Transmission Modes

The RLC sublayer supports three transmission modes:

- Transparent Mode (TM);
- Unacknowledged Mode (UM);
- Acknowledged Mode (AM).

The RLC configuration is per logical channel with no dependency on numerologies and/or transmission durations, and ARQ can operate on any of the numerologies and/or transmission durations the logical channel is configured with.

For SRB0, paging and broadcast system information, TM mode is used. For other SRBs AM mode used. For DRBs, either UM or AM mode are used.

6.3.2 Services and Functions

The main services and functions of the RLC sublayer depend on the transmission mode and include:

- Transfer of upper layer PDUs;
- Sequence numbering independent of the one in PDCP (UM and AM);
- Error Correction through ARQ (AM only);
- Segmentation (AM and UM) and re-segmentation (AM only) of RLC SDUs;
- Reassembly of SDU (AM and UM);
- Duplicate Detection (AM only);
- RLC SDU discard (AM and UM);
- RLC re-establishment;
- Protocol error detection (AM only).

6.3.3 ARQ

The ARQ within the RLC sublayer has the following characteristics:

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

在上行链路中，逻辑信道和传输信道之间存在以下连接：

- CCCH可以映射到UL-SCH；
- DCCH可以映射到UL-SCH；
- DTCH可以映射到UL-SCH。

6.2.4 HARQ

HARQ 功能确保第 1 层对等实体之间的传送。当物理层未配置为下行链路/上行链路空间复用时，单个 HARQ 进程支持 1 TB；而当物理层配置为下行链路/上行链路空间复用时，单个 HARQ 进程支持 1 TB。进程支持一个或多个 TB。

6.3 RLC子层

6.3.1 传输方式

RLC子层支持三种传输模式：

- 透明模式（TM）；
- 未确认模式（UM）；
- 确认模式 (AM)。

RLC 配置是针对每个逻辑信道的，不依赖于数字学和/或传输持续时间，并且 ARQ 可以对逻辑信道配置的任何数字学和/或传输持续时间进行操作。

对于SRB0、寻呼和广播系统信息，使用TM模式。对于其他 SRB，使用 AM 模式。对于 DRB，使用 UM 或 AM 模式。

6.3.2 服务与功能

RLC子层的主要服务和功能取决于传输模式，包括：

- 上层PDU的传输；
- 序列编号独立于 PDCP 中的编号（UM 和 AM）；
- 通过 ARQ 纠错（仅限 AM）；
- RLC SDU 的分段（AM 和 UM）和重新分段（仅 AM）；
- SDU（AM 和 UM）的重新组装；
- 重复检测（仅限 AM）；
- RLC SDU 丢弃（AM 和 UM）；
- RLC重建；
- 协议错误检测（仅限 AM）。

6.3.3 ARQ

RLC子层内的ARQ具有以下特征：

- ARQ根据RLC状态报告重传RLC SDU或RLC SDU段；
- RLC需要时使用轮询RLC状态报告；
- RLC接收器还可以在检测到丢失的RLC SDU或RLC SDU段之后触发RLC状态报告。

6.4 PDCP Sublayer

6.4.1 Services and Functions

The main services and functions of the PDCP sublayer for the user plane include:

- Sequence Numbering;
- Header compression and decompression: ROHC only;
- Transfer of user data;
- Reordering and duplicate detection;
- in-order delivery;
- PDCP PDU routing (in case of split bearers);
- Retransmission of PDCP SDUs;
- Ciphering, deciphering and integrity protection;
- PDCP SDU discard;
- PDCP re-establishment and data recovery for RLC AM;
- PDCP status reporting for RLC AM;
- Duplication of PDCP PDUs (see subclause 16.1.3) and duplicate discard indication to lower layers.

The main services and functions of the PDCP sublayer for the control plane include:

- Sequence Numbering;
- Ciphering, deciphering and integrity protection;
- Transfer of control plane data;
- Reordering and duplicate detection;
- in-order delivery;
- Duplication of PDCP PDUs (see subclause 16.1.3) and duplicate discard indication to lower layers.

Since PDCP does not allow COUNT to wrap around in DL and UL, it is up to the network to prevent it from happening (e.g. by using a release and add of the corresponding radio bearer or a full configuration).

6.5 SDAP Sublayer

The main services and functions of SDAP include:

- Mapping between a QoS flow and a data radio bearer;
- Marking QoS flow ID (QFI) in both DL and UL packets.

A single protocol entity of SDAP is configured for each individual PDU session.

6.6 L2 Data Flow

An example of the Layer 2 Data Flow is depicted on Figure 6.6-1, where a transport block is generated by MAC by concatenating two RLC PDUs from RB_x and one RLC PDU from RB_y. The two RLC PDUs from RB_x each corresponds to one IP packet (*n* and *n+1*) while the RLC PDU from RB_y is a segment of an IP packet (*m*).

NOTE: H depicts the headers and subheaders.

6.4 PDCP子层

6.4.1 服务与功能

PDCP子层为用户面提供的主要服务和功能包括：

- 序列编号；
- 标头压缩和解压缩：仅限 ROHC；
- 用户数据的传输；
- 重新排序和重复检测；
- 按顺序交货；
- PDCP PDU 路由（在分离承载的情况下）；
- PDCP SDU 的重传；
- 加密、解密和完整性保护；
- PDCP SDU 丢弃；
- RLC AM的PDCP重建和数据恢复；
- RLC AM 的 PDCP 状态报告；
- PDCP PDU 的重复（参见子条款 16.1.3）以及对较低层的重复丢弃指示。

PDCP子层为控制平面提供的主要服务和功能包括：

- 序列编号；
- 加密、解密和完整性保护；
- 控制平面数据传输；
- 重新排序和重复检测；
- 按顺序交货；
- PDCP PDU 的重复（参见子条款 16.1.3）以及对较低层的重复丢弃指示。

由于 PDCP 不允许 COUNT 在 DL 和 UL 中回绕，因此需要由网络来防止其发生（例如，通过释放并添加相应的无线承载或完整配置）。

6.5 SDAP子层

SDAP的主要服务和功能包括：

- QoS流和数据无线承载之间的映射；
- 在 DL 和 UL 数据包中标记 QoS 流 ID (QFI)。

SDAP 的单个协议实体是为每个单独的 PDU 会话配置的。

6.6 L2数据流

图 6.6-1 描述了第 2 层数据流的示例，其中传输块是由 MAC 通过连接来自 RB 的两个 RLC PDU 和来自 RB 的一个 RLC PDU 生成的。
来自RBeach的两个RLC PDU对应于一个IP分组（n和n+1），而来自RB的RLC PDU是IP分组（m）的一段。

笔记： H 描述标题和子标题。

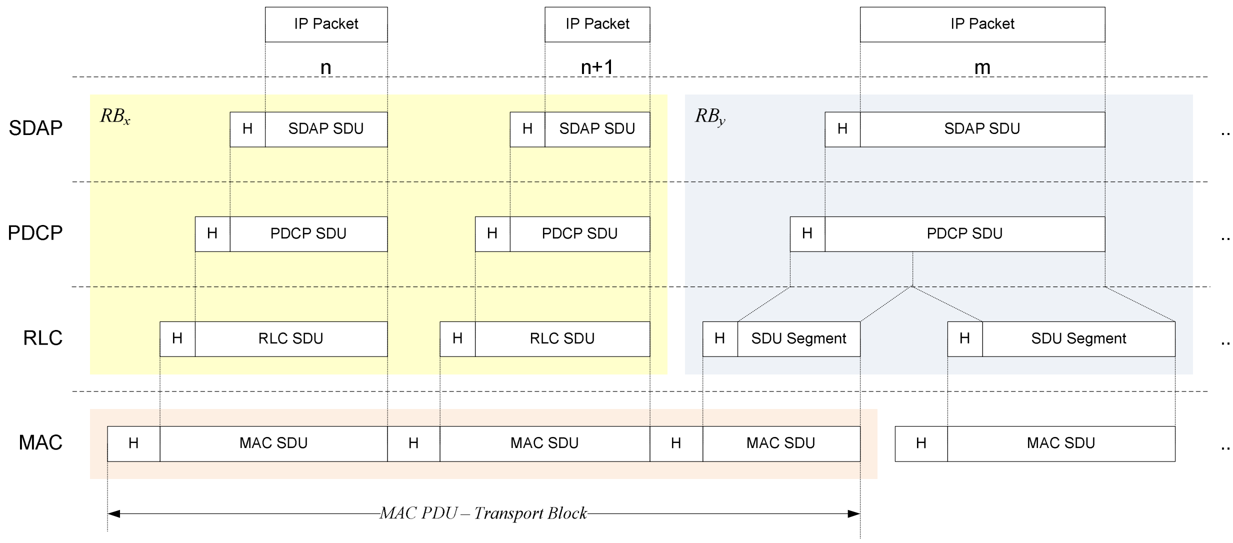


Figure 6.6-1: Data Flow Example

6.7 Carrier Aggregation

In case of CA, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per serving cell as depicted on Figures 6.7-1 and 6.7-2 below:

- In both uplink and downlink, there is one independent hybrid-ARQ entity per serving cell and one transport block is generated per assignment/grant per serving cell in the absence of spatial multiplexing. Each transport block and its potential HARQ retransmissions are mapped to a single serving cell.

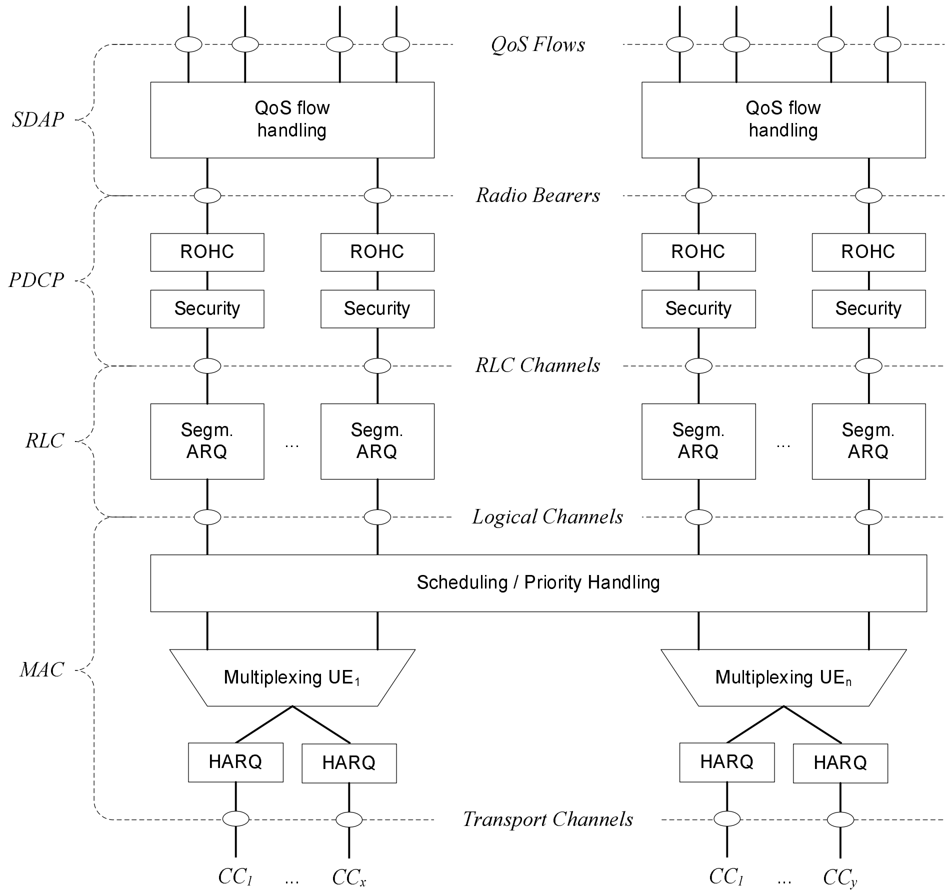


Figure 6.7-1: Layer 2 Structure for DL with CA configured

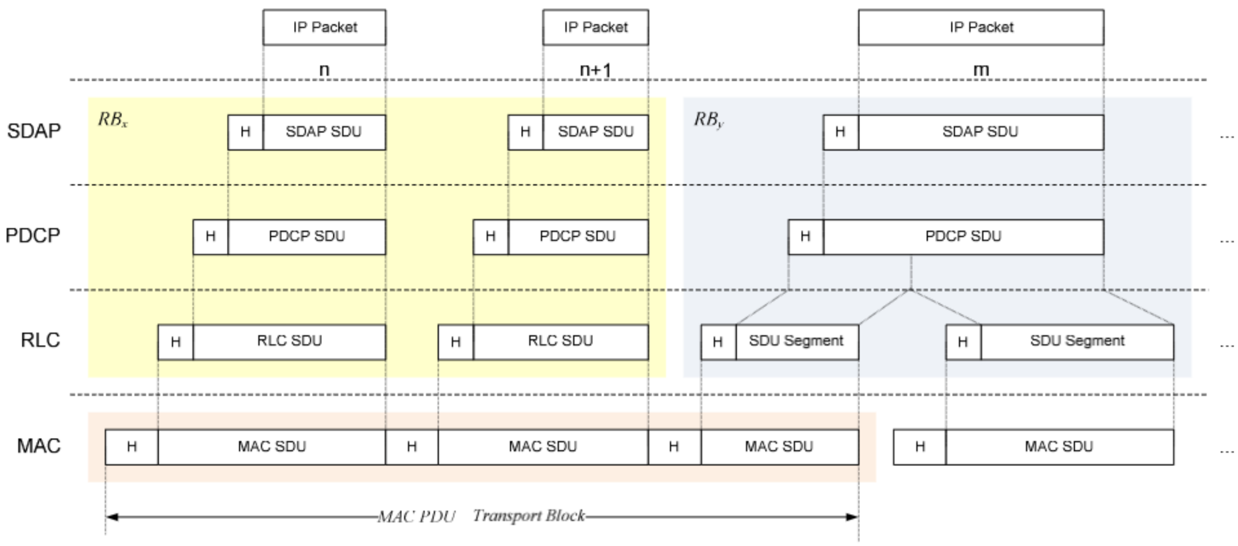


图 6.6-1：数据流示例

6.7 载波聚合

在 CA 的情况下，物理层的多载波特性仅暴露给 MAC 层，每个服务小区需要一个 HARQ 实体，如下图 6.7-1 和 6.7-2 所示：

- 在上行链路和下行链路中，每个服务小区都有一个独立的混合ARQ实体，并且在没有空间复用的情况下，每个服务小区的每个分配/授权生成一个传输块。
  每个传输块及其潜在的 HARQ 重传都被映射到单个服务小区。

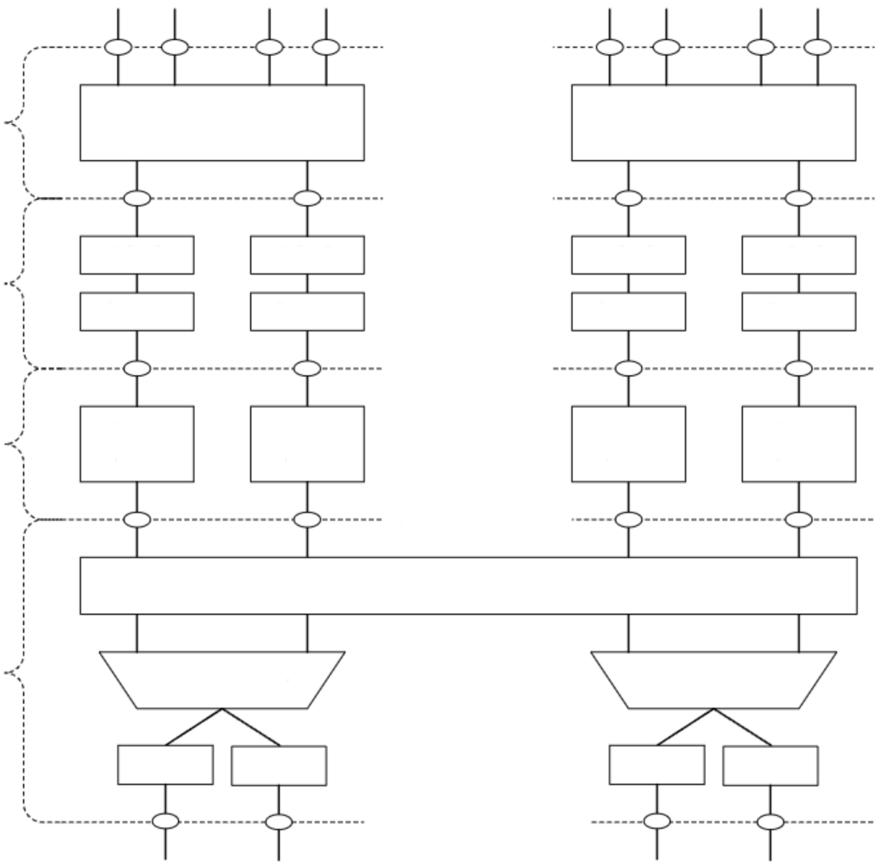


图 6.7-1：配置了 CA 的 DL 的第 2 层结构

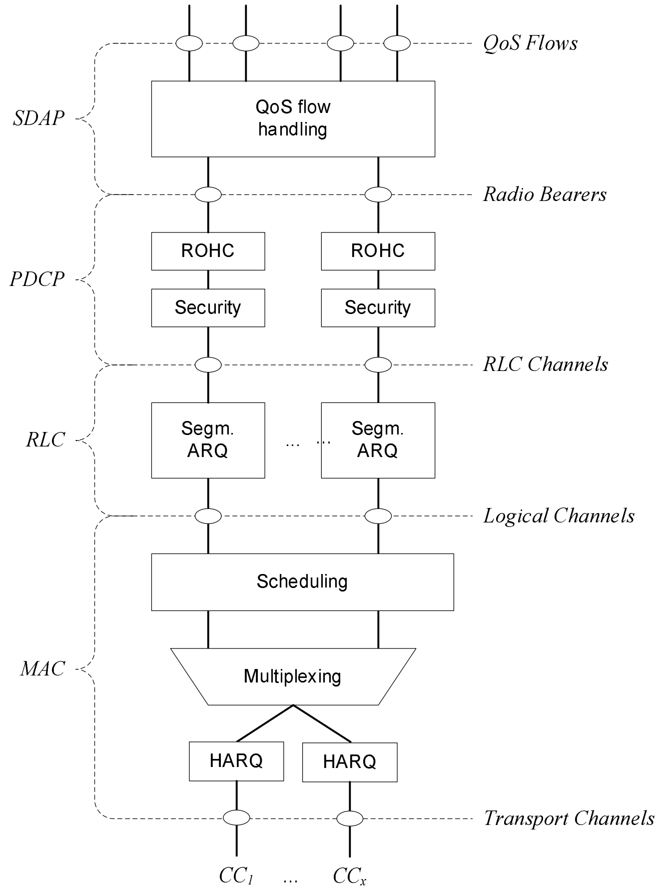


Figure 6.7-2: Layer 2 Structure for UL with CA configured

6.8 Dual Connectivity

When the UE is configured with SCG, the UE is configured with two MAC entities: one MAC entity for the MCG and one MAC entity for the SCG. Further details of DC operation can be found in 3GPP TS 37.340 [21].

6.9 Supplementary Uplink

In case of Supplementary Uplink (SUL, see 3GPP TS 38.101 [18]), the UE is configured with 2 ULs for one DL of the same cell, and uplink transmissions on those two ULs are controlled by the network to avoid overlapping PUSCH/PUCCH transmissions in time. Overlapping transmissions on PUSCH are avoided through scheduling while overlapping transmissions on PUCCH are avoided through configuration (PUCCH can only be configured for only one of the 2 ULs of the cell). In addition, initial access is supported in each of the uplink (see subclause 9.2.6). An example of SUL is given in Annex B.

6.10 Bandwidth Adaptation

With Bandwidth Adaptation (BA), the receive and transmit bandwidth of a UE need not be as large as the bandwidth of the cell and can be adjusted: the width can be ordered to change (e.g. to shrink during period of low activity to save power); the location can move in the frequency domain (e.g. to increase scheduling flexibility); and the subcarrier spacing can be ordered to change (e.g. to allow different services). A subset of the total cell bandwidth of a cell is referred to as a Bandwidth Part (BWP) and BA is achieved by configuring the UE with BWP(s) and telling the UE which of the configured BWPs is currently the active one.

Figure 6.10-1 below describes a scenario where 3 different BWPs are configured:

- BWP_1 with a width of 40 MHz and subcarrier spacing of 15 kHz;
- BWP_2 with a width of 10 MHz and subcarrier spacing of 15 kHz;
- BWP_3 with a width of 20 MHz and subcarrier spacing of 60 kHz.

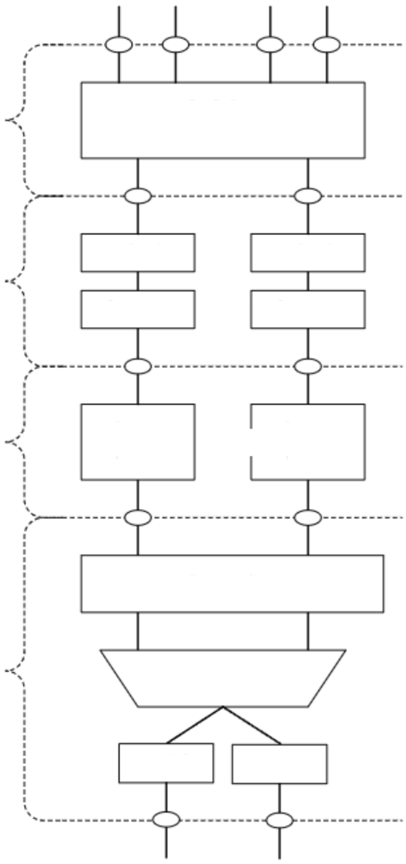


图 6.7-2：配置了 CA 的 UL 第 2 层结构

6.8 双连接

当UE配置SCG时，UE配置2个MAC实体：1个用于MCG的MAC实体，1个用于SCG的MAC实体。 DC 操作的更多细节可以在 3GPP TS 37.340 [21] 中找到。

6.9 补充上行链路

在补充上行链路（SUL，参见 3GPP TS 38.101 [18]）的情况下，UE 为同一小区的一个 DL 配置 2 个 UL，并且这两个 UL 上的上行链路传输由网络控制，以避免重叠 PUSCH/PUCCH及时传输。
通过调度避免PUSCH上的重叠传输，通过配置避免PUCCH上的重叠传输（PUCCH只能配置给小区的2个UL之一）。
此外，每个上行链路都支持初始接入（参见第 9.2.6 节）。附录 B 中给出了 SUL 的示例。

6.10 带宽适配

通过带宽自适应（BA），UE的接收和发送带宽不需要与小区的带宽一样大并且可以调整：可以命令改变宽度（例如，改变带宽）。
在低活动期间缩小以节省电量）；位置可以在频域中移动（例如，以增加调度灵活性）；并且可以命令改变子载波间隔（例如，允许不同的服务）。
小区的总小区带宽的子集被称为带宽部分(BWP)，并且BA是通过为UE配置BWP并告诉UE所配置的BWP中的哪一个当前是活动的来实现的。

下图6.10-1描述了配置3个不同BWP的场景：

- BWP宽度为40 MHz，子载波间隔为15 kHz；
- BWP宽度为10 MHz，子载波间隔为15 kHz；
- BWP 宽度为 20 MHz，子载波间隔为 60 kHz。

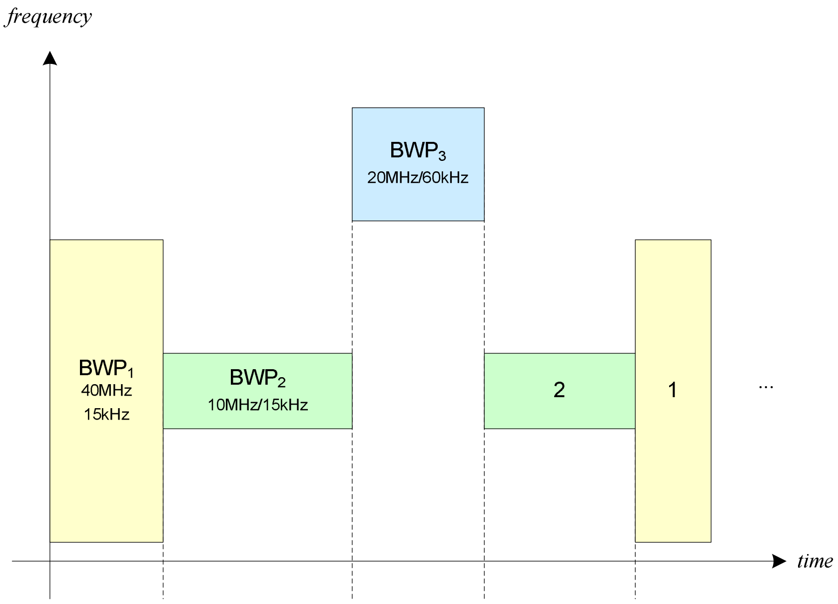


Figure 6.10-1: BA Example

7 RRC

7.1 Services and Functions

The main services and functions of the RRC sublayer include:

- Broadcast of System Information related to AS and NAS;
- Paging initiated by 5GC or NG-RAN;
- Establishment, maintenance and release of an RRC connection between the UE and NG-RAN including:
  - Addition, modification and release of carrier aggregation;
  - Addition, modification and release of Dual Connectivity in NR or between E-UTRA and NR.
- Security functions including key management;
- Establishment, configuration, maintenance and release of Signalling Radio Bearers (SRBs) and Data Radio Bearers (DRBs);
- Mobility functions including:
  - Handover and context transfer;
  - UE cell selection and reselection and control of cell selection and reselection;
  - Inter-RAT mobility.
- QoS management functions;
- UE measurement reporting and control of the reporting;
- Detection of and recovery from radio link failure;
- NAS message transfer to/from NAS from/to UE.

7.2 Protocol States

RRC supports the following states which can be characterised as follows:

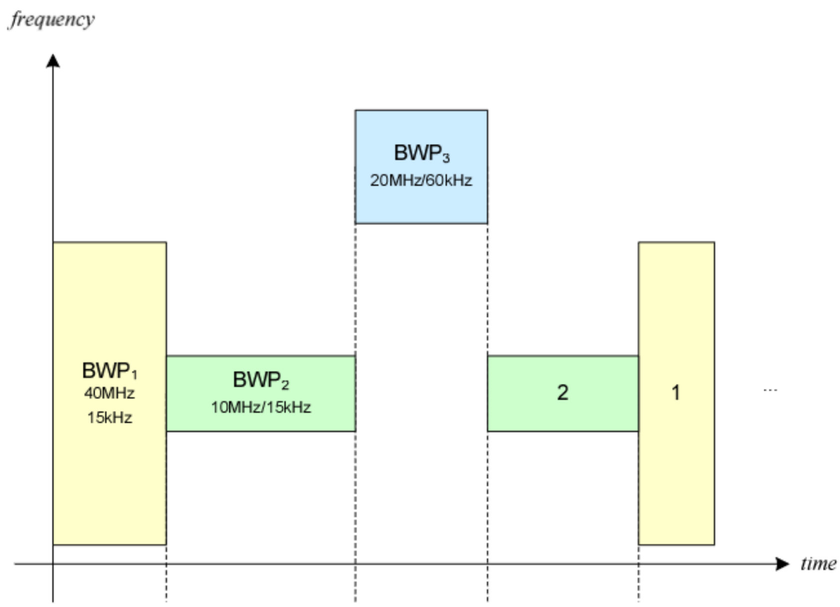


图 6.10-1：BA 示例

7 RRC

7.1 服务与功能

RRC子层的主要服务和功能包括：

- 广播与AS和NAS相关的系统信息；
- 5GC或NG-RAN发起的寻呼；
- UE与NG-RAN之间RRC连接的建立、维护和释放包括：
  - 载波聚合的增加、修改和释放；
  - 添加、修改和释放 NR 中或 E-UTRA 与 NR 之间的双连接。
- 安全功能包括密钥管理；
- 信令无线承载（SRB）和数据无线承载（DRB）的建立、配置、维护和释放；
- 移动功能包括：
  - 切换和上下文传输；
  - UE小区选择和重选以及小区选择和重选的控制；
  - RAT 间移动性。
- QoS管理功能；
- UE测量报告和报告控制；
- 无线链路故障的检测和恢复；
- NAS 消息从 UE 传送到 NAS 或从 NAS 传送到 UE。

7.2 协议状态

RRC 支持以下状态，其特征如下：

- **RRC_IDLE**:
  - PLMN selection;
  - Broadcast of system information;
  - Cell re-selection mobility;
  - Paging for mobile terminated data is initiated by 5GC;
  - Paging for mobile terminated data area is managed by 5GC;
  - DRX for CN paging configured by NAS.
- **RRC_INACTIVE**:
  - PLMN selection;
  - Broadcast of system information;
  - Cell re-selection mobility;
  - Paging is initiated by NG-RAN (RAN paging);
  - RAN-based notification area (RNA) is managed by NG- RAN;
  - DRX for RAN paging configured by NG-RAN;
  - 5GC - NG-RAN connection (both C/U-planes) is established for UE;
  - The UE AS context is stored in NG-RAN and the UE;
  - NG-RAN knows the RNA which the UE belongs to.
- **RRC_CONNECTED**:
  - 5GC - NG-RAN connection (both C/U-planes) is established for UE;
  - The UE AS context is stored in NG-RAN and the UE;
  - NG-RAN knows the cell which the UE belongs to;
  - Transfer of unicast data to/from the UE;
  - Network controlled mobility including measurements.

7.3 System Information Handling

7.3.1 Overview

System Information (SI) is divided into Minimum SI and Other SI, where Minimum SI is transmitted over two different downlink channels using different messages (*MIB* and *SIB1*) and Other SI is transmitted in *SystemInformation* messages (*SIB2* and above):

- *MIB* contains cell barred status information and essential physical layer information of the cell required to receive further system information;
- *SIB1* defines the scheduling of other system information blocks and contains information required for initial access;
- *SIB2* contains cell re-selection information, mainly related to the serving cell;
- *SIB3* contains information about the serving frequency and intra-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);

- RRC_空闲：
  - PLMN选择；
  - 系统信息的广播；
  - 小区重选移动性；
  - 移动端数据寻呼由5GC发起；
  - 移动终止数据区的寻呼由5GC管理；
  - NAS 配置的 CN 寻呼的 DRX。
- RRC_INACTIVE：
  - PLMN选择；
  - 系统信息的广播；
  - 小区重选移动性；
  - 寻呼由NG-RAN发起（RAN寻呼）；
  - 基于RAN的通知区域（RNA）由NG-RAN管理；
  - NG-RAN配置的用于RAN寻呼的DRX；
  - 5GC - 为UE建立NG-RAN连接（C/U平面）；
  - UE AS上下文存储在NG-RAN和UE中；
  - NG-RAN知道UE所属的RNA。
- RRC_已连接：
  - 5GC - 为UE建立NG-RAN连接（C/U平面）；
  - UE AS上下文存储在NG-RAN和UE中；
  - NG-RAN知道UE所属的小区；
  - 向/从UE传输单播数据；
  - 网络控制的移动性，包括测量。

7.3 系统信息处理

7.3.1 概述

系统信息（SI）分为最小SI和其他SI，其中最小SI使用不同的消息（MIB和SIB1）在两个不同的下行链路信道上传输，而其他SI在SystemInformation消息（SIB2及以上）中传输：

- MIB包含小区禁止状态信息和接收进一步系统信息所需的小区的基本物理层信息；

- SIB1定义了其他系统信息块的调度，包含初始访问所需的信息；

- SIB2包含小区重选信息，主要与服务小区相关；
- SIB3包含与小区重选相关的服务频率和同频邻区的信息（包括频率公共的小区重选参数以及小区特定的重选参数）；

- *SIB4* contains information about other NR frequencies and inter-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SIB5* contains information about E-UTRA frequencies and E-UTRA neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SIB6* contains an ETWS primary notification;
- *SIB7* contains an ETWS secondary notification;
- *SIB8* contains a CMAS warning notification;
- *SIB9* contains information related to GPS time and Coordinated Universal Time (UTC).

The term Remaining Minimum SI (RMSI) is also used to refer to *SIB1*. Minimum SI is periodically broadcast and comprises basic information required for initial access and information for acquiring any other SI broadcast periodically or provisioned on-demand, i.e. scheduling information. The Other SI encompasses everything not broadcast in the Minimum SI and may be broadcast either triggered by the network or upon request from the UE as illustrated in Figure 7.3-1 below.

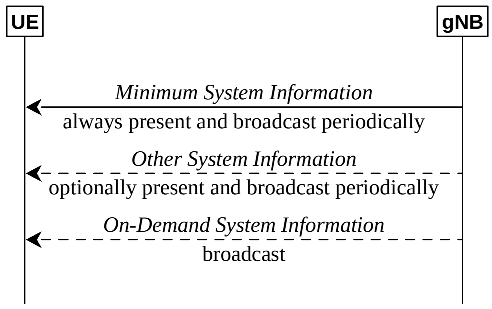


Figure 7.3-1: System Information Provisioning

For a cell/frequency that is considered for camping by the UE, the UE is not required to acquire the contents of the minimum SI of that cell/frequency from another cell/frequency layer. This does not preclude the case that the UE applies stored SI from previously visited cell(s).

If the UE cannot determine the full contents of the minimum SI of a cell (by receiving from that cell or from valid stored SI from previous cells), the UE shall consider that cell as barred.

In case of BA, the UE only acquires SI on the active BWP.

7.3.2 Scheduling

The MIB is mapped on the BCCH and carried on BCH while all other SI messages are mapped on the BCCH, and carried on DL-SCH, where they are dynamically carried on DL-SCH. The scheduling of SI messages part of Other SI is indicated by *SIB1*.

For UEs in RRC_IDLE and RRC_INACTIVE, a request for Other SI triggers a random access procedure (see subclause 9.2.6) where MSG3 includes the SI request message unless the requested SI is associated to a subset of the PRACH resources, in which case MSG1 is used for indication of the requested Other SI. When MSG1 is used, the minimum granularity of the request is one SI message (i.e. a set of SIBs), one RACH preamble and/or PRACH resource can be used to request multiple SI messages and the gNB acknowledges the request in MSG2. When MSG 3 is used, the gNB acknowledges the request in MSG4.

The Other SI may be broadcast at a configurable periodicity and for a certain duration. The Other SI may also be broadcast when it is requested by UE in RRC_IDLE/RRC_INACTIVE.

For a UE to be allowed to camp on a cell it must have acquired the contents of the Minimum SI from that cell. There may be cells in the system that do not broadcast the Minimum SI and where the UE therefore cannot camp.

- SIB4包含与小区重选相关的其他NR频率和异频邻区的信息（包括频率公共的小区重选参数以及小区特定的重选参数）；

- SIB5包含与小区重选相关的E-UTRA频率和E-UTRA相邻小区的信息（包括频率公共的小区重选参数以及小区特定的重选参数）；

- SIB6 包含 ETWS 主要通知;
- SIB7 包含 ETWS 辅助通知;
- SIB8包含CMAS警告通知;
- SIB9 包含与 GPS 时间和协调世界时 (UTC) 相关的信息。

术语剩余最小 SI (RMSI) 也用于指 SIB1。最小SI被周期性地广播并且包括初始接入所需的基本信息和用于获取周期性广播或按需提供的任何其他SI的信息，即
调度信息。其他 SI 包含最小 SI 中未广播的所有内容，并且可以由网络触发或根据 UE 的请求进行广播，如下图 7.3-1 所示。

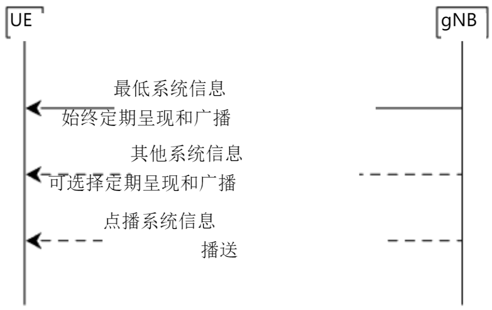


图 7.3-1：系统信息配置

对于UE考虑驻留的小区/频率，UE不需要从其他小区/频率层获取该小区/频率的最小SI的内容。这并不排除UE应用来自先前访问的小区的存储的SI的情况。

如果 UE 无法确定小区的最小 SI 的完整内容（通过从该小区接收或从先前小区的有效存储的 SI 接收），则 UE 应认为该小区被禁止。

在BA的情况下，UE仅获取活动BWP上的SI。

7.3.2 调度

MIB 映射到 BCCH 上并承载在 BCH 上，而所有其他 SI 消息映射到 BCCH 上并承载在 DL-SCH 上，其中它们动态地承载在 DL-SCH 上。其他SI的SI消息部分的调度由SIB1指示。

对于处于 RRC_IDLE 和 RRC_INACTIVE 中的 UE，对其他 SI 的请求会触发随机接入过程（参见子条款 9.2.6），其中 MSG3 包括 SI 请求消息，除非所请求的 SI 与 PRACH 资源的子集相关联，在这种情况下，MSG1 是用于指示所请求的其他 SI。
当使用 MSG1 时，请求的最小粒度是一个 SI 消息（即一组 SIB），一个 RACH 前导码和/或 PRACH 资源可用于请求多个 SI 消息，并且 gNB 在 MSG2 中确认该请求。当使用 MSG 3 时，gNB 在 MSG4 中确认请求。

可以以可配置的周期并在特定的持续时间内广播其他SI。当UE在RRC_IDLE/RRC_INACTIVE中请求时，其他SI也可以被广播。

为了允许 UE 驻留在某个小区，它必须从该小区获取最小 SI 的内容。系统中可能存在不广播最小SI的小区，因此UE不能驻留在其中。

7.3.3 SI Modification

Change of system information (other than for ETWS/CMAS, see subclause 16.4) only occurs at specific radio frames, i.e. the concept of a modification period is used. System information may be transmitted a number of times with the same content within a modification period, as defined by its scheduling. The modification period is configured by system information.

When the network changes (some of the) system information, it first notifies the UEs about this change, i.e. this may be done throughout a modification period. In the next modification period, the network transmits the updated system information. Upon receiving a change notification, the UE acquires the new system information from the start of the next modification period. The UE applies the previously acquired system information until the UE acquires the new system information.

The Short Message transmitted with P-RNTI over DCI (see subclause 6.5 of 3GPP TS 38.331 [12]) on PDCCH is used to inform UEs in RRC_IDLE, RRC_INACTIVE and in RRC_CONNECTED about a system information change. If the UE receives a Short Message with system information change indication, it knows that the system information (other than for ETWS/CMAS) will change at the next modification period boundary.

7.4 Access Control

NG-RAN supports overload and access control functionality such as RACH back off, RRC Connection Reject, RRC Connection Release and UE based access barring mechanisms.

One unified access control framework as specified in 3GPP TS 22.261 [19] is applied for NR. For each access attempt one Access Category and one or more Access Identities are selected.

NG-RAN broadcasts barring control information associated with Access Categories and Access Identities and the UE determines whether an identified access attempt is authorized or not, based on the broadcasted barring information and the selected Access Category and Access Identities. In the case of multiple core networks sharing the same NG-RAN, the NG-RAN provides broadcasted barring control information for each PLMN individually.

The unified access control framework is applicable to all UE states (RRC_IDLE, RRC_INACTIVE and RRC_CONNECTED state).

For NAS triggered requests, the UE NAS determines one access category and access identity(ies) for the given access attempt and provides them to RRC for access control check. The RRC performs access barring check based on the access control information and the determined access category and access identities. The RRC indicates whether the access attempt is allowed or not to NAS layer. The NAS also performs the mapping of the access category and access identity(ies) associated with the access attempt to establishment cause and provides the establishment cause to RRC for inclusion in connection request to enable the gNB to decide whether to reject the request.

For AS triggered request (i.e. RNA update), the RRC determines the resume cause value and the corresponding access category.

7.5 UE Capability Retrieval framework

The UE reports its UE radio access capabilities which are static at least when the network requests. The gNB can request what capabilities for the UE to report based on band information.

When allowed by the network, a temporary capability restriction request maybe sent by the UE to signal the limited availability of some capabilities (e.g. due to hardware sharing, interference or overheating) to the gNB. The gNB can then confirm or reject the request. The temporary capability restriction should be transparent to 5GC. Namely, only static capabilities are stored in 5GC.

7.6 Transport of NAS Messages

Void.

Transport of NAS Messages is not complete and is targeted for completion in June 2018.

7.3.3 国际单位制修改

系统信息的改变（ETWS/CMAS 除外，参见子条款 16.4）仅发生在特定的无线电帧，即使用修改周期的概念。
系统信息可以在修改周期内以相同的内容传输多次，如其调度所定义的。修改周期由系统信息配置。

当网络改变（一些）系统信息时，它首先向UE通知该改变，即这可以在整个修改周期内完成。在下一个修改周期中，网络传输更新后的系统信息。
当UE接收到改变通知时，从下一个修改周期开始时获取新的系统信息。 UE应用先前获取的系统信息直到UE获取新的系统信息。
在 PDCCH 上通过 DCI（参见 3GPP TS 38.331 [12] 的子条款 6.5）使用 P-RNTI 发送的短消息用于向处于 RRC_IDLE、RRC_INACTIVE 和 RRC_CONNECTED 状态的 UE 通知系统信息更改。
如果 UE 接收到带有系统信息更改指示的短消息，则它知道系统信息（除了 ETWS/CMAS 之外）将在下一个修改周期边界发生更改。

7.4 访问控制

NG-RAN 支持过载和接入控制功能，例如 RACH 回退、RRC 连接拒绝、RRC 连接释放和基于 UE 的接入禁止机制。

3GPP TS 22.261 [19]中规定的一种统一的访问控制框架适用于NR。对于每次访问尝试，选择一个访问类别和一个或多个访问身份。

NG-RAN广播与接入类别和接入标识相关联的禁止控制信息，并且UE基于广播的禁止信息和选择的接入类别和接入标识来确定所识别的接入尝试是否被授权。
在多个核心网络共享相同NG-RAN的情况下，NG-RAN单独为每个PLMN提供广播的限制控制信息。

统一的接入控制框架适用于所有UE状态（RRC_IDLE、RRC_INACTIVE和RRC_CONNECTED状态）。

对于 NAS 触发的请求，UE NAS 确定给定接入尝试的一个接入类别和接入标识，并将它们提供给 RRC 进行接入控制检查。
RRC根据接入控制信息以及确定的接入类别和接入标识进行接入限制检查。 RRC 向 NAS 层指示是否允许接入尝试。
NAS还执行与接入尝试相关联的接入类别和接入标识到建立原因的映射，并将建立原因提供给RRC以包含在连接请求中，以使gNB能够决定是否拒绝该请求。

对于AS触发的请求（即RNA更新），RRC确定恢复原因值和相应的接入类别。

7.5 UE能力检索框架

UE报告其UE无线电接入能力，该能力至少在网络请求时是静态的。 gNB可以基于频带信息请求UE报告哪些能力。

当网络允许时，UE 可以发送临时能力限制请求，以向 gNB 告知某些能力的有限可用性（例如，由于硬件共享、干扰或过热）。然后 gNB 可以确认或拒绝该请求。
临时能力限制对于5GC应该是透明的。即，5GC中仅存储静态能力。

7.6 NAS消息传输

空白。

NAS 消息的传输尚未完成，预计于 2018 年 6 月完成。

7.7 Carrier Aggregation

When CA is configured, the UE only has one RRC connection with the network. At RRC connection establishment/re-establishment/handover, one serving cell provides the NAS mobility information, and at RRC connection re-establishment/handover, one serving cell provides the security input. This cell is referred to as the Primary Cell (PCell). Depending on UE capabilities, Secondary Cells (SCells) can be configured to form together with the PCell a set of serving cells. The configured set of serving cells for a UE therefore always consists of one PCell and one or more SCells.

The reconfiguration, addition and removal of SCells can be performed by RRC. At intra-NR handover, RRC can also add, remove, or reconfigure SCells for usage with the target PCell. When adding a new SCell, dedicated RRC signalling is used for sending all required system information of the SCell i.e. while in connected mode, UEs need not acquire broadcast system information directly from the SCells.

7.8 Bandwidth Adaptation

To enable BA on the PCell, the gNB configures the UE with UL and DL BWP(s). To enable BA on SCells in case of CA, the gNB configures the UE with DL BWP(s) at least (i.e. there may be none in the UL). For the PCell, the initial BWP is the BWP used for initial access. For the SCell(s), the initial BWP is the BWP configured for the UE to first operate at SCell activation.

In paired spectrum, DL and UL can switch BWP independently. In unpaired spectrum, DL and UL switch BWP simultaneously. Switching between configured BWPs happens by means of RRC signalling, DCI or inactivity timer. When an inactivity timer is configured for a serving cell, the expiry of the inactivity timer associated to that cell switches the active BWP to a default BWP configured by the network. There can be at most one active BWP per cell.

8 NG Identities

8.1 UE Identities

In this subclause, the identities used by NR connected to 5GC are listed. For scheduling at cell level, the following identities are used:

- C-RNTI: unique UE identification used as an identifier of the RRC Connection and for scheduling;
- CS-RNTI: unique UE identification used for Semi-Persistent Scheduling in the downlink;
- INT-RNTI: identification of pre-emption in the downlink;
- P-RNTI: identification of Paging and System Information change notification in the downlink;
- SI-RNTI: identification of Broadcast and System Information in the downlink;
- SP-CSI-RNTI: unique UE identification used for semi-persistent CSI reporting on PUSCH;

For power and slot format control, the following identities are used:

- SFI-RNTI: identification of slot format;
- TPC-PUCCH-RNTI: unique UE identification to control the power of PUCCH;
- TPC-PUSCH-RNTI: unique UE identification to control the power of PUSCH;
- TPC-SRS-RNTI: unique UE identification to control the power of SRS;

During the random access procedure, the following identities are also used:

- RA-RNTI: identification of the Random Access Response in the downlink;
- Temporary C-RNTI: UE identification temporarily used for scheduling during the random access procedure;
- Random value for contention resolution: UE identification temporarily used for contention resolution purposes during the random access procedure.

7.7 载波聚合

当配置CA时，UE与网络之间只有一个RRC连接。
在RRC连接建立/重建/切换时，一个服务小区提供NAS移动性信息，并且在RRC连接重建/切换时，一个服务小区提供安全输入。该小区称为主小区（PCell）。
根据 UE 功能，辅助小区 (SCell) 可以配置为与 PCell 一起形成一组服务小区。因此，为UE配置的一组服务小区总是由一个PCell和一个或多个SCell组成。

SCell的重新配置、添加和删除可以由RRC来执行。在 NR 内切换时，RRC 还可以添加、删除或重新配置 SCell 以与目标 PCell 一起使用。
当添加新的 SCell 时，专用 RRC 信令用于发送 SCell 的所有所需系统信息，即在连接模式下，UE 不需要直接从 SCell 获取广播系统信息。

7.8 带宽适配

为了在 PCell 上启用 BA，gNB 为 UE 配置 UL 和 DL BWP。为了在 CA 的情况下在 SCell 上启用 BA，gNB 至少为 UE 配置 DL BWP（即，UL 中可能没有）。对于PCell来说，初始BWP是初始接入时使用的BWP。
对于SCell，初始BWP是配置给UE在SCell激活时首先操作的BWP。

在成对频谱中，DL和UL可以独立切换BWP。在不成对频谱中，DL和UL同时切换BWP。配置的 BWP 之间的切换通过 RRC 信令、DCI 或不活动定时器进行。
当为服务小区配置不活动定时器时，与该小区关联的不活动定时器到期将活动BWP切换到由网络配置的默认BWP。每个单元最多可以有一个活动 BWP。

8 OF恒等式

8.1 UE身份

在本子条款中，列出了连接到 5GC 的 NR 使用的身份。对于小区级别的调度，使用以下标识：

- C-RNTI：唯一的UE标识，用作RRC连接的标识符并用于调度；
- CS-RNTI：用于下行半静态调度的唯一UE标识；
- INT-RNTI：下行抢占标识；
- P-RNTI：下行寻呼和系统信息变化通知的标识；
- SI-RNTI：下行链路中广播和系统信息的标识；
- SP-CSI-RNTI：用于PUSCH上半持久CSI报告的唯一UE标识；

对于电源和插槽格式控制，使用以下标识：

- SFI-RNTI：时隙格式的标识；
- TPC-PUCCH-RNTI：唯一的UE标识，用于控制PUCCH的功率；
- TPC-PUSCH-RNTI：唯一的UE标识，用于控制PUSCH的功率；
- TPC-SRS-RNTI：唯一的UE标识，用于控制SRS的功率；

在随机接入过程中，还使用以下身份：

- RA-RNTI：下行随机接入响应的标识；
- Temporary C-RNTI：随机接入过程中临时用于调度的UE标识；
- 用于竞争解决的随机值：在随机接入过程期间临时用于竞争解决目的的UE标识。

For NR connected to 5GC, the following UE identities are used at NG-RAN level:

- I-RNTI: used to identify the UE context in RRC_INACTIVE.

8.2 Network Identities

The following identities are used in NG-RAN for identifying a specific network entity:

- AMF Name: used to identify an AMF.
- NR Cell Global Identifier (NCGI): used to identify NR cells globally. The NCGI is constructed from the PLMN identity the cell belongs to and the NR Cell Identity (NCI) of the cell.
- gNB Identifier (gNB ID): used to identify gNBs within a PLMN. The gNB ID is contained within the NCI of its cells.
- Global gNB ID: used to identify gNBs globally. The Global gNB ID is constructed from the PLMN identity the gNB belongs to and the gNB ID. The MCC and MNC are the same as included in the NCGI.
- Tracking Area identity (TAI): used to identify tracking areas. The TAI is constructed from the PLMN identity the tracking area belongs to and the TAC (Tracking Area Code) of the Tracking Area.
- Single Network Slice Selection Assistance information (S-NSSAI): identifies a network slice.

9 Mobility and State Transitions

9.1 Overview

Load balancing is achieved in NR with handover, redirection mechanisms upon RRC release and through the usage of inter-frequency and inter-RAT absolute priorities and inter-frequency Qoffset parameters.

Measurements to be performed by a UE for connected mode mobility are classified in at least three measurement types:

- Intra-frequency NR measurements;
- Inter-frequency NR measurements;
- Inter-RAT measurements for E-UTRA.

For each measurement type one or several measurement objects can be defined (a measurement object defines e.g. the carrier frequency to be monitored).

For each measurement object one or several reporting configurations can be defined (a reporting configuration defines the reporting criteria). Three reporting criteria are used: event triggered reporting, periodic reporting and event triggered periodic reporting.

The association between a measurement object and a reporting configuration is created by a measurement identity (a measurement identity links together one measurement object and one reporting configuration of the same RAT). By using several measurement identities (one for each measurement object, reporting configuration pair) it is then possible to:

- associate several reporting configurations to one measurement object and;
- associate one reporting configuration to several measurement objects.

The measurements identity is as well used when reporting results of the measurements.

Measurement quantities are considered separately for each RAT.

Measurement commands are used by NG-RAN to order the UE to start, modify or stop measurements.

Inter system fallback towards E-UTRAN is performed when 5GC does not support emergency services, voice services, for load balancing etc. Depending on factors such as CN interface availability, network configuration and radio

对于连接到 5GC 的 NR，在 NG-RAN 级别使用以下 UE 标识：

- I-RNTI：用于标识RRC_INACTIVE中的UE上下文。

8.2 网络身份

NG-RAN 中使用以下标识来标识特定网络实体：

- AMF名称：用于标识AMF。
- NR小区全局标识符（NCGI）：用于全局识别NR小区。 NCGI 由小区所属的 PLMN 标识和小区的 NR 小区标识（NCI）构成。
- gNB 标识符（gNB ID）：用于识别 PLMN 内的 gNB。 gNB ID 包含在其小区的 NCI 内。
- 全球gNB ID：用于识别全球gNB。全局 gNB ID 由 gNB 所属的 PLMN 标识和 gNB ID 构成。 MCC 和 MNC 与 NCGI 中包含的相同。
- 跟踪区域标识（TAI）：用于识别跟踪区域。 TAI 由跟踪区域所属的 PLMN 标识和跟踪区域的 TAC（跟踪区域代码）构成。
- 单一网络切片选择辅助信息（S-NSSAI）：标识网络切片。

9 移动性和状态转换

9.1 概述

NR 中的负载平衡是通过 RRC 释放时的切换、重定向机制以及使用异频和异 RAT 绝对优先级以及异频 Qoffset 参数来实现的。

UE 针对连接模式移动性执行的测量至少分为三种测量类型：

- 同频NR
- 异频NR
- E-UTRA 的 RAT 间测量。

对于每种测量类型，可以定义一个或多个测量对象（测量对象定义例如要监视的载波频率）。

对于每个测量对象，可以定义一个或多个报告配置（报告配置定义报告标准）。使用三种报告标准：事件触发报告、定期报告和事件触发定期报告。

测量对象和报告配置之间的关联是由测量标识创建的（测量标识将同一RAT的一个测量对象和一个报告配置链接在一起）。通过使用多个测量标识（每个测量对象一个，报告配置对），可以：

- 将多个报告配置与一个测量对象相关联；
- 将一个报告配置与多个测量对象相关联。

当报告测量结果时也使用测量标识。

每种 RAT 的测量量都是单独考虑的。

NG-RAN 使用测量命令来命令 UE 开始、修改或停止测量。

当 5GC 不支持紧急服务、语音服务、负载均衡等时，会执行向 E-UTRAN 的系统间回退。取决于 CN 接口可用性、网络配置和无线电等因素

conditions, the fallback procedure results in either CONNECTED state mobility (handover procedure) or IDLE state mobility (redirection) - see 3GPP TS 23.501 [3] and 3GPP TS 38.331 [12].

In the N2 signalling procedure, the AMF based on support for emergency services, voice service, any other services or for load balancing etc, may indicate the target CN type as EPC or 5GC to the gNB node. When the target CN type is received by gNB, the target CN type is also conveyed to the UE in *RRCRelease* Message.

9.2 Intra-NR

9.2.1 Mobility in RRC_IDLE

9.2.1.1 Cell Selection

The principles of PLMN selection in NR are based on the 3GPP PLMN selection principles. Cell selection is required on transition from RM-DEREGISTERED to RM-REGISTERED, from CM-IDLE to CM-CONNECTED and from CM-CONNECTED to CM-IDLE and is based on the following principles:

- The UE NAS layer identifies a selected PLMN and equivalent PLMNs;
- Cell selection is always based on CD-SSBs located on the synchronization raster (see subclause 5.2.4):
  - The UE searches the NR frequency bands and for each carrier frequency identifies the strongest cell as per the CD-SSB. It then reads cell system information broadcast to identify its PLMN(s):
    - The UE may search each carrier in turn ("initial cell selection") or make use of stored information to shorten the search ("stored information cell selection").
- The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure:
  - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of "forbidden tracking areas for roaming";
  - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred.

Transition to RRC_IDLE:

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

Recovery from out of coverage:

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

In multi-beam operations, the cell quality is derived amongst the beams corresponding to the same cell (see subclause 9.2.4).

9.2.1.2 Cell Reselection

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

- Cell reselection is always based on CD-SSBs located on the synchronization raster (see subclause 5.2.4).
- The UE makes measurements of attributes of the serving and neighbour cells to enable the reselection process:
  - For the search and measurement of inter-frequency neighbouring cells, only the carrier frequencies need to be indicated.

在这种情况下，回退过程会导致 CONNECTED 状态移动性（切换过程）或 IDLE 状态移动性（重定向） - 请参阅 3GPP TS 23.501 [3] 和 3GPP TS 38.331 [12]。

在N2信令过程中，基于对紧急服务、语音服务、任何其他服务或负载平衡等的支持的AMF可以向gNB节点指示目标CN类型为EPC或5GC。
当 gNB 接收到目标 CN 类型时，目标 CN 类型也会在 RRCRRelease 消息中传达给 UE。

9.2 内部编号

9.2.1 RRC_IDLE 状态下的移动性

9.2.1.1 细胞选择

NR中PLMN选择原则基于3GPP PLMN选择原则。从 RM-DEREGISTERED 转换到 RM-REGISTERED、从 CM-IDLE 转换到 CM-CONNECTED、从 CMCONNECTED 转换到 CM-IDLE 时需要进行小区选择，并且基于以下原则：

- UE NAS层识别选定的PLMN和等效的PLMN；
- 小区选择始终基于同步栅格上的 CD-SSB（参见第 5.2.4 节）：
  - UE 搜索 NR 频段，并针对每个载波频率根据 CD-SSB 识别最强的小区。然后，它读取小区系统信息广播以识别其 PLMN：
    - UE可以依次搜索每个载波（“初始小区选择”）或利用存储的信息来缩短搜索（“存储的信息小区选择”）。
- UE寻求识别合适的小区；如果它不能识别合适的小区，它会寻求识别可接受的小区。当找到合适的小区或仅找到可接受的小区时，它驻留在该小区上并开始小区重选过程：
  - 合适的小区是测量的小区属性满足小区选择标准的小区；小区PLMN是选择的PLMN、注册的PLMN或等效的PLMN；该小区未被禁止或保留，并且该小区不属于“漫游禁止跟踪区域”列表中的跟踪区域；
  - 可接受的小区是测量的小区属性满足小区选择标准并且未被禁止的小区。

转换到RRC_IDLE：

在从 RRC_CONNECTED 转换到 RRC_IDLE 时，UE 应驻留在其处于 RRC_CONNECTED 状态的最后一个小区或状态转换消息中由 RRC 分配的小区/小区集合或频率中的任何小区。

从承保范围外恢复：

UE应该尝试以上述存储信息或初始小区选择所描述的方式找到合适的小区。如果在任何频率或RAT上都没有找到合适的小区，则UE应该尝试寻找可接受的小区。

在多波束操作中，小区质量是在对应于同一小区的波束之间导出的（参见子条款 9.2.4）。

9.2.1.2 小区重选

RRC_IDLE中的UE执行小区重选。该程序的原则如下：

- 小区重选始终基于位于同步光栅上的 CD-SSB（参见子条款 5.2.4）。
- UE 测量服务小区和相邻小区的属性以启用重选过程：
  - 对于异频邻区的搜索和测量，只需要指示载频即可。

- 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:
  - Intra-frequency reselection is based on ranking of cells;
  - Inter-frequency reselection is based on absolute priorities where a UE tries to camp on the highest priority frequency available;
  - An NCL can be provided by the serving cell to handle specific cases for intra- and inter-frequency neighbouring cells;
  - Black lists can be provided to prevent the UE from reselecting to specific intra- and inter-frequency neighbouring cells;
  - Cell reselection can be speed dependent;
  - Service specific prioritisation.

In multi-beam operations, the cell quality is derived amongst the beams corresponding to the same cell (see subclause 9.2.4).

9.2.1.3 State Transitions

The following figure describes the UE triggered transition from RRC_IDLE to RRC_CONNECTED (for the NAS part, see 3GPP TS 23.502 [22]):

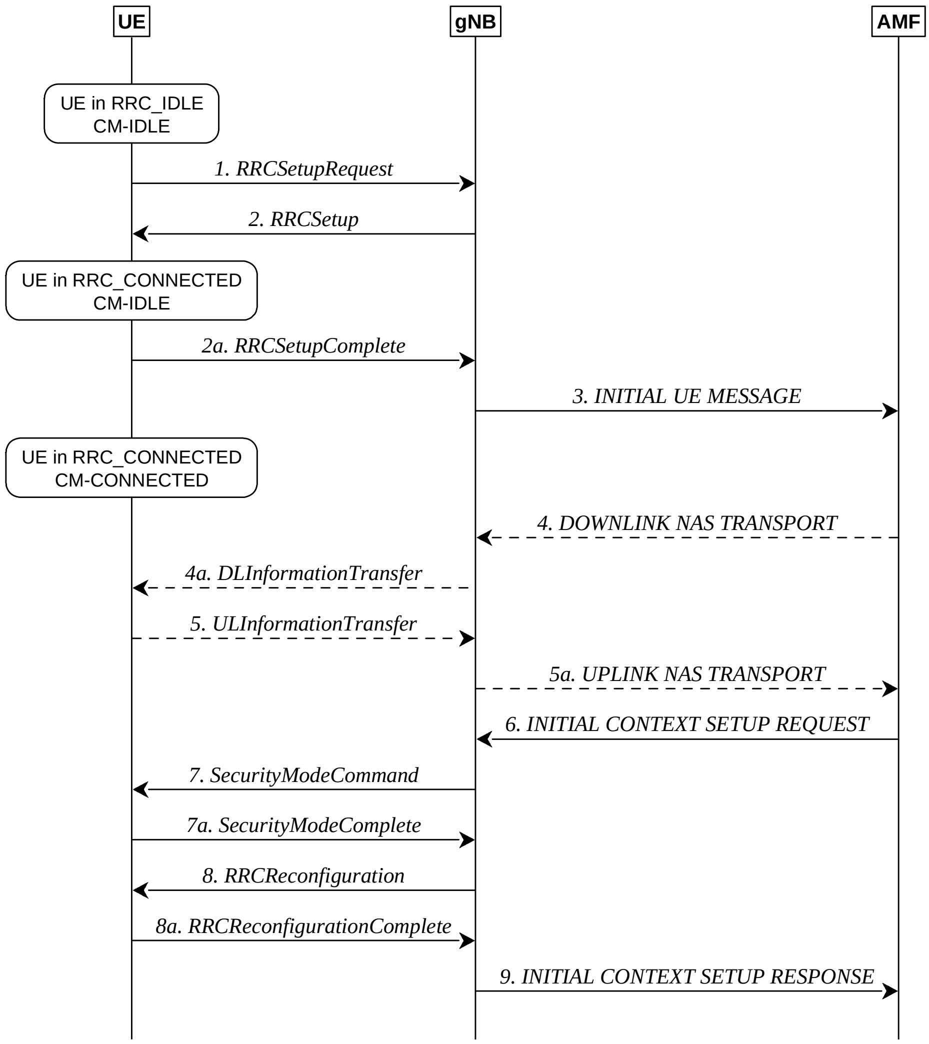


Figure 9.2.1.3-1: UE triggered transition from RRC_IDLE to RRC_CONNECTED

1. The UE requests to setup a new connection from RRC_IDLE.

- 小区重选标识UE应该驻留的小区。它基于小区重选标准，涉及服务小区和相邻小区的测量：
  - 同频重选基于小区的排序；
  - 频率间重选基于绝对优先级，其中UE尝试驻留在可用的最高优先级频率上；
  - 服务小区可以提供NCL来处理同频和异频相邻小区的特定情况；
  - 可以提供黑名单，防止UE重选到特定的同频、异频邻区；
  - 小区重选可以取决于速度；
  - 服务特定优先级。

在多波束操作中，小区质量是在对应于同一小区的波束之间导出的（参见子条款 9.2.4）。

9.2.1.3 状态转换

下图描述了UE触发从RRC_IDLE到RRC_CONNECTED的转变（NAS部分参见3GPP TS 23.502[22]）：

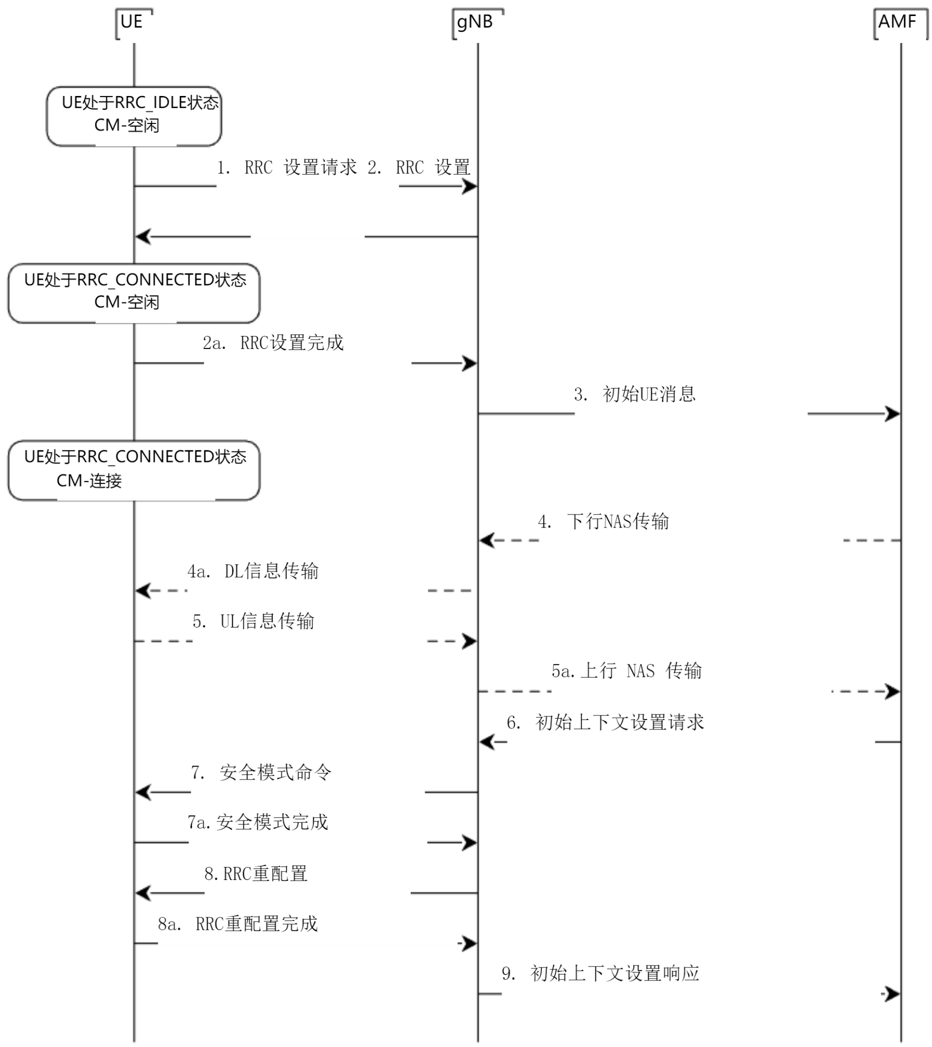


图9.2.1.3-1：UE触发从RRC_IDLE到RRC_CONNECTED的转换

1. UE从RRC_IDLE请求建立新的连接。

2/2a. The gNB completes the RRC setup procedure.

NOTE: The scenario where the gNB rejects the request is described below.

3. The first NAS message from the UE, piggybacked in *RRCSetupComplete*, is sent to AMF.

4/4a/5/5a. Additional NAS messages may be exchanged between UE and AMF [22].

6. The AMF prepares the UE context data (including PDU session context, the Security Key, UE Radio Capability and UE Security Capabilities, etc.) and sends it to the gNB.

7/7a. The gNB activates the AS security with the UE.

8/8a. The gNB performs the reconfiguration to setup SRB2 and DRBs.

9. The gNB informs the AFM that the setup procedure is completed.

NOTE: RRC messages in step 1 and 2 use SRB0, all the subsequent messages use SRB1. Messages in step 6 are integrity protected. From step 7 on, all the messages are integrity protected and ciphered.

The following figure describes the rejection from the network when the UE attempts to setup a connection from RRC_IDLE:

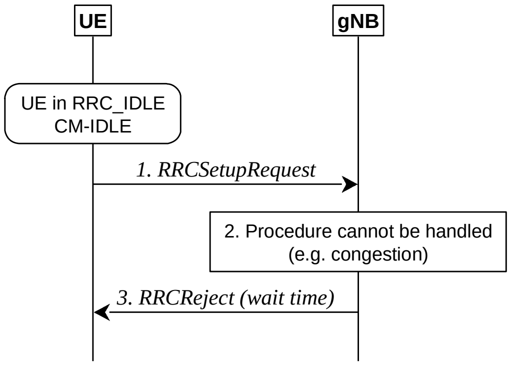


Figure 9.2.1.3-2: Rejection of UE triggered transition from RRC_IDLE

1. UE attempts to setup a new connection from RRC_IDLE.
2. The gNB is not able to handle the procedure, for instance due to congestion.
3. The gNB sends *RRCReject* (with a wait time) to keep the UE in RRC_IDLE.

9.2.2 Mobility in RRC_INACTIVE

9.2.2.1 Overview

RRC_INACTIVE is a state where a UE remains in CM-CONNECTED and can move within an area configured by NG-RAN (the RNA) without notifying NG-RAN. In RRC_INACTIVE, the last serving gNB node keeps the UE context and the UE-associated NG connection with the serving AMF and UPF.

If the last serving gNB receives DL data from the UPF or DL UE-associated signalling from the AMF (except the UE Context Release Command message) while the UE is in RRC_INACTIVE, it pages in the cells corresponding to the RNA and may send XnAP RAN Paging to neighbour gNB(s) if the RNA includes cells of neighbour gNB(s).

Upon receiving the UE Context Release Command message while the UE is in RRC_INACTIVE, the last serving gNB may page in the cells corresponding to the RNA and may send XnAP RAN Paging to neighbour gNB(s) if the RNA includes cells of neighbour gNB(s), in order to release UE explicitly.

Upon RAN paging failure, the gNB behaves according to 3GPP TS 23.501 [3].

The AMF provides to the NG-RAN node the RRC Inactive Assistance Information to assist the NG-RAN node's decision whether the UE can be sent to RRC_INACTIVE. The RRC Inactive Assistance Information includes the registration area configured for the UE, the UE specific DRX, Periodic Registration Update timer, an indication if the UE is configured with Mobile Initiated Connection Only (MICO) mode by the AMF, and UE Identity Index value. The

2/2a。 gNB完成RRC建立过程。

笔记： 下面描述gNB拒绝请求的场景。

3. 来自 UE 的第一个 NAS 消息搭载在 RRCSetupComplete 中，发送到 AMF。

4/4a/5/5a。额外的 NAS 消息可以在 UE 和 AMF 之间交换 [22]。

6. AMF准备UE上下文数据（包括PDU会话上下文、安全密钥、UE无线能力和UE安全能力等）并发送给gNB。

7/7a。 gNB激活与UE的AS安全。

8/8a。 gNB 执行重新配置以设置 SRB2 和 DRB。

9. gNB 通知 AFM 设置过程已完成。

笔记： 步骤1和步骤2中的RRC消息使用SRB0，后续消息均使用SRB1。步骤 6 中的消息受到完整性保护。从第 7 步开始，所有消息都受到完整性保护和加密。

下图描述了当UE尝试从RRC_IDLE建立连接时来自网络的拒绝：

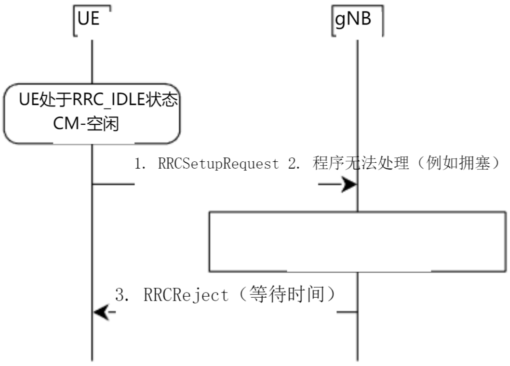


图9.2.1.3-2：拒绝UE触发的RRC_IDLE转换

1. UE 尝试从 RRC_IDLE 建立新连接。

2. gNB 无法处理该过程，例如由于拥塞。

3. gNB 发送 RRCReject（带有等待时间）以使 UE 保持在 RRC_IDLE 状态。

9.2.2 RRC_INACTIVE 状态下的移动性

9.2.2.1 概述

RRC_INACTIVE是UE保持在CM-CONNECTED并且可以在NGRAN（RNA）配置的区域内移动而无需通知NG-RAN的状态。在 RRC_INACTIVE 中，最后一个服务 gNB 节点与服务 AMF 和 UPF 保持 UE 上下文和 UE 关联的 NG 连接。

如果最后一个服务 gNB 在 UE 处于 RRC_INACTIVE 状态时从 UPF 接收到 DL 数据或从 AMF 接收到 DL UE 相关信令（UE 上下文释放命令消息除外），则它会在与 RNA 相对应的小区中寻呼，并可能发送 XnAP RAN如果 RNA 包含相邻 gNB 的小区，则寻呼至相邻 gNB。

当 UE 处于 RRC_INACTIVE 状态时接收到 UE 上下文释放命令消息后，最后一个服务 gNB 可以在与 RNA 相对应的小区中进行寻呼，并且如果 RNA 包括相邻 gNB 的小区，则可以向相邻 gNB 发送 XnAP RAN 寻呼），以便显式释放UE。

当 RAN 寻呼失败时，gNB 根据 3GPP TS 23.501 [3] 进行操作。

AMF向NG-RAN节点提供RRC Inactive辅助信息，以辅助NG-RAN节点决定是否可以将UE发送至RRC_INACTIVE。
RRC 非活动辅助信息包括为 UE 配置的注册区域、UE 特定 DRX、定期注册更新定时器、AMF 是否为 UE 配置了仅移动发起连接 (MICO) 模式的指示以及 UE 身份索引值。
这

UE registration area is taken into account by the NG-RAN node when configuring the RNA. The UE specific DRX and UE Identity Index value are used by the NG-RAN node for RAN paging. The Periodic Registration Update timer is taken into account by the NG-RAN node to configure Periodic RNA Update timer.

At transition to RRC_INACTIVE the NG-RAN node may configure the UE with a periodic RNA Update timer value. At periodic RNA Update timer expiry without notification from the UE, the gNB behaves as specified in 3GPP TS 23.501 [3].

If the UE accesses a gNB other than the last serving gNB, the receiving gNB triggers the XnAP Retrieve UE Context procedure to get the UE context from the last serving gNB and may also trigger a Data Forwarding procedure including tunnel information for potential recovery of data from the last serving gNB. Upon successful UE context retrieval, the receiving gNB shall perform the slice-aware admission control in case of receiving slice information and becomes the serving gNB and it further triggers the NGAP Path Switch Request and RRC procedures properly. After the path switch procedure, the serving gNB triggers release of the UE context at the last serving gNB by means of the XnAP UE Context Release procedure.

In case the UE is not reachable at the last serving gNB, the gNB shall fail AMF initiated UE-associated class 1 procedures if any, and shall trigger the NAS Non Delivery Indication procedure to report the non-delivery of any NAS PDU received from the AMF for the UE.

If the UE accesses a gNB other than the last serving gNB and the receiving gNB does not find a valid UE Context, the receiving gNB can perform establishment of a new RRC connection instead of resumption of the previous RRC connection.

A UE in the RRC_INACTIVE state is required to initiate RNA update procedure when it moves out of the configured RNA. When receiving RNA update request from the UE, the receiving gNB triggers the XnAP Retrieve UE Context procedure to get the UE context from the last serving gNB and may decide to send the UE back to RRC_INACTIVE state, move the UE into RRC_CONNECTED state, or send the UE to RRC_IDLE.

9.2.2.2 Cell Reselection

A UE in RRC_INACTIVE performs cell reselection. The principles of the procedure are as for the RRC_IDLE state (see subclause 9.2.1.2).

9.2.2.3 RAN-Based Notification Area

A UE in the RRC_INACTIVE state can be configured by the last serving NG-RAN node with an RNA, where:

- the RNA can cover a single or multiple cells, and shall be contained within the CN registration area; in this release Xn connectivity should be available within the RNA;
- a RAN-based notification area update (RNAU) is periodically sent by the UE and is also sent when the cell reselection procedure of the UE selects a cell that does not belong to the configured RNA.

There are several different alternatives on how the RNA can be configured:

- List of cells:
    - A UE is provided an explicit list of cells (one or more) that constitute the RNA.
- List of RAN areas:
    - A UE is provided (at least one) RAN area ID, where a RAN area is a subset of a CN Tracking Area or equal to a CN Tracking Area. A RAN area is specified by one RAN area ID, which consists of a TAI and optionally a RAN area Code;
    - A cell broadcasts one or more RAN area IDs in the system information.

NG-RAN may provide different RNA definitions to different UEs but not mix different definitions to the same UE at the same time. UE shall support all RNA configuration options listed above.

NG-RAN 节点在配置 RNA 时会考虑 UE 注册区域。 UE 特定 DRX 和 UE 身份索引值由 NG-RAN 节点用于 RAN 寻呼。
NG-RAN 节点会考虑定期注册更新定时器来配置定期 RNA 更新定时器。

在转换到 RRC_INACTIVE 时，NG-RAN 节点可以使用周期性 RNA 更新定时器值来配置 UE。当定期 RNA 更新定时器到期且没有来自 UE 的通知时，gNB 的行为如 3GPP TS 23.501 [3] 中所指定。

如果 UE 接入除最后一个服务 gNB 之外的 gNB，则接收 gNB 会触发 XnAP 检索 UE 上下文过程，以从最后一个服务 gNB 获取 UE 上下文，并且还可能触发包含隧道信息的数据转发过程，用于潜在地恢复来自最后一个服务 gNB 的数据。最后一个服务 gNB。
成功获取 UE 上下文后，接收 gNB 在接收分片信息的情况下应执行分片感知准入控制，并成为服务 gNB，并进一步正确触发 NGAP 路径切换请求和 RRC 过程。
在路径切换过程之后，服务gNB通过XnAP UE触发最后一个服务gNB处的UE上下文的释放
上下文释放过程。

如果 UE 在最后一个服务 gNB 处无法到达，则 gNB 将使 AMF 发起的 UE 相关 1 类过程（如果有）失败，并应触发 NAS 未交付指示过程来报告从服务 gNB 接收到的任何 NAS PDU 未交付。 UE 的 AMF。

如果UE接入除最后一个服务gNB之外的gNB并且接收gNB没有找到有效的UE上下文，则接收gNB可以执行新的RRC连接的建立，而不是恢复先前的RRC连接。

处于RRC_INACTIVE状态的UE在移出配置的RNA时需要发起RNA更新过程。
当接收到来自 UE 的 RNA 更新请求时，接收 gNB 触发 XnAP 检索 UE 上下文过程，以从最后一个服务 gNB 获取 UE 上下文，并可能决定将 UE 发送回 RRC_INACTIVE 状态、将 UE 移至 RRC_CONNECTED 状态，或者发送UE 进入 RRC_IDLE。

9.2.2.2 小区重选

RRC_INACTIVE中的UE执行小区重选。该过程的原理与 RRC_IDLE 状态相同（参见第 9.2.1.2 节）。

9.2.2.3 基于 RAN 的通知区域

处于 RRC_INACTIVE 状态的 UE 可以由最后一个服务 NG-RAN 节点使用 RNA 配置，其中：

- RNA可以覆盖单个或多个小区，并且应包含在CN注册区域内；在此版本中，Xn 连接应在 RNA 内可用；
- 基于RAN的通知区域更新(RNAU)由UE周期性地发送，并且当UE的小区重选过程选择不属于所配置的RNA的小区时也发送。

关于如何配置 RNA，有几种不同的替代方案：

- 单元格列表：
  - 向UE提供构成RNA的小区（一个或多个）的明确列表。
- RAN 区域列表：
  - 向UE提供（至少一个）RAN区域ID，其中RAN区域是CN跟踪区域的子集或者等于CN跟踪区域。一个RAN区域由一个RAN区域ID指定，该ID由TAI和可选的RAN区域代码组成；
  - 小区在系统信息中广播一个或多个RAN区域ID。

NG-RAN可以向不同的UE提供不同的RNA定义，但不能同时向同一UE混合不同的定义。 UE 应支持上面列出的所有 RNA 配置选项。

9.2.2.4 State Transitions

9.2.2.4.1 UE triggered transition from RRC_INACTIVE to RRC_CONNECTED

The following figure describes the UE triggered transition from RRC_INACTIVE to RRC_CONNECTED in case of UE context retrieval success:

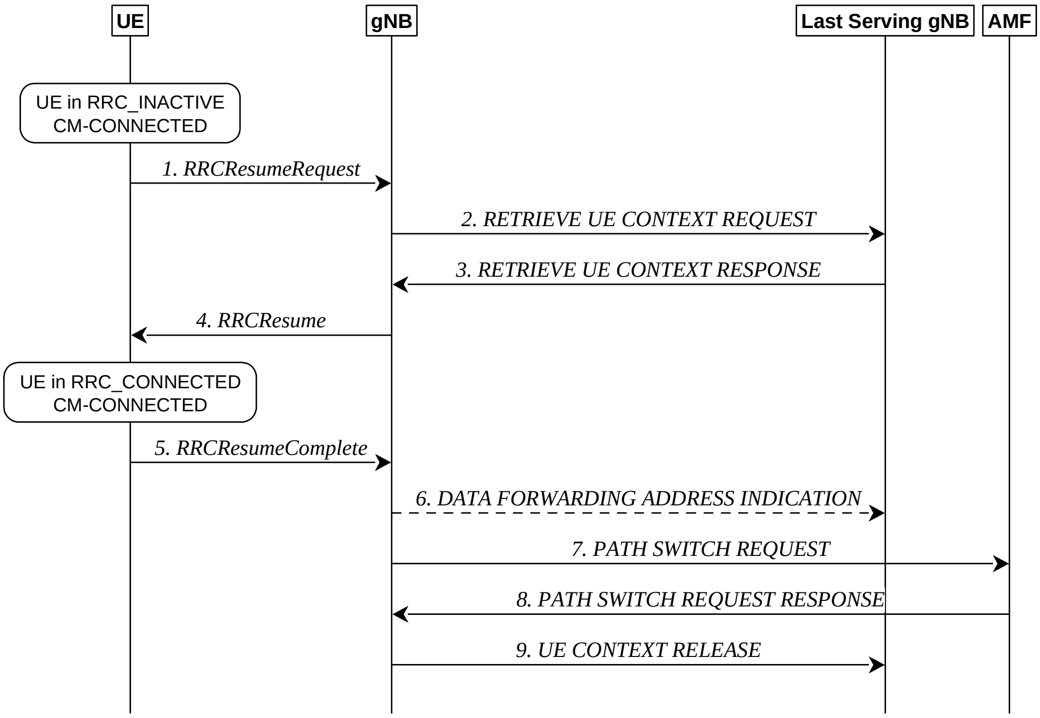


Figure 9.2.2.4.1-1: UE triggered transition from RRC_INACTIVE to RRC_CONNECTED (UE context retrieval success)

1. The UE resumes from RRC_INACTIVE, providing the I-RNTI, allocated by the last serving gNB.
2. The gNB, if able to resolve the gNB identity contained in the I-RNTI, requests the last serving gNB to provide UE Context data.
3. The last serving gNB provides UE context data.

4/5. The gNB and UE completes the resumption of the RRC connection.

NOTE: User Data can also be sent in step 5 if the grant allows.

6. If loss of DL user data buffered in the last serving gNB shall be prevented, the gNB provides forwarding addresses.

7/8. The gNB performs path switch.

9. The gNB triggers the release of the UE resources at the last serving gNB.

After step 1 above, when the gNB decides to reject the Resume Request and keep the UE in RRC_INACTIVE without any reconfiguration (e.g. as described in the two examples below), or when the gNB decides to setup a new RRC connection, SRB0 (without security) can be used. When the gNB decides to reconfigure the UE (e.g. with a new DRX cycle or RNA) or when the gNB decides to push the UE to RRC_IDLE, SRB1 (with at least integrity protection) shall be used.

NOTE: SRB1 can only be used once the UE Context is retrieved i.e. after step 3.

The following figure describes the UE triggered transition from RRC_INACTIVE to RRC_CONNECTED in case of UE context retrieval failure:

9.2.2.4 状态转换

9.2.2.4.1 UE触发从RRC_INACTIVE到RRC_CONNECTED的转换

下图描述了在UE上下文检索成功的情况下UE触发的从RRC_INACTIVE到RRC_CONNECTED的转换：

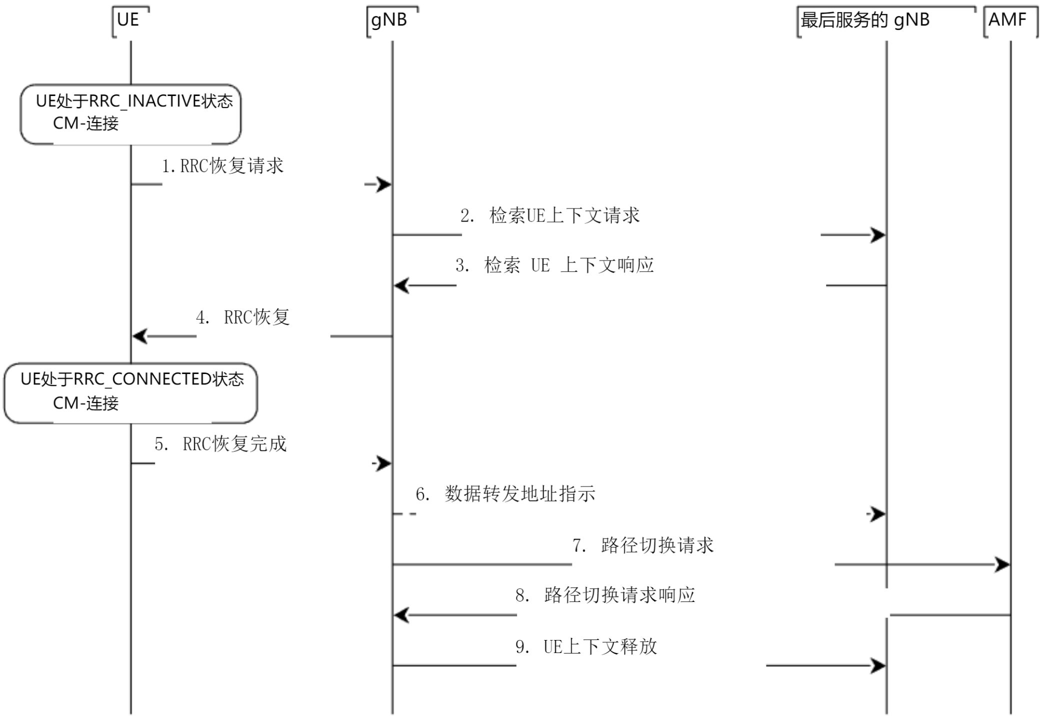


图9.2.2.4.1-1：UE触发从RRC_INACTIVE到RRC_CONNECTED的转换（UE上下文检索成功）

1. UE 从 RRC_INACTIVE 恢复，提供由最后一个服务 gNB 分配的 I-RNTI。

2. 如果 gNB 能够解析 I-RNTI 中包含的 gNB 标识，则 gNB 请求最后一个服务 gNB 提供 UE 上下文数据。

3. 最后一个服务 gNB 提供 UE 上下文数据。

4/5。 gNB和UE完成RRC连接的恢复。

笔记： 如果授权允许，也可以在步骤 5 中发送用户数据。

6. 如果应防止最后一个服务 gNB 中缓冲的 DL 用户数据丢失，则 gNB 提供转发地址。

7/8。 gNB执行路径切换。

9. gNB 在最后一个服务 gNB 处触发 UE 资源的释放。

在上述步骤 1 之后，当 gNB 决定拒绝恢复请求并将 UE 保持在 RRC_INACTIVE 状态而不进行任何重新配置时（例如，如下面两个示例中所述），或者当 gNB 决定建立新的 RRC 连接时，SRB0（没有安全性） ）可以使用。
当 gNB 决定重新配置 UE（例如，使用新的 DRX 周期或 RNA）或当 gNB 决定将 UE 推至 RRC_IDLE 时，应使用 SRB1（至少具有完整性保护）。

笔记： SRB1 仅可在检索到 UE 上下文后（即在步骤 3 之后）使用。

下图描述了在UE上下文检索失败的情况下UE触发的从RRC_INACTIVE到RRC_CONNECTED的转换：

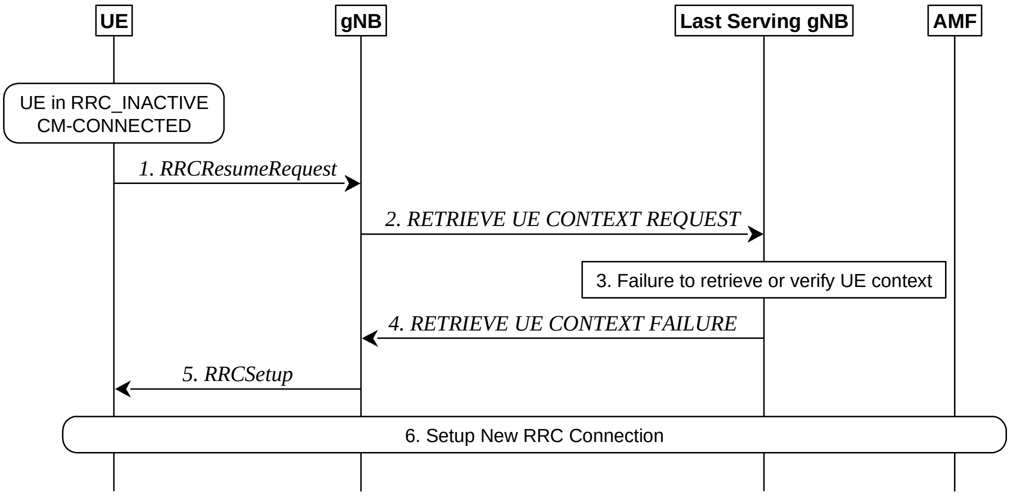


Figure 9.2.2.4.1-2: UE triggered transition from RRC_INACTIVE to RRC_CONNECTED (UE context retrieval failure)

1. The UE resumes from RRC_INACTIVE, providing the I-RNTI, allocated by the last serving gNB.
2. The gNB, if able to resolve the gNB identity contained in the I-RNTI, requests the last serving gNB to provide UE Context data.
3. The last serving gNB cannot retrieve or verify the UE context data.
4. The last serving gNB indicates the failure to the gNB.
5. The gNB performs a fallback to establish a new RRC connection by sending *RRCSetup*.
6. A new connection is setup as described in sub-clause 9.2.1.3.1.

The following figure describes the rejection form the network when the UE attempts to resume a connection from RRC_INACTIVE:

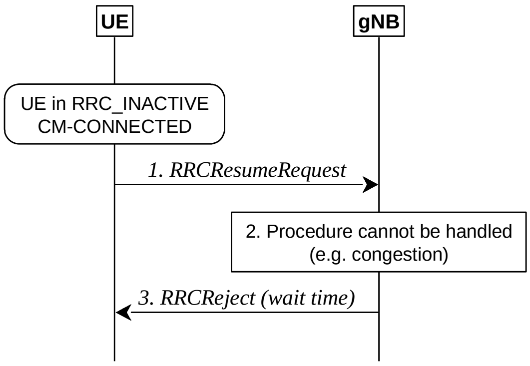


Figure 9.2.2,4.1-3: Reject from the network, UE attempts to resume a connection

1. UE attempts to resume the connection from RRC_INACTIVE.
2. The gNB is not able to handle the procedure, for instance due to congestion.
3. The gNB sends *RRCReject* (with a wait time) to keep the UE in RRC_INACTIVE.

9.2.2.4.2 Network triggered transition from RRC_INACTIVE to RRC_CONNECTED

The following figure describes the network triggered transition from RRC_INACTIVE to RRC_CONNECTED:

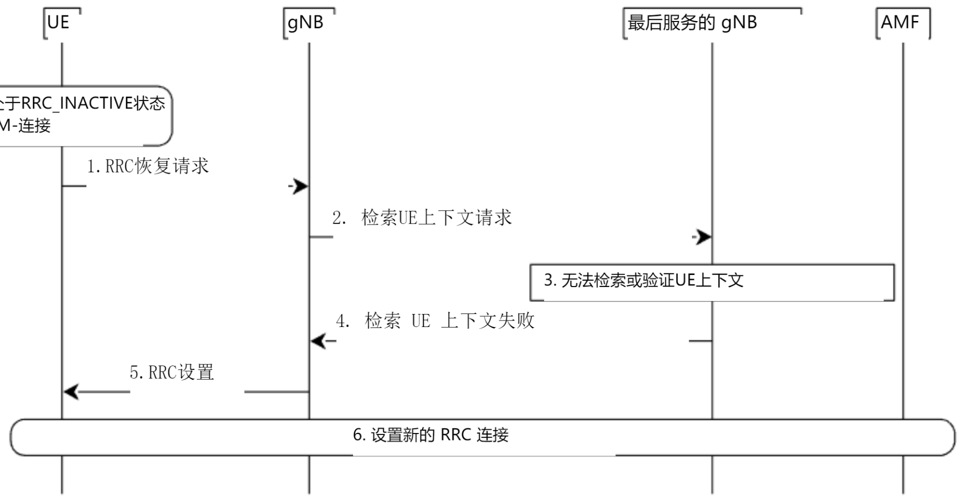


图9.2.2.4.1-2：UE触发从RRC_INACTIVE到RRC_CONNECTED的转换（UE上下文检索失败）

1. UE 从 RRC_INACTIVE 恢复，提供由最后一个服务 gNB 分配的 I-RNTI。
2. 如果 gNB 能够解析 I-RNTI 中包含的 gNB 标识，则 gNB 请求最后一个服务 gNB 提供 UE 上下文数据。
3. 最后一个服务 gNB 无法检索或验证 UE 上下文数据。
4. 最后一个服务 gNB 向 gNB 指示故障。
5. gNB 通过发送 RRCSetup 执行回退以建立新的 RRC 连接。
6. 如第 9.2.1.3.1 节所述建立新连接。

下图描述了当UE尝试从RRC_INACTIVE恢复连接时网络的拒绝：

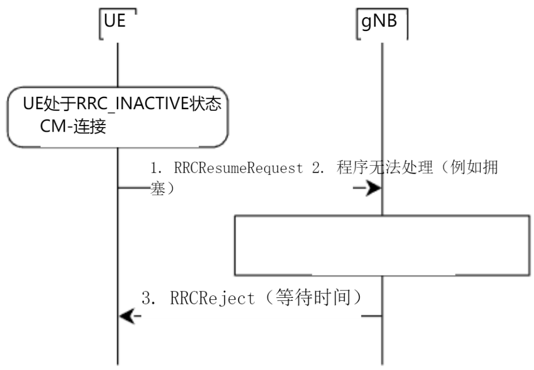


图9.2.2,4.1-3：网络拒绝，UE尝试恢复连接

1. UE尝试从RRC_INACTIVE状态恢复连接。
2. gNB 无法处理该过程，例如由于拥塞。
3. gNB 发送 RRCReject（带有等待时间）以将 UE 保持在 RRC_INACTIVE 状态。

9.2.2.4.2 网络触发从 RRC_INACTIVE 到 RRC_CONNECTED 的转换

下图描述了网络触发从RRC_INACTIVE到RRC_CONNECTED的转换：

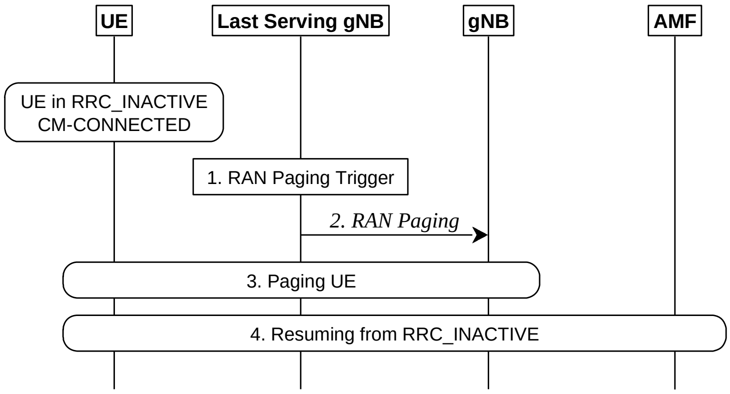


Figure 9.2.2.4.2-1: Network triggered transition from RRC_INACTIVE to RRC_CONNECTED

1. A RAN paging trigger event occurs (incoming DL user plane, DL signalling from 5GC, etc.).
2. RAN paging is triggered; either only in the cells controlled by the last serving gNB or also by means of Xn RAN Paging in cells controlled by other gNBs, configured to the UE in the RAN-based Notification Area (RNA).
3. The UE is paged with the I-RNTI.
4. If the UE has been successfully reached, it attempts to resume from RRC_INACTIVE, as described in sub-clause 9.2.2.4.1.

9.2.2.5 RNA update

The following figure describes the UE triggered RNA update procedure involving context retrieval over Xn. The procedure may be triggered when the UE moves out of the configured RNA, or at the expiry of a periodic RNA Update timer.

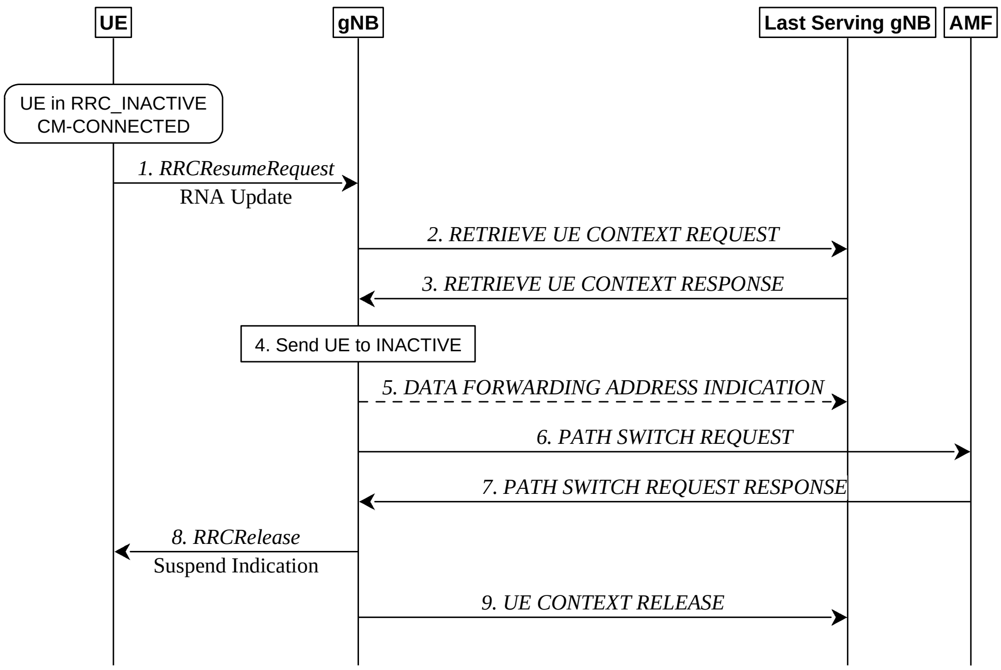


Figure 9.2.2.5-1: RNA update procedure with UE context relocation

1. The UE resumes from RRC_INACTIVE, providing the I-RNTI allocated by the last serving gNB and appropriate cause value, e.g., RAN notification area update.
2. The gNB, if able to resolve the gNB identity contained in the I-RNTI, requests the last serving gNB to provide UE Context, providing the cause value received in step 1.
3. The last serving gNB provides UE context.

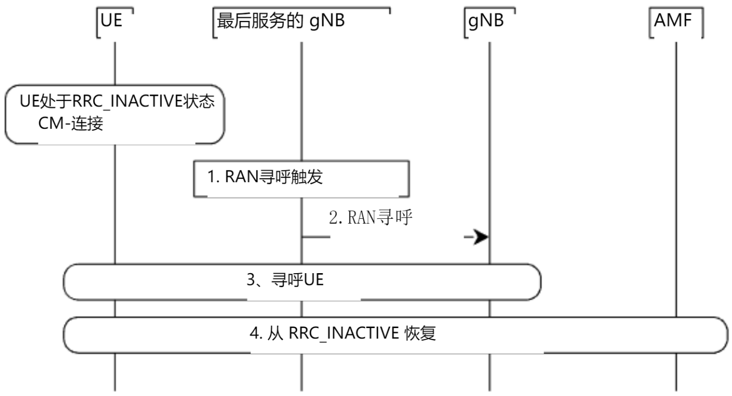


图 9.2.2.4.2-1：网络触发从 RRC_INACTIVE 到 RRC_CONNECTED 的转换

1. 发生 RAN 寻呼触发事件（传入 DL 用户平面、来自 5GC 的 DL 信令等）。
2. RAN寻呼被触发；要么仅在最后一个服务 gNB 控制的小区中，要么在其他 gNB 控制的小区中通过 Xn RAN 寻呼，在基于 RAN 的通知区域 (RNA) 中配置给 UE。
3. 使用 I-RNTI 寻呼 UE。
4. 如果已成功到达 UE，则它尝试从 RRC_INACTIVE 恢复，如子条款 9.2.2.4.1 中所述。

9.2.2.5 RNA更新

下图描述了涉及 Xn 上的上下文检索的 UE 触发的 RNA 更新过程。当UE移出配置的RNA时，或者在周期性RNA更新定时器到期时，可以触发该过程。

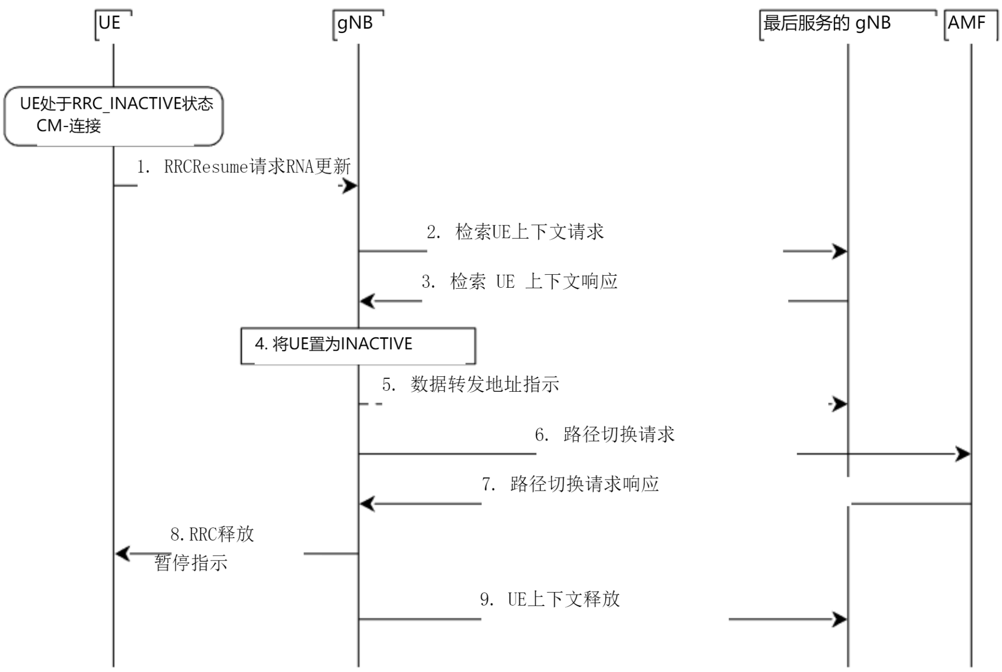


图9.2.2.5-1：UE上下文重定位的RNA更新过程

1. UE从RRC_INACTIVE恢复，提供最后一个服务gNB分配的I-RNTI和适当的原因值，例如RAN通知区域更新。
2. 如果 gNB 能够解析 I-RNTI 中包含的 gNB 标识，则请求最后一个服务 gNB 提供 UE 上下文，并提供在步骤 1 中接收到的原因值。
3. 最后一个服务 gNB 提供 UE 上下文。

4. The gNB may move the UE to RRC_CONNECTED (and the procedure follows step 4 of Figure 9.2.2.4.1-1), or send the UE back to RRC_IDLE (in which case an *RRCRelease* message is sent by the gNB and the procedure ends), or send the UE back to RRC_INACTIVE as assumed in the following.

5. If loss of DL user data buffered in the last serving gNB shall be prevented, the gNB provides forwarding addresses.

6./7. The gNB performs path switch.

8. The gNB moves the UE back to RRC_INACTIVE state by sending *RRCRelease* with suspend indication.

9. The gNB triggers the release of the UE resources at the last serving gNB.

The following figure describes the periodic RNA update procedure for the case when the last serving gNB decides not to relocate the UE context:

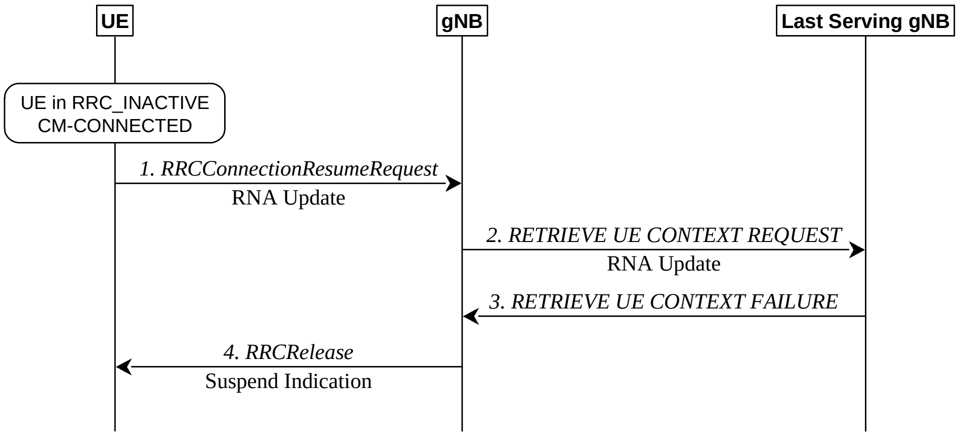


Figure 9.2.2.5-2: Periodic RNA update procedure without UE context relocation

1. The UE resumes from RRC_INACTIVE, providing the I-RNTI allocated by the last serving gNB and appropriate cause value, e.g., RAN notification area update.

2. The gNB, if able to resolve the gNB identity contained in the I-RNTI, requests the last serving gNB to provide UE Context, providing the cause value received in step 1.

3. The last serving gNB responds to the gNB with the RETRIEVE UE CONTEXT FAILURE message including an encapsulated RRC Connection Release message. The RRC message includes suspend configuration, if the last serving gNB decides to keep the UE in RRC_INACTIVE.

4. The gNB forwards the RRC Connection Release message to the UE.

9.2.3 Mobility in RRC_CONNECTED

9.2.3.1 Overview

Network controlled mobility applies to UEs in RRC_CONNECTED and is categorized into two types of mobility: cell level mobility and beam level mobility.

Cell Level Mobility requires explicit RRC signalling to be triggered, i.e. handover. For inter-gNB handover, the signalling procedures consist of at least the following elemental components illustrated in Figure 9.2.3.1-1:

4. gNB 可以将 UE 移至 RRC_CONNECTED（该过程遵循图 9.2.2.4.1-1 的步骤 4），或者将 UE 发送回 RRC_IDLE（在这种情况下，gNB 发送 RRCRelease 消息，并且该过程结束），或将 UE 发送回 RRC_INACTIVE，如下所示。

5. 如果应防止最后一个服务 gNB 中缓冲的 DL 用户数据丢失，则 gNB 提供转发地址。

6./7. gNB执行路径切换。

8. gNB 通过发送带有挂起指示的 RRCRRelease 将 UE 移回 RRC_INACTIVE 状态。

9. gNB 在最后一个服务 gNB 处触发 UE 资源的释放。

下图描述了最后一个服务 gNB 决定不重新定位 UE 上下文时的周期性 RNA 更新过程：

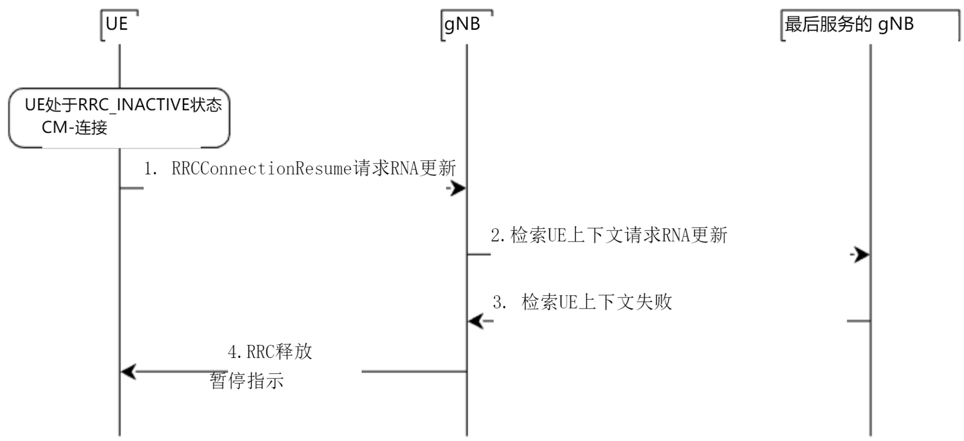


图9.2.2.5-2：无需UE上下文重定位的周期性RNA更新过程

1. UE从RRC_INACTIVE恢复，提供最后一个服务gNB分配的I-RNTI和适当的原因值，例如RAN通知区域更新。

2. 如果 gNB 能够解析 I-RNTI 中包含的 gNB 标识，则请求最后一个服务 gNB 提供 UE 上下文，并提供在步骤 1 中接收到的原因值。

3. 最后一个服务 gNB 使用 RETRIEVE UE CONTEXT FAILURE 消息（包括封装的 RRC 连接释放消息）来响应 gNB。如果最后一个服务 gNB 决定将 UE 保持在 RRC_INACTIVE 状态，则 RRC 消息包括暂停配置。

4. gNB将RRC连接释放消息转发给UE。

9.2.3 RRC_CONNECTED 中的移动性

9.2.3.1 概述

网络控制的移动性适用于RRC_CONNECTED中的UE，并分为两种类型的移动性：小区级移动性和波束级移动性。

小区级移动性需要触发显式的 RRC 信令，即切换。对于 gNB 间切换，信令过程至少由图 9.2.3.1-1 所示的以下基本组件组成：

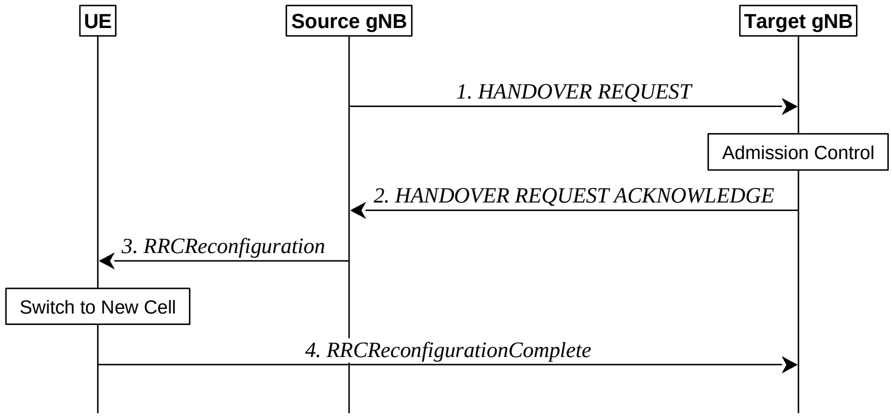


Figure 9.2.3.1-1: Inter-gNB handover procedures

1. The source gNB initiates handover and issues a Handover Request over the Xn interface.
2. The target gNB performs admission control and provides the RRC configuration as part of the Handover Acknowledgement.
3. The source gNB provides the RRC configuration to the UE in the Handover Command. The Handover Command message includes at least cell ID and all information required to access the target cell so that the UE can access the target cell without reading system information. For some cases, the information required for contention-based and contention-free random access can be included in the Handover Command message. The access information to the target cell may include beam specific information, if any.
4. The UE moves the RRC connection to the target gNB and replies the Handover Complete.

NOTE: User Data can also be sent in step 4 if the grant allows.

The handover mechanism triggered by RRC requires the UE at least to reset the MAC entity and re-establish RLC. RRC managed handovers with and without PDCP entity re-establishment are both supported. For DRBs using RLC AM mode, PDCP can either be re-established together with a security key change or initiate a data recovery procedure without a key change. For DRBs using RLC UM mode and for SRBs, PDCP can either be re-established together with a security key change or remain as it is without a key change.

Data forwarding, in-sequence delivery and duplication avoidance at handover can be guaranteed when the target gNB uses the same DRB configuration as the source gNB.

Timer based handover failure procedure is supported in NR. RRC connection re-establishment procedure is used for recovering from handover failure.

Beam Level Mobility does not require explicit RRC signalling to be triggered. The gNB provides via RRC signalling the UE with measurement configuration containing configurations of SSB/CSI resources and resource sets, reports and trigger states for triggering channel and interference measurements and reports. Beam Level Mobility is then dealt with at lower layers by means of physical layer and MAC layer control signalling, and RRC is not required to know which beam is being used at a given point in time.

9.2.3.2 Handover

9.2.3.2.1 C-Plane Handling

The intra-NR RAN handover performs the preparation and execution phase of the handover procedure performed without involvement of the 5GC, i.e. preparation messages are directly exchanged between the gNBs. The release of the resources at the source gNB during the handover completion phase is triggered by the target gNB. The figure below depicts the basic handover scenario where neither the AMF nor the UPF changes:

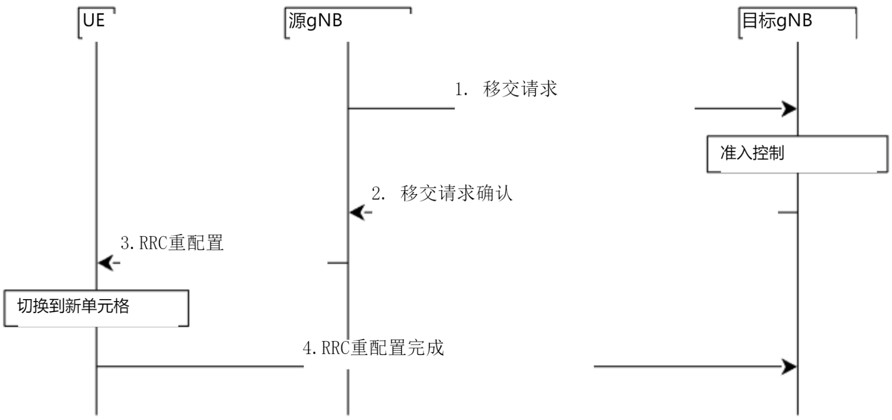


图9.2.3.1-1：gNB间切换流程

1. 源gNB发起切换并通过Xn接口发出切换请求。

2. 目标 gNB 执行准入控制并提供 RRC 配置作为切换确认的一部分。

3. 源gNB在切换命令中向UE提供RRC配置。切换命令消息至少包括小区ID和接入目标小区所需的所有信息，使得UE无需读取系统信息即可接入目标小区。
对于某些情况，基于竞争和无竞争的随机接入所需的信息可以包括在切换命令消息中。对目标小区的接入信息可以包括波束特定信息（如果有的话）。

4. UE将RRC连接移动到目标gNB并回复切换完成。

笔记： 如果授权允许，也可以在步骤 4 中发送用户数据。

RRC触发的切换机制需要UE至少重置MAC实体并重新建立RLC。支持 RRC 管理的带或不带 PDCP 实体重建的切换。
对于使用 RLC AM 模式的 DRB，PDCP 可以与安全密钥更改一起重新建立，也可以在不更改密钥的情况下启动数据恢复过程。
对于使用 RLC UM 模式的 DRB 和 SRB，PDCP 可以与安全密钥更改一起重新建立，也可以保持原样而不更改密钥。

当目标 gNB 使用与源 gNB 相同的 DRB 配置时，可以保证切换时的数据转发、按顺序传送和避免重复。

NR 支持基于计时器的切换失败过程。 RRC连接重建过程用于从切换失败中恢复。

波束级移动性不需要触发显式的 RRC 信令。
gNB 通过 RRC 信令向 UE 提供测量配置，其中包含 SSB/CSI 资源和资源集的配置、报告以及用于触发信道和干扰测量和报告的触发状态。
然后，波束级移动性通过物理层和MAC层控制信令在较低层进行处理，并且RRC不需要知道在给定时间点正在使用哪个波束。

9.2.3.2 交出

9.2.3.2.1 C 平面处理

NR RAN 内切换执行切换过程的准备和执行阶段，而无需 5GC 的参与，即准备消息在 gNB 之间直接交换。
切换完成阶段源gNB资源的释放由目标gNB触发。下图描述了AMF和UPF均不改变的基本切换场景：

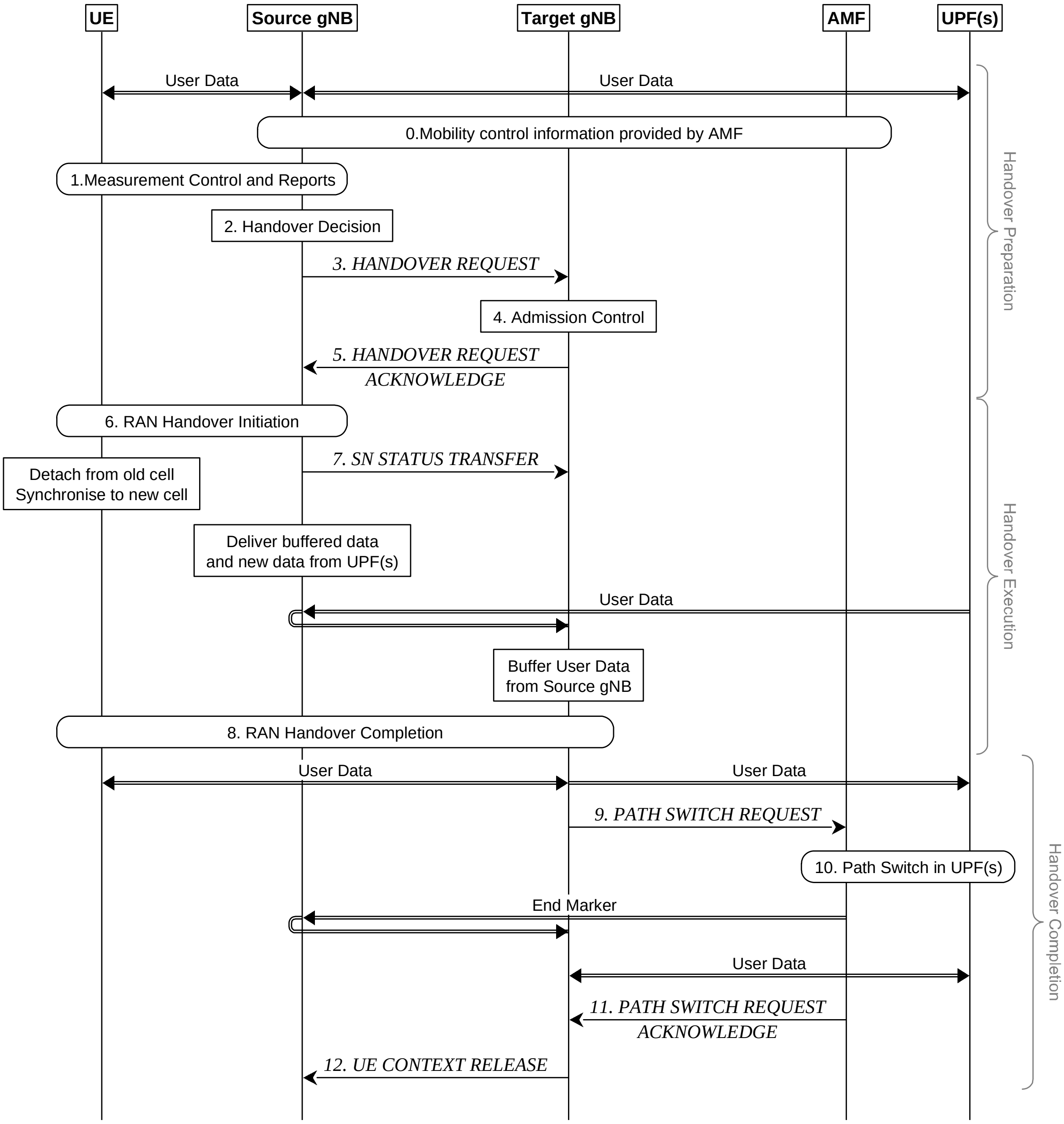


Figure 9.2.3.2.1-1: Intra-AMF/UPF Handover

0. The UE context within the source gNB contains information regarding roaming and access restrictions which were provided either at connection establishment or at the last TA update.

1. The source gNB configures the UE measurement procedures and the UE reports according to the measurement configuration.

2. The source gNB decides to handover the UE, based on *MeasurementReport* and RRM information.

3. The source gNB issues a Handover Request message to the target gNB passing a transparent RRC container with necessary information to prepare the handover at the target side. The information includes at least the target cell ID, KgNB*, the C-RNTI of the UE in the source gNB, RRM-configuration including UE inactive time, basic AS-configuration including *antenna Info and DL Carrier Frequency*, the current QoS flow to DRB mapping rules applied to the UE, the minimum system information from source gNB, the UE capabilities for different RATs, PDU session related information, and can include the UE reported measurement information including beam-related information if available. The PDU session related information includes the slice information (if supported) and QoS flow level QoS profile(s).

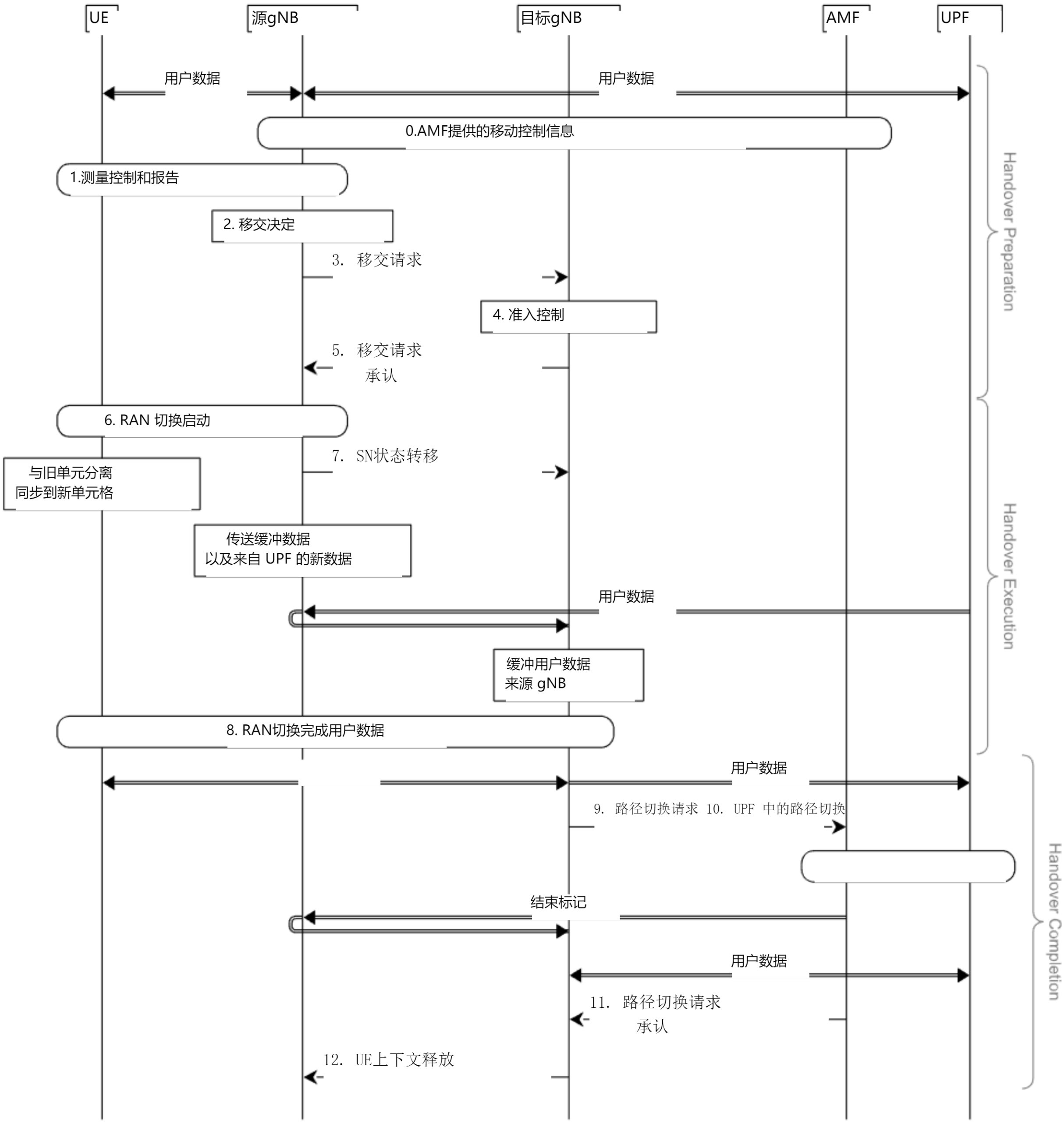


图 9.2.3.2.1-1：AMF/UPF 内切换

0. 源 gNB 内的 UE 上下文包含有关漫游和接入限制的信息，这些信息在连接建立时或最后一次 TA 更新时提供。

1. 源gNB配置UE测量过程，并且UE根据测量配置进行报告。

2. 源gNB根据MeasurementReport和RRM信息决定切换UE。

3. 源 gNB 向目标 gNB 发出切换请求消息，传递带有必要信息的透明 RRC 容器，以便在目标侧准备切换。
   该信息至少包括目标小区 ID、KgNB*、源 gNB 中 UE 的 C-RNTI、包括 UE 不活动时间的 RRM 配置、包括天线信息和 DL 载波频率的基本 AS 配置、当前 QoS 流应用于UE的DRB映射规则、来自源gNB的最小系统信息、不同RAT的UE能力、PDU会话相关信息，并且可以包括UE报告的测量信息，包括波束相关信息（如果可用）。
   PDU 会话相关信息包括切片信息（如果支持）和 QoS 流级别 QoS 配置文件。

4. Admission Control may be performed by the target gNB. Slice-aware admission control shall be performed if the slice information is sent to the target gNB. If the PDU sessions are associated with non-supported slices the target gNB shall reject such PDU Sessions.

5. The target gNB prepares the handover with L1/L2 and sends the HANDOVER REQUEST ACKNOWLEDGE to the source gNB, which includes a transparent container to be sent to the UE as an RRC message to perform the handover.

6. The source gNB triggers the Uu handover by sending an *RRCReconfiguration* message to the UE, containing the information required to access the target cell: at least the target cell ID, the new C-RNTI, the target gNB security algorithm identifiers for the selected security algorithms. It can also include a set of dedicated RACH resources, the association between RACH resources and SSB(s), the association between RACH resources and UE-specific CSI-RS configuration(s), common RACH resources, and target cell SIBs, etc.

7. The source gNB sends the SN STATUS TRANSFER message to the target gNB.

8. The UE synchronises to the target cell and completes the RRC handover procedure by sending *RRCReconfigurationComplete* message to target gNB.

9. The target gNB sends a PATH SWITCH REQUEST message to AMF to trigger 5GC to switch the DL data path towards the target gNB and to establish an NG-C interface instance towards the target gNB.

10. 5GC switches the DL data path towards the target gNB. The UPF sends one or more "end marker" packets on the old path to the source gNB per PDU session/tunnel and then can release any U-plane/TNL resources towards the source gNB.

11. The AMF confirms the PATH SWITCH REQUEST message with the PATH SWITCH REQUEST ACKNOWLEDGE message.

12. Upon reception of the PATH SWITCH REQUEST ACKNOWLEDGE message from the AMF, the target gNB sends the UE CONTEXT RELEASE to inform the source gNB about the success of the handover. The source gNB can then release radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

The RRM configuration can include both beam measurement information (for layer 3 mobility) associated to SSB(s) and CSI-RS(s) for the reported cell(s) if both types of measurements are available. Also, if CA is configured, the RRM configuration can include the list of best cells on each frequency for which measurement information is available. And the RRM measurement information can also include the beam measurement for the listed cells that belong to the target gNB.

The common RACH configuration for beams in the target cell is only associated to the SSB(s). The network can have dedicated RACH configurations associated to the SSB(s) and/or have dedicated RACH configurations associated to CSI-RS(s) within a cell. The target gNB can only include one of the following RACH configurations in the Handover Command to enable the UE to access the target cell:

i) Common RACH configuration;

ii) Common RACH configuration + Dedicated RACH configuration associated with SSB;

iii) Common RACH configuration + Dedicated RACH configuration associated with CSI-RS.

The dedicated RACH configuration allocates RACH resource(s) together with a quality threshold to use them. When dedicated RACH resources are provided, they are prioritized by the UE and the UE shall not switch to contention-based RACH resources as long as the quality threshold of those dedicated resources is met. The order to access the dedicated RACH resources is up to UE implementation.

9.2.3.2.2 U-Plane Handling

The U-plane handling during the Intra-NR-Access mobility activity for UEs in RRC_CONNECTED takes the following principles into account to avoid data loss during HO:

- During HO preparation U-plane tunnels can be established between the source gNB and the target gNB;
- During HO execution, user data can be forwarded from the source gNB to the target gNB.

4. 准入控制可以由目标gNB执行。如果分片信息发送到目标 gNB，则应执行分片感知准入控制。如果 PDU 会话与不支持的切片相关联，则目标 gNB 应拒绝此类 PDU 会话。

5. 目标 gNB 使用 L1/L2 准备切换，并将切换请求确认发送到源 gNB，其中包括要作为 RRC 消息发送到 UE 以执行切换的透明容器。

6. 源gNB通过向UE发送RRCReconfiguration消息来触发Uu切换，该消息包含接入目标小区所需的信息：至少目标小区ID、新的C-RNTI、所选安全算法的目标gNB安全算法标识符。它还可以包括一组专用RACH资源、RACH资源和SSB之间的关联、RACH资源和UE特定的CSI-RS配置之间的关联、公共RACH资源和目标小区SIB等。

7. 源gNB向目标gNB发送SN STATUS TRANSFER消息。

8. UE通过向目标gNB发送RRCReconfigurationComplete消息来同步到目标小区并完成RRC切换过程。

9. 目标 gNB 向 AMF 发送 PATH SWITCH REQUEST 消息，以触发 5GC 将 DL 数据路径切换到目标 gNB，并建立到目标 gNB 的 NG-C 接口实例。

10. 5GC 将 DL 数据路径切换到目标 gNB。 UPF 在每个 PDU 会话/隧道的旧路径上向源 gNB 发送一个或多个“结束标记”数据包，然后可以向源 gNB 释放任何 U 平面/TNL 资源。

11. AMF 使用 PATH SWITCH REQUEST ACKNOWLEDGE 消息确认 PATH SWITCH REQUEST 消息。

12. 当接收到来自 AMF 的 PATH SWITCH REQUEST ACKNOWLEDGE 消息时，目标 gNB 发送 UE CONTEXT RELEASE 以通知源 gNB 切换成功。然后，源 gNB 可以释放与 UE 上下文关联的无线电和 C 平面相关资源。
任何正在进行的数据转发都可以继续。

如果两种类型的测量都可用，则 RRM 配置可以包括与所报告的小区的 SSB 和 CSI-RS 相关联的波束测量信息（用于第 3 层移动性）。
此外，如果配置了 CA，则 RRM 配置可以包括每个频率上可获得测量信息的最佳小区列表。并且RRM测量信息还可以包括属于目标gNB的所列出的小区的波束测量。

目标小区中波束的公共 RACH 配置仅与 SSB 相关联。网络可以具有与SSB相关联的专用RACH配置和/或具有与小区内的CSI-RS相关联的专用RACH配置。
目标gNB只能在切换命令中包含以下RACH配置之一，以使UE能够接入目标小区：

i） 通用RACH配置；

ii） 公共RACH配置+与SSB相关的专用RACH配置；

iii） 公共RACH配置+与CSI-RS相关联的专用RACH配置。

专用 RACH 配置分配 RACH 资源以及使用它们的质量阈值。
当提供专用RACH资源时，它们由UE确定优先级，并且只要满足这些专用资源的质量阈值，UE就不应切换到基于竞争的RACH资源。
访问专用RACH资源的顺序取决于UE的实现。

9.2.3.2.2 U 平面处理

RRC_CONNECTED 中的 UE 的 Intra-NR-Access 移动性活动期间的 U 平面处理考虑以下原则，以避免 HO 期间的数据丢失：

- 在HO准备期间，可以在源gNB和目标gNB之间建立U平面隧道；
- 在HO执行期间，可以将用户数据从源gNB转发到目标gNB。

  - Forwarding should take place in order as long as packets are received at the source gNB from the UPF or the source gNB buffer has not been emptied.

- During HO completion:

  - The target gNB sends a path switch request message to the AMF to inform that the UE has gained access and the AMF then triggers path switch related 5GC internal signalling and actual path switch of the source gNB to the target gNB in UPF;

  - The source gNB should continue forwarding data as long as packets are received at the source gNB from the UPF or the source gNB buffer has not been emptied.

For RLC-AM bearers:

- For in-sequence delivery and duplication avoidance, PDCP SN is maintained on a per DRB basis and the source gNB informs the target gNB about the next DL PDCP SN to allocate to a packet which does not have a PDCP sequence number yet (either from source gNB or from the UPF).

- For security synchronisation, HFN is also maintained and the source gNB provides to the target one reference HFN for the UL and one for the DL i.e. HFN and corresponding SN.

- In both the UE and the target gNB, a window-based mechanism is used for duplication detection and reordering.

- The occurrence of duplicates over the air interface in the target gNB is minimised by means of PDCP SN based reporting at the target gNB by the UE. In uplink, the reporting is optionally configured on a per DRB basis by the gNB and the UE should first start by transmitting those reports when granted resources are in the target gNB. In downlink, the gNB is free to decide when and for which bearers a report is sent and the UE does not wait for the report to resume uplink transmission.

- The target gNB re-transmits and prioritizes all downlink data forwarded by the source gNB (i.e. the target gNB should first send all forwarded PDCP SDUs with PDCP SNs, then all forwarded downlink SDAP SDUs before sending new data from 5GC), excluding PDCP SDUs for which the reception was acknowledged through PDCP SN based reporting by the UE.

NOTE: Lossless delivery when a QoS flow is mapped to a different DRB at handover, requires the old DRB to be configured in the target cell. For in-order delivery in the DL, the target gNB should first transmit the forwarded PDCP SDUs on the old DRB before transmitting new data from 5GCN on the new DRB. In the UL, the target gNB should not deliver data of the QoS flow from the new DRB to 5GCN before receiving the end marker on the old DRB from the UE.

- The UE re-transmits in the target gNB all uplink PDCP SDUs starting from the oldest PDCP SDU that has not been acknowledged at RLC in the source, excluding PDCP SDUs for which the reception was acknowledged through PDCP SN based reporting by the target.

For RLC-UM bearers:

- The PDCP SN and HFN are reset in the target gNB;

- No PDCP SDUs are retransmitted in the target gNB;

- The target gNB prioritises all downlink SDAP SDUs forwarded by the source gNB over the data from the core network;

NOTE: To minimise losses when a QoS flow is mapped to a different DRB at handover, the old DRB needs to be configured in the target cell. For in-order delivery in the DL, the target gNB should first transmit the forwarded PDCP SDUs on the old DRB before transmitting new data from 5GCN on the new DRB. In the UL, the target gNB should not deliver data of the QoS flow from the new DRB to 5GCN before receiving the end marker on the old DRB from the UE.

- The UE does not retransmit any PDCP SDU in the target cell for which transmission had been completed in the source cell.

9.2.3.2.3 Data Forwarding

The following description depicts the data forwarding principles for intra-system handover.

  - 只要源 gNB 从 UPF 接收到数据包或者源 gNB 缓冲区尚未清空，转发就应该按顺序进行。

- HO 完成期间：

  - 目标gNB向AMF发送路径切换请求消息，告知UE已接入，AMF触发路径切换相关的5GC内部信令以及UPF中源gNB到目标gNB的实际路径切换；

  - 只要源 gNB 从 UPF 接收到数据包或者源 gNB 缓冲区尚未清空，源 gNB 就应该继续转发数据。

对于 RLC-AM 承载：

- 为了按顺序传送和避免重复，PDCP SN 以每个 DRB 为基础进行维护，并且源 gNB 通知目标 gNB 下一个 DL PDCP SN，以分配给尚未具有 PDCP 序列号的数据包（来自源gNB 或来自 UPF）。

- 为了安全同步，还维护 HFN，并且源 gNB 向目标提供一个用于 UL 的参考 HFN 和一个用于 DL 的参考 HFN，即 HFN 和相应的 SN。

- 在UE和目标gNB中，基于窗口的机制用于重复检测和重新排序。

- 通过 UE 在目标 gNB 处进行基于 PDCP SN 的报告，可以最大程度地减少目标 gNB 中空中接口上重复的发生。
  在上行链路中，报告可选地由 gNB 基于每个 DRB 进行配置，并且当授权的资源位于目标 gNB 中时，UE 应首先开始发送这些报告。
  在下行链路中，gNB 可以自由决定何时以及针对哪些承载发送报告，并且 UE 无需等待报告即可恢复上行链路传输。

- 目标 gNB 重传源 gNB 转发的所有下行数据并确定优先级（即
  目标 gNB 应首先发送带有 PDCP SN 的所有转发的 PDCP SDU，然后在从 5GC 发送新数据之前发送所有转发的下行链路 SDAP SDU，不包括通过 UE 基于 PDCP SN 的报告确认接收的 PDCP SDU。

笔记： 当 QoS 流在切换时映射到不同的 DRB 时，无损传送需要在目标小区中配置旧的 DRB。
对于 DL 中的按顺序传递，目标 gNB 应首先在旧 DRB 上传输转发的 PDCP SDU，然后再在新 DRB 上传输来自 5GCN 的新数据。
在 UL 中，在从 UE 接收到旧 DRB 上的结束标记之前，目标 gNB 不应将 QoS 流的数据从新 DRB 传递到 5GCN。

- UE在目标gNB中重传从源中的RLC尚未确认的最旧的PDCP SDU开始的所有上行链路PDCP SDU，不包括通过目标通过基于PDCP SN的报告确认接收的PDCP SDU。

对于 RLC-UM 承载者：

- PDCP SN和HFN在目标gNB中重置；

- 目标 gNB 中没有重传 PDCP SDU；

- 目标gNB将源gNB转发的所有下行SDAP SDU优先于来自核心网的数据；

笔记： 为了最大限度地减少切换时 QoS 流映射到不同 DRB 时的损失，需要在目标小区中配置旧 DRB。
对于 DL 中的按顺序传递，目标 gNB 应首先在旧 DRB 上传输转发的 PDCP SDU，然后再在新 DRB 上传输来自 5GCN 的新数据。
在 UL 中，在从 UE 接收到旧 DRB 上的结束标记之前，目标 gNB 不应将 QoS 流的数据从新 DRB 传递到 5GCN。

- UE不在目标小区中重传已经在源小区中完成传输的任何PDCP SDU。

9.2.3.2.3 数据转发

下面描述系统内切换的数据转发原理。

The source NG-RAN node may suggest downlink data forwarding per QoS flow established for a PDU session and may provide information how it maps QoS flows to DRBs. The target NG-RAN node decides data forwarding per QoS flow established for a PDU Session.

If "lossless handover" is required and the target NG-RAN node applies the same QoS flows to DRB mapping for a DRB and if all QoS flows mapped to that DRB are accepted for data forwarding, the target NG-RAN node establishes a downlink forwarding tunnel for that DRB.

For a DRB for which preservation of SN status applies, the target NG-RAN node may decide to establish an UL data forwarding tunnel.

The target NG-RAN node may also decide to establish a downlink forwarding tunnel for each PDU session. In this case the target NG-RAN node provides information for which QoS flows data forwarding has been accepted and corresponding UP TNL information for data forwarding tunnels to be established between the source NG-RAN node and the target NG-RAN node.

As long as data forwarding of DL user data packets takes place, the source NG-RAN node shall forward user data in the same forwarding tunnel, i.e.

- for any QoS flow accepted for data forwarding by the target NG-RAN node and for which a DRB DL forwarding tunnel was established for a DRB to which this QoS flow was mapped at the source NG-RAN node, any fresh packets of this QoS flow shall be forwarded as PDCP SDUs via the mapped DRB DL forwarding tunnel.
- for DRBs for which preservation of SN status applies, the source NG-RAN node may forward in order to the target NG-RAN node via the DRB DL forwarding tunnel all downlink PDCP SDUs with their SN corresponding to PDCP PDUs which have not been acknowledged by the UE.
- for DRBs for which preservation of SN status applies the source NG-RAN node either:
    - discards the uplink PDCP PDUs received out of sequence if the source NG-RAN node has not accepted the request from the target NG-RAN node for uplink forwarding or if the target NG-RAN node has not requested uplink forwarding for the bearer during the Handover Preparation procedure; or
    - forwards to the target NG-RAN node the uplink PDCP PDUs received out of sequence if the source NG-RAN node has accepted the request from the target NG-RAN node for uplink forwarding for the bearer during the Handover Preparation procedure.

Handling of end marker packets:

- The source NG-RAN node receives one or several GTP-U end marker packets per PDU session from the UPF and replicates the end marker packets into each data forwarding tunnel when no more user data packets are to be forwarded over that tunnel.
- End marker packets sent via a data forwarding tunnel are applicable to all QoS flows forwarded via that tunnel. After end marker packets have been received over a forwarding tunnel, the target NG-RAN node can start taking into account the packets of QoS flows associated with that forwarding tunnel received at the target NG-RAN node from the NG-U PDU session tunnel.

9.2.3.3 Re-establishment procedure

A UE in RRC_CONNECTED may initiate the re-establishment procedure to continue the RRC connection when a failure condition occurs (e.g. radio link failure, reconfiguration failure, integrity check failure…).

The following figure describes the re-establishment procedure started by the UE:

源NG-RAN节点可以建议为PDU会话建立的每个QoS流的下行链路数据转发，并且可以提供其如何将QoS流映射到DRB的信息。目标 NG-RAN 节点决定为 PDU 会话建立的每个 QoS 流的数据转发。

如果需要“无损切换”并且目标 NG-RAN 节点将相同的 QoS 流应用于 DRB 的 DRB 映射，并且如果映射到该 DRB 的所有 QoS 流都被接受用于数据转发，则目标 NG-RAN 节点建立下行链路转发该 DRB 的隧道。

对于适用SN状态保留的DRB，目标NG-RAN节点可以决定建立UL数据转发隧道。

目标NG-RAN节点还可以决定为每个PDU会话建立下行链路转发隧道。

在这种情况下，目标NG-RAN节点提供已接受其QoS流数据转发的信息以及用于要在源NG-RAN节点和目标NG-RAN节点之间建立的数据转发隧道的相应UP TNL信息。

只要发生DL用户数据包的数据转发，源NG-RAN节点就应在同一个转发隧道中转发用户数据，即

- 对于目标 NG-RAN 节点接受用于数据转发的任何 QoS 流，并且为该 QoS 流在源 NG-RAN 节点处映射到的 DRB 建立了 DRB DL 转发隧道，该 QoS 流的任何新鲜数据包应通过映射的 DRB DL 转发隧道作为 PDCP SDU 转发。

- 对于适用SN状态保留的DRB，源NG-RAN节点可以通过DRB DL转发隧道按顺序向目标NG-RAN节点转发所有下行链路PDCP SDU，其SN对应于尚未由源NG-RAN节点确认的PDCP PDU用户设备。

- 对于源 NG-RAN 节点应用 SN 状态保存的 DRB：
  - 如果源 NG-RAN 节点未接受目标 NG-RAN 节点的上行转发请求，或者目标 NG-RAN 节点在切换期间未请求承载的上行转发，则丢弃乱序接收的上行 PDCP PDU准备程序；或者
  - 如果源 NGRAN 节点在切换准备过程期间接受了目标 NG-RAN 节点对承载的上行转发请求，则将乱序接收到的上行 PDCP PDU 转发到目标 NG-RAN 节点。

结束标记数据包的处理：

- 源 NG-RAN 节点从 UPF 接收每个 PDU 会话的一个或多个 GTP-U 结束标记数据包，并在不再需要通过该隧道转发用户数据包时将结束标记数据包复制到每个数据转发隧道中。

- 通过数据转发隧道发送的结束标记数据包适用于通过该隧道转发的所有 QoS 流。
  在通过转发隧道接收到结束标记分组之后，目标NG-RAN节点可以开始考虑与在目标NG-RAN节点处从NG-U PDU会话隧道接收到的转发隧道相关联的QoS流的分组。

9.2.3.3 重建程序

当发生故障情况（例如无线链路故障、重新配置失败、完整性检查失败……）时，RRC_CONNECTED 中的 UE 可以发起重建过程以继续 RRC 连接。

下图描述了UE发起的重建过程：

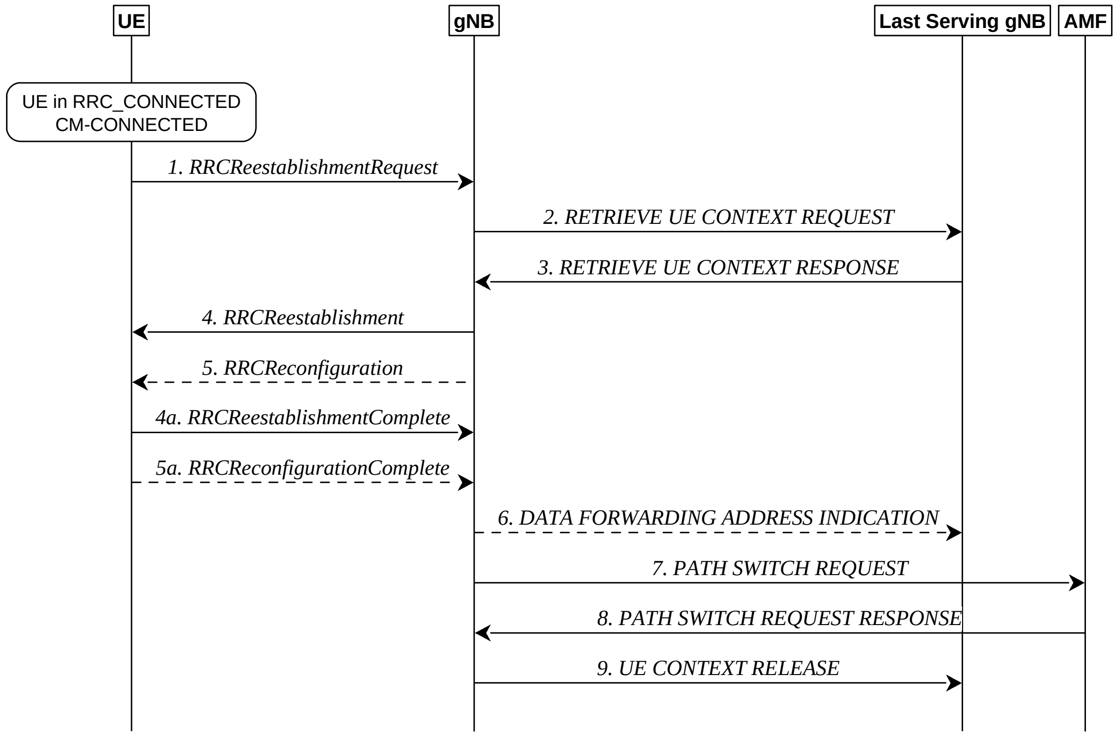


Figure 9.2.3.3-1: Re-establishment procedure

1. The UE re-establishes the connection, providing the UE Identity (PCI+C-RNTI) to the gNB where the trigger for the re-establishment occurred.

2. If the UE Context is not locally available, the gNB, requests the last serving gNB to provide UE Context data.

3. The last serving gNB provides UE context data.

4/4a. The gNB continues the re-establishment of the RRC connection. The message is sent on SRB1.

5/5a. The gNB may perform the reconfiguration to re-establish SRB2 and DRBs when the re-establishment procedure is ongoing.

6. If loss of DL user data buffered in the last serving gNB shall be prevented, the gNB provides forwarding addresses.

7/8. The gNB performs path switch.

9. The gNB triggers the release of the UE resources at the last serving gNB.

9.2.4 Measurements

In RRC_CONNECTED, the UE measures multiple beams (at least one) of a cell and the measurements results (power values) are averaged to derive the cell quality. In doing so, the UE is configured to consider a subset of the detected beams. Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams. Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s). Measurement reports may contain the measurement results of the *X* best beams if the UE is configured to do so by the gNB.

The corresponding high-level measurement model is described below:

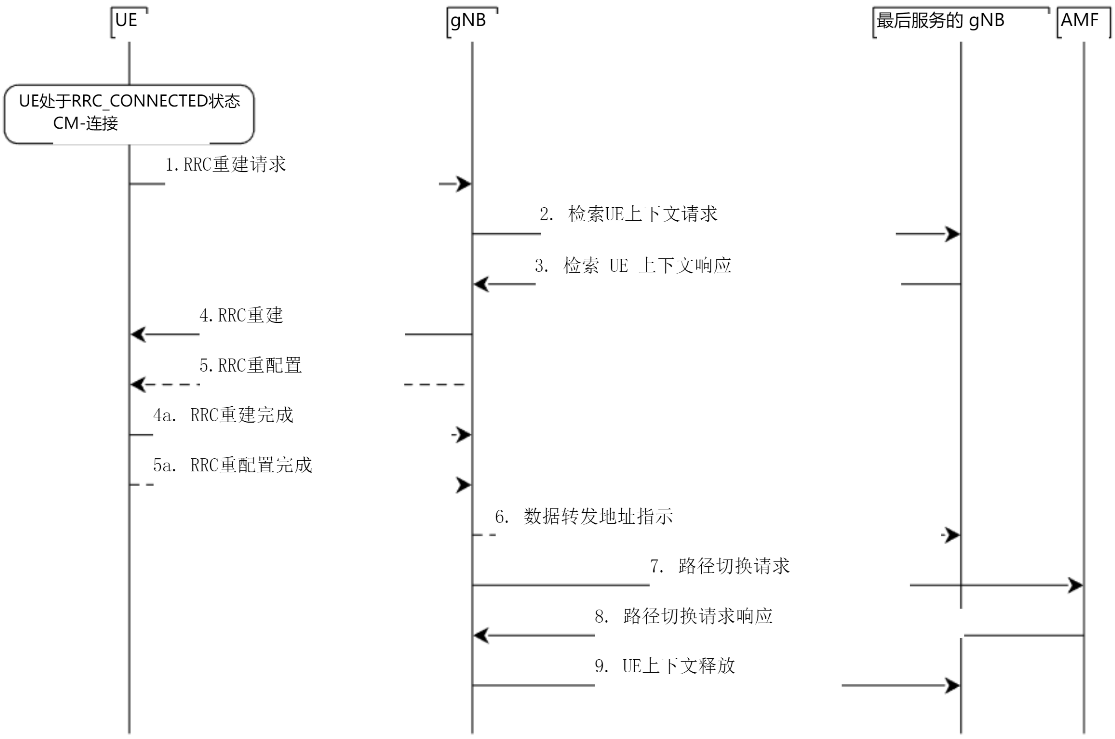


图9.2.3.3-1：重建过程

1. UE 重新建立连接，向发生重建触发的 gNB 提供 UE 身份 (PCI+C-RNTI)。

2. 如果 UE 上下文在本地不可用，则 gNB 请求最后一个服务 gNB 提供 UE 上下文数据。

3. 最后一个服务 gNB 提供 UE 上下文数据。

4/4a。 gNB继续重建RRC连接。该消息在 SRB1 上发送。

5/5a。当重建过程正在进行时，gNB可以执行重新配置以重建SRB2和DRB。

6. 如果应防止最后一个服务 gNB 中缓冲的 DL 用户数据丢失，则 gNB 提供转发地址。

7/8。 gNB执行路径切换。

9. gNB 在最后一个服务 gNB 处触发 UE 资源的释放。

9.2.4 测量

在RRC_CONNECTED中，UE测量小区的多个波束（至少一个）并对测量结果（功率值）进行平均以得出小区质量。这样做时，UE被配置为考虑检测到的波束的子集。过滤发生在两个不同的级别：在物理层导出波束质量，然后在 RRC 级别从多个波束导出小区质量。对于服务小区和非服务小区，以相同的方式从波束测量得出小区质量。
如果 gNB 将 UE 配置为这样做，则测量报告可以包含 X 个最佳波束的测量结果。

相应的高级测量模型描述如下：

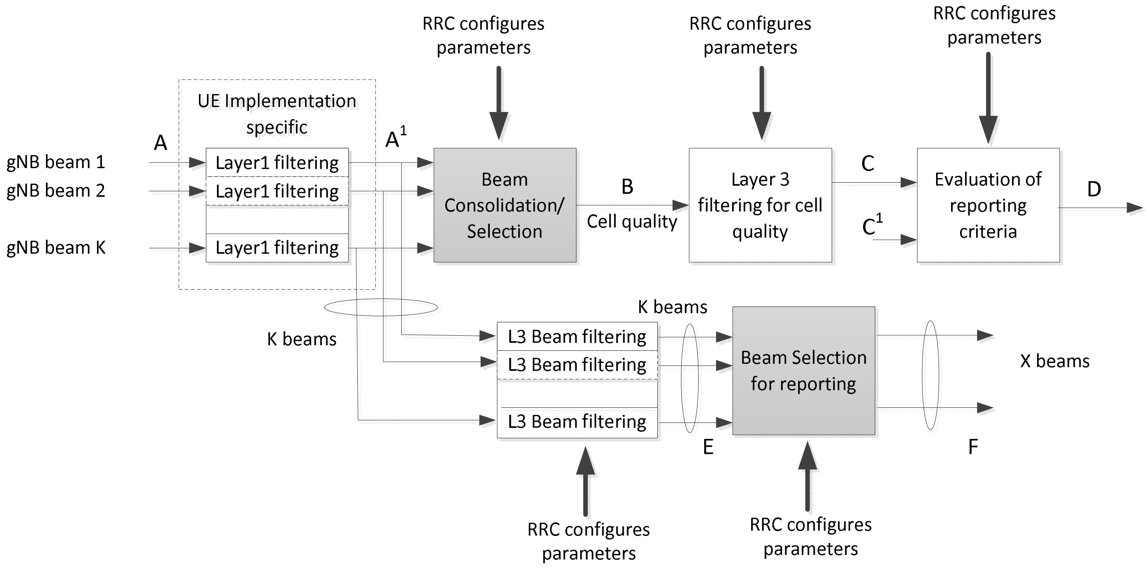


Figure 9.2.4-1: Measurement Model

NOTE: K beams correspond to the measurements on SSB or CSI-RS resources configured for L3 mobility by gNB and detected by UE at L1.

- **A**: measurements (beam specific samples) internal to the physical layer.
- **Layer 1 filtering**: internal layer 1 filtering of the inputs measured at point A. Exact filtering is implementation dependent. How the measurements are actually executed in the physical layer by an implementation (inputs A and Layer 1 filtering) in not constrained by the standard.
- **A^1**: measurements (i.e. beam specific measurements) reported by layer 1 to layer 3 after layer 1 filtering.
- **Beam Consolidation/Selection**: beam specific measurements are consolidated to derive cell quality. The behaviour of the Beam consolidation/selection is standardised and the configuration of this module is provided by RRC signalling. Reporting period at B equals one measurement period at A^1.
- **B**: a measurement (i.e. cell quality) derived from beam-specific measurements reported to layer 3 after beam consolidation/selection.
- **Layer 3 filtering for cell quality**: filtering performed on the measurements provided at point B. The behaviour of the Layer 3 filters is standardised and the configuration of the layer 3 filters is provided by RRC signalling. Filtering reporting period at C equals one measurement period at B.
- **C**: a measurement after processing in the layer 3 filter. The reporting rate is identical to the reporting rate at point B. This measurement is used as input for one or more evaluation of reporting criteria.
- **Evaluation of reporting criteria**: checks whether actual measurement reporting is necessary at point D. The evaluation can be based on more than one flow of measurements at reference point C e.g. to compare between different measurements. This is illustrated by input C and C^1. The UE shall evaluate the reporting criteria at least every time a new measurement result is reported at point C, C^1. The reporting criteria are standardised and the configuration is provided by RRC signalling (UE measurements).
- **D**: measurement report information (message) sent on the radio interface.
- **L3 Beam filtering**: filtering performed on the measurements (i.e. beam specific measurements) provided at point A^1. The behaviour of the beam filters is standardised and the configuration of the beam filters is provided by RRC signalling. Filtering reporting period at E equals one measurement period at A^1.
- **E**: a measurement (i.e. beam-specific measurement) after processing in the beam filter. The reporting rate is identical to the reporting rate at point A^1. This measurement is used as input for selecting the X measurements to be reported.

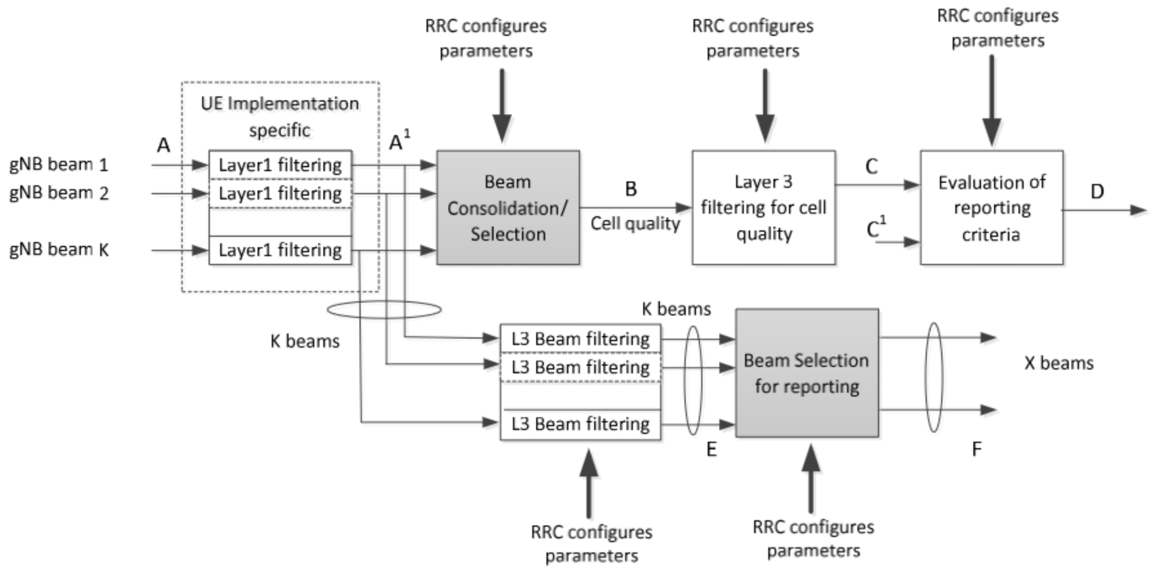


图 9.2.4-1：测量模型

笔记： K 个波束对应于 gNB 为 L3 移动性配置并由 UE 在 L1 处检测到的 SSB 或 CSI-RS 资源上的测量。

- A：物理层内部的测量（波束特定样本）。
- 第 1 层过滤：对 A 点测量的输入进行内部第 1 层过滤。精确的过滤取决于实现。如何通过实现（输入 A 和第 1 层过滤）在物理层中实际执行测量，不受标准限制。
- A：第 1 层过滤后由第 1 层向第 3 层报告的测量结果（即波束特定测量结果）。
- 波束合并/选择：合并波束特定测量值以得出小区质量。波束合并/选择的行为是标准化的，并且该模块的配置由 RRC 信令提供。
  B 处的报告周期等于 A 处的一个测量周期。
- B：从波束合并/选择后报告给第 3 层的波束特定测量得出的测量结果（即小区质量）。
- 针对小区质量的第 3 层过滤：对 B 点提供的测量结果执行过滤。第 3 层过滤器的行为是标准化的，并且第 3 层过滤器的配置由 RRC 信令提供。
  C 处的过滤报告周期等于 B 处的一个测量周期。
- C：在第 3 层滤波器中处理后的测量结果。报告速率与B点处的报告速率相同。该测量被用作对报告标准的一个或多个评估的输入。
- 报告标准评估：检查 D 点是否需要实际测量报告。评估可以基于参考点 C 处的多个测量流，例如比较不同的测量结果。输入 C 和 C 说明了这一点。
  UE应至少每次在点C、C报告新的测量结果时评估报告标准。报告标准是标准化的并且配置由RRC信令（UE测量）提供。
- D：无线接口上发送的测量报告信息（消息）。
- L3 波束过滤：对 A 点提供的测量（即波束特定测量）执行过滤。波束过滤器的行为是标准化的，并且波束过滤器的配置由 RRC 信令提供。
  E 处的过滤报告周期等于 A 处的一个测量周期。
- E：在光束滤波器中处理后的测量（即光束特定测量）。报告速率与A点的报告速率相同。该测量用作选择要报告的X个测量的输入。

- **Beam Selection for beam reporting**: selects the X measurements from the measurements provided at point E. The behaviour of the beam selection is standardised and the configuration of this module is provided by RRC signalling.
- **F**: beam measurement information included in measurement report (sent) on the radio interface.

Layer 1 filtering introduces a certain level of measurement averaging. How and when the UE exactly performs the required measurements is implementation specific to the point that the output at B fulfils the performance requirements set in 3GPP TS 38.133 [13]. Layer 3 filtering for cell quality and related parameters used are specified in 3GPP TS 38.331 [12] and do not introduce any delay in the sample availability between B and C. Measurement at point C, C^1 is the input used in the event evaluation. L3 Beam filtering and related parameters used are specified in 3GPP TS 38.331 [12] and do not introduce any delay in the sample availability between E and F.

Measurement reports are characterized by the following:

- Measurement reports include the measurement identity of the associated measurement configuration that triggered the reporting;
- Cell and beam measurement quantities to be included in measurement reports are configured by the network;
- The number of non-serving cells to be reported can be limited through configuration by the network;
- Cells belonging to a blacklist configured by the network are not used in event evaluation and reporting, and conversely when a whitelist is configured by the network, only the cells belonging to the whitelist are used in event evaluation and reporting;
- Beam measurements to be included in measurement reports are configured by the network (beam identifier only, measurement result and beam identifier, or no beam reporting).

Intra-frequency neighbour (cell) measurements and inter-frequency neighbour (cell) measurements are defined as follows:

- SSB based intra-frequency measurement: a measurement is defined as an SSB based intra-frequency measurement provided the center frequency of the SSB of the serving cell and the center frequency of the SSB of the neighbour cell are the same, and the subcarrier spacing of the two SSBs is also the same.
- SSB based inter-frequency measurement: a measurement is defined as an SSB based inter-frequency measurement provided the center frequency of the SSB of the serving cell and the center frequency of the SSB of the neighbour cell are different, or the subcarrier spacing of the two SSBs is different.

NOTE: for SSB based measurements, one measurement object corresponds to one SSB and the UE considers different SSBs as different cells.

- CSI-RS based intra-frequency measurement: a measurement is defined as a CSI-RS based intra-frequency measurement provided the bandwidth of the CSI-RS resource on the neighbour cell configured for measurement is within the bandwidth of the CSI-RS resource on the serving cell configured for measurement, and the subcarrier spacing of the two CSI-RS resources is the same.
- CSI-RS based inter-frequency measurement: a measurement is defined as a CSI-RS based inter-frequency measurement provided the bandwidth of the CSI-RS resource on the neighbour cell configured for measurement is not within the bandwidth of the CSI-RS resource on the serving cell configured for measurement, or the subcarrier spacing of the two CSI-RS resources is different.

Whether a measurement is non-gap-assisted or gap-assisted depends on the capability of the UE, the active BWP of the UE and the current operating frequency. In non-gap-assisted scenarios, the UE shall be able to carry out such measurements without measurement gaps. In gap-assisted scenarios, the UE cannot be assumed to be able to carry out such measurements without measurement gaps.

9.2.5 Paging

Paging allows the network to reach UEs in RRC_IDLE and in RRC_INACTIVE state, and to notify UEs in RRC_IDLE, RRC_INACTIVE and RRC_CONNECTED state of system information change (see subclause 7.3.3) and ETWS/CMAS indications (see subclause 16.4).

- 用于波束报告的波束选择：从 E 点提供的测量中选择 X 测量。波束选择的行为是标准化的，并且该模块的配置由 RRC 信令提供。

- F：无线电接口上（发送）的测量报告中包含的波束测量信息。

第 1 层过滤引入了一定程度的测量平均。 UE 如何以及何时准确地执行所需的测量是特定于 B 处的输出满足 3GPP TS 38.133 [13] 中设置的性能要求这一点的实现。
3GPP TS 38.331 [12] 中规定了针对小区质量和相关参数的第 3 层过滤，并且不会在 B 和 C 之间的样本可用性中引入任何延迟。C 点的测量，C 是事件评估中使用的输入。
3GPP TS 38.331 [12] 中规定了 L3 波束过滤和相关参数，并且不会在 E 和 F 之间的样本可用性中引入任何延迟。

测量报告具有以下特点：

- 测量报告包括触发报告的关联测量配置的测量标识；

- 测量报告中包含的小区和波束测量量由网络配置；

- 网络可以通过配置来限制上报的非服务小区的数量；

- 属于网络配置的黑名单的小区不用于事件评估和上报，反之当网络配置白名单时，只有属于白名单的小区用于事件评估和上报；

- 要包含在测量报告中的波束测量由网络配置（仅波束标识符、测量结果和波束标识符，或无波束报告）。

同频邻区（小区）测量和异频邻区（小区）测量定义如下：

- 基于SSB的同频测量：如果服务小区的SSB的中心频率与相邻小区的SSB的中心频率相同，并且子载波间隔为两个SSB也是一样的。

- 基于SSB的异频测量：如果服务小区的SSB中心频率与相邻小区的SSB中心频率不同，或者相邻小区的子载波间隔不同，则测量被定义为基于SSB的异频测量。两个SSB是不同的。

笔记： 对于基于SSB的测量，一个测量对象对应一个SSB，UE将不同的SSB视为不同的小区。

- 基于CSI-RS的频率内测量：如果配置用于测量的相邻小区上的CSI-RS资源的带宽在邻小区上的CSI-RS资源的带宽内，则测量被定义为基于CSI-RS的频率内测量。配置测量的服务小区，且两个CSI-RS资源的子载波间隔相同。

- 基于CSI-RS的异频测量：如果配置用于测量的相邻小区上的CSI-RS资源的带宽不在CSI-RS资源的带宽内，则测量被定义为基于CSI-RS的异频测量在配置测量的服务小区上，或者两个CSI-RS资源的子载波间隔不同。

测量是非间隙辅助还是间隙辅助取决于UE的能力、UE的活动BWP和当前工作频率。在非间隙辅助场景中，UE应能够在没有测量间隙的情况下执行此类测量。
在间隙辅助场景中，不能假设UE能够在没有测量间隙的情况下执行此类测量。

9.2.5 寻呼

寻呼允许网络到达处于RRC_IDLE和RRC_INACTIVE状态的UE，并通知处于RRC_IDLE、RRC_INACTIVE和RRC_CONNECTED状态的UE系统信息改变（参见子条款7.3.3）和ETWS/CMAS指示（参见子条款16.4）。

While in RRC_IDLE the UE monitors the paging channels for CN-initiated paging; in RRC_INACTIVE the UE also monitors paging channels for RAN-initiated paging. A UE need not monitor paging channels continuously though; Paging DRX is defined where the UE in RRC_IDLE or RRC_INACTIVE is only required to monitor paging channels during one Paging Occasions (PO) per DRX cycle (see 3GPP TS 38.304 [10]). The Paging DRX cycles are configured by the network:

1) For CN-initiated paging, a default cycle is broadcast in system information;

2) For CN-initiated paging, a UE specific cycle can be configured via NAS signalling;

3) For RAN-initiated paging, a UE-specific cycle can be configured via RRC signalling;

- The UE uses the shortest of the DRX cycles applicable i.e. a UE in RRC_IDLE uses the shortest of the first two cycles above, while a UE in RRC_INACTIVE uses the shortest of the three.

The POs of a UE for CN-initiated and RAN-initiated paging are based on the same UE ID, resulting in overlapping POs for both. The number of different POs in a DRX cycle is configurable via system information and a network may distribute UEs to those POs based on their IDs.

When in RRC_CONNECTED, the UE monitors the paging channels in any PO signalled in system information. In case of BA, a UE in RRC_CONNECTED only monitors paging channels on the active BWP.

Paging optimization for UEs in CM_IDLE: at UE context release, the NG-RAN node may provide the AMF with a list of recommended cells and NG-RAN nodes as assistance info for subsequent paging. The AMF may also provide Paging Attempt Information consisting of a Paging Attempt Count and the Intended Number of Paging Attempts and may include the Next Paging Area Scope. If Paging Attempt Information is included in the Paging message, each paged NG-RAN node receives the same information during a paging attempt. The Paging Attempt Count shall be increased by one at each new paging attempt. The Next Paging Area Scope, when present, indicates whether the AMF plans to modify the paging area currently selected at next paging attempt. If the UE has changed its state to CM CONNECTED the Paging Attempt Count is reset.

Paging optimization for UEs in RRC_INACTIVE: at RAN Paging, the serving NG-RAN node provides RAN Paging area information. The serving NG-RAN node may also provide RAN Paging attempt information. Each paged NG-RAN node receives the same RAN Paging attempt information during a paging attempt with the following content: Paging Attempt Count, the intended number of paging attempts and the Next Paging Area Scope. The Paging Attempt Count shall be increased by one at each new paging attempt. The Next Paging Area Scope, when present, indicates whether the serving NG_RAN node plans to modify the RAN Paging Area currently selected at next paging attempt. If the UE leaves RRC_INACTIVE state the Paging Attempt Count is reset.

9.2.6 Random Access Procedure

The random access procedure is triggered by a number of events, for instance:

- Initial access from RRC_IDLE;
- RRC Connection Re-establishment procedure;
- Handover;
- DL or UL data arrival during RRC_CONNECTED when UL synchronisation status is "non-synchronised";
- Transition from RRC_INACTIVE;
- To establish time alignment at SCell addition;
- Request for Other SI (see subclause 7.3);
- Beam failure recovery.

Furthermore, the random access procedure takes two distinct forms: contention-based random access (CBRA) and contention-free random access (CFRA) as shown on Figure 9.2.6-1 below.

For initial access in a cell configured with SUL, the UE selects the SUL carrier if and only if the measured quality of the DL is lower than a broadcast threshold. Once started, all uplink transmissions of the random access procedure remain on the selected carrier.

当处于 RRC_IDLE 状态时，UE 监视寻呼信道以进行 CN 发起的寻呼；在 RRC_INACTIVE 中，UE 还监视 RAN 发起的寻呼的寻呼信道。
不过，UE 不需要连续监视寻呼信道；寻呼 DRX 的定义是，处于 RRC_IDLE 或 RRC_INACTIVE 状态的 UE 仅需要在每个 DRX 周期的一个寻呼时机 (PO) 期间监控寻呼信道（参见 3GPP TS 38.304 [10]）。
寻呼 DRX 周期由网络配置：

1）对于CN发起的寻呼，系统信息中广播默认周期；

2) 对于CN发起的寻呼，可以通过NAS信令配置UE特定周期；

3) 对于RAN发起的寻呼，可以通过RRC信令配置UE特定的周期；

- UE 使用最短的可用 DRX 周期，即，RRC_IDLE 中的 UE 使用上述前两个周期中最短的一个，而 RRC_INACTIVE 中的 UE 使用三个周期中最短的一个。

用于 CN 发起的寻呼和 RAN 发起的寻呼的 UE 的 PO 基于相同的 UE ID，导致两者的 PO 重叠。 DRX周期中不同PO的数量可通过系统信息进行配置，并且网络可以基于UE的ID将UE分配给这些PO。

当处于 RRC_CONNECTED 状态时，UE 监视系统信息中用信号通知的任何 PO 中的寻呼信道。在BA的情况下，RRC_CONNECTED中的UE仅监视活动BWP上的寻呼信道。

CM_IDLE 中 UE 的寻呼优化：在 UE 上下文释放时，NG-RAN 节点可以向 AMF 提供推荐小区和 NG-RAN 节点的列表，作为后续寻呼的辅助信息。
AMF 还可以提供由寻呼尝试计数和预期寻呼尝试次数组成的寻呼尝试信息，并且可以包括下一个寻呼区域范围。
如果寻呼消息中包含寻呼尝试信息，则每个被寻呼的 NG-RAN 节点在寻呼尝试期间接收相同的信息。每次新的寻呼尝试时，寻呼尝试计数应增加 1。
下一个寻呼区域范围（如果存在）指示 AMF 是否计划在下一次寻呼尝试时修改当前选择的寻呼区域。如果 UE 已将其状态更改为 CM CONNECTED，则重置寻呼尝试计数。

RRC_INACTIVE 中 UE 的寻呼优化：在 RAN 寻呼中，服务 NG-RAN 节点提供 RAN 寻呼区域信息。服务 NG-RAN 节点还可以提供 RAN 寻呼尝试信息。
每个被寻呼的 NGRAN 节点在寻呼尝试期间接收相同的 RAN 寻呼尝试信息，其中包含以下内容：寻呼尝试计数、预期寻呼尝试次数和下一个寻呼区域范围。
每次新的寻呼尝试时，寻呼尝试计数应增加 1。下一个寻呼区域范围（如果存在）指示服务 NG_RAN 节点是否计划在下一次寻呼尝试时修改当前选择的 RAN 寻呼区域。
如果 UE 离开 RRC_INACTIVE 状态，则寻呼尝试计数将被重置。

9.2.6 随机接入过程

随机接入过程由许多事件触发，例如：

- 从 RRC_IDLE 初始访问；
- RRC连接重建过程；
- 交出；
- 当UL同步状态为“非同步”时，RRC_CONNECTED期间DL或UL数据到达；
- 从 RRC_INACTIVE 转变；
- 在添加 SCell 时建立时间对齐；
- 请求其他 SI（参见第 7.3 款）；
- 光束故障恢复。

此外，随机接入过程采用两种不同的形式：基于竞争的随机接入（CBRA）和无竞争随机接入（CFRA），如下图9.2.6-1所示。

对于配置有SUL的小区中的初始接入，当且仅当测量的DL的质量低于广播阈值时，UE才选择SUL载波。一旦开始，随机接入过程的所有上行链路传输都保留在所选载波上。

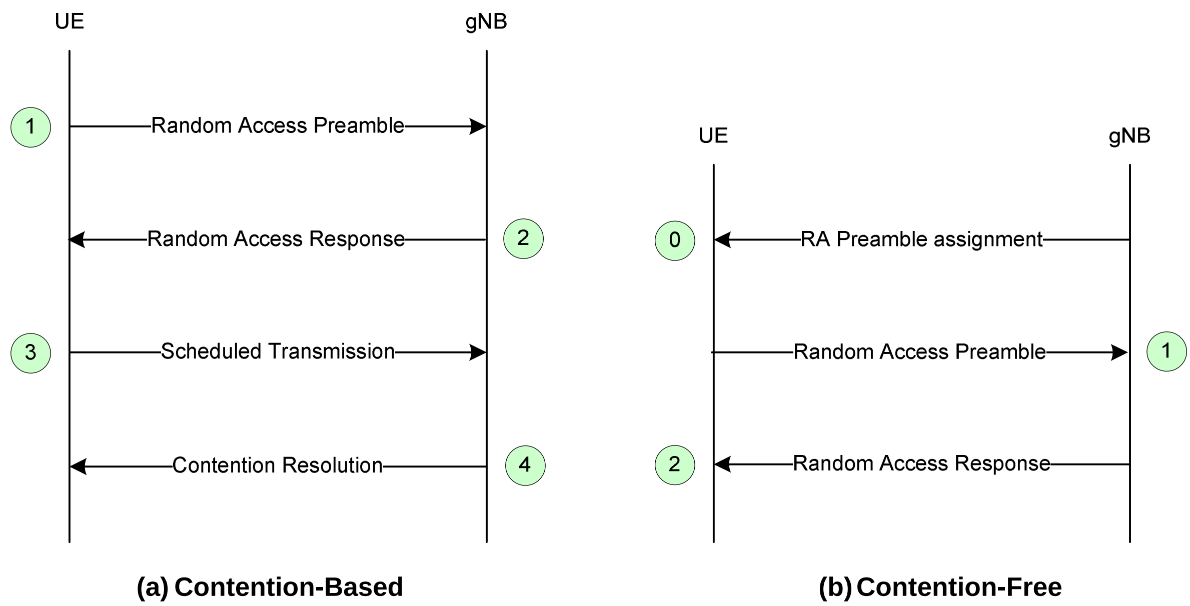


Figure 9.2.6-1: Random Access Procedures

9.2.7 Radio Link Failure

In RRC_CONNECTED, the UE declares Radio Link Failure (RLF) when one of the following criteria are met:

- Expiry of a timer started after indication of radio problems from the physical layer (if radio problems are recovered before the timer is expired, the UE stops the timer);
- Random access procedure failure;
- RLC failure.

After RLF is declared, the UE:

- stays in RRC_CONNECTED;
- selects a suitable cell and then initiates RRC re-establishment;
- enters RRC_IDLE if a suitable cell wasn't found within a certain time after RLF was declared.

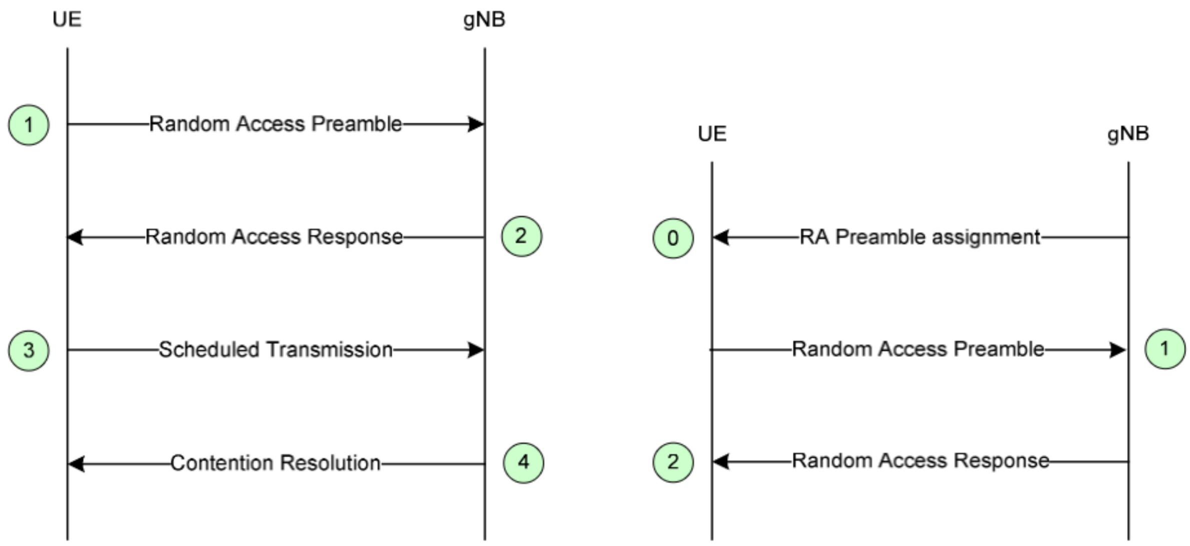
9.2.8 Beam failure detection and recovery

For beam failure detection, the gNB configures the UE with beam failure detection reference signals and the UE declares beam failure when the number of beam failure instance indications from the physical layer reaches a configured threshold within a configured period.

After beam failure is detected, the UE:

- triggers beam failure recovery by initiating a Random Access procedure on the PCell;
- selects a suitable beam to perform beam failure recovery (if the gNB has provided dedicated Random Access resources for certain beams, those will be prioritized by the UE).

Upon completion of the Random Access procedure, beam failure recovery is considered complete.



(a) 基于争用的　　(b) 无争用

图 9.2.6-1：随机接入过程

9.2.7 无线电链路故障

在 RRC_CONNECTED 中，当满足以下条件之一时，UE 声明无线链路失败 (RLF)：

- 物理层指示无线问题后启动的定时器到期（如果无线问题在定时器到期之前恢复，则 UE 停止定时器）；

- 随机接入过程失败；
- RLC 故障。

声明RLF后，UE：

- 保持RRC_CONNECTED状态；
- 选择合适的小区，然后发起RRC重建；
- 如果声明RLF后一定时间内没有找到合适的小区，则进入RRC_IDLE。

9.2.8 光束故障检测和恢复

对于波束故障检测，gNB为UE配置波束故障检测参考信号，并且当来自物理层的波束故障实例指示的数量在配置的周期内达到配置的阈值时，UE宣告波束故障。

检测到波束失败后，UE：

- 通过在PCell上发起随机接入过程来触发波束故障恢复；
- 选择合适的波束来执行波束故障恢复（如果 gNB 为某些波束提供了专用随机接入资源，则 UE 将优先考虑这些资源）。

随机接入过程完成后，波束故障恢复被视为完成。

9.3 Inter RAT

9.3.1 Intra 5GC

9.3.1.1 Cell Reselection

Cell reselection is characterised by the following:

- Cell reselection between NR RRC_IDLE and E-UTRA RRC_IDLE is supported;
- Cell reselection from NR RRC_INACTIVE to E-UTRA RRC_IDLE is supported.

9.3.1.2 Handover

Inter RAT mobility is characterised by the following:

- The Source RAT configures Target RAT measurement and reporting.
- The source RAT decides on the preparation initiation and provides the necessary information to the target RAT in the format required by the target RAT:
  - For handover preparation from E-UTRA to NR, the source RAT issues a handover preparation request message to the target RAT passing a transparent RRC container with necessary information to prepare the handover at the target side. The information for the target RAT is the same type as specified in section 9.2.3.2.1 including the current QoS flow to DRB mapping applied to the UE and RRM configuration.
  - The details of RRM configuration are the same type as specified for NR in section 9.2.3.2.1 including beam measurement information for the listed cells if the measurements are available.
- Radio resources are prepared in the target RAT before the handover.
- The RRC reconfiguration message from the target RAT is delivered to the source RAT via a transparent container, and is passed to the UE by the source RAT in the handover command:
  - The inter-RAT handover command message carries the same type of information required to access the target cell as specified for NR baseline handover in section 9.2.3.2.1.
- The in-sequence and lossless handover is supported for the handover between gNB and ng-eNB.
- Both Xn and NG based inter-RAT handover between NG-RAN nodes is supported. Whether the handover is over Xn or CN is transparent to the UE.
- In order to keep the SDAP and PDCP configurations for in-sequence and lossless inter-RAT handover, delta-configuration for the radio bearer configuration is used.

9.3.1.3 Measurements

Inter RAT measurements in NR are limited to E-UTRA.

9.3.2 From 5GC to EPC

9.3.2.1 Cell Reselection

Cell reselection is characterised by the following:

- Cell reselection between NR RRC_IDLE and E-UTRA RRC_IDLE is supported;
- Cell reselection from NR RRC_INACTIVE to E-UTRA RRC_IDLE is supported.

9.3.2.2 Handover

Inter RAT mobility is characterised by the following:

- The Source RAT configures Target RAT measurement and reporting.

9.3 不同RAT

9.3.1 5GC内

9.3.1.1 小区重选

小区重选的特点如下：

- 支持NR RRC_IDLE和E-UTRA RRC_IDLE之间的小区重选；
- 支持从NR RRC_INACTIVE到E-UTRA RRC_IDLE的小区重选。

9.3.1.2 交出

RAT 间移动性具有以下特点：

- 源 RAT 配置目标 RAT 测量和报告。
- 源 RAT 决定准备启动，并以目标 RAT 所需的格式向目标 RAT 提供必要的信息：
  - 对于从 E-UTRA 到 NR 的切换准备，源 RAT 向目标 RAT 发出切换准备请求消息，传递带有必要信息的透明 RRC 容器，以在目标侧准备切换。
    目标 RAT 的信息与第 9.2.3.2.1 节中指定的类型相同，包括当前 QoS 流到应用于 UE 的 DRB 映射和 RRM 配置。
  - RRM 配置的详细信息与第 9.2.3.2.1 节中为 NR 指定的类型相同，包括所列小区的波束测量信息（如果测量可用）。
- 在切换之前，在目标 RAT 中准备无线资源。
- 来自目标 RAT 的 RRC 重配置消息通过透明容器传递到源 RAT，并由源 RAT 在切换命令中传递给 UE：
  - RAT间切换命令消息携带与第9.2.3.2.1节中为NR基线切换指定的接入目标小区所需的相同类型的信息。
- gNB和ng-eNB之间的切换支持有序、无损切换。
- 支持 NG-RAN 节点之间基于 Xn 和 NG 的 RAT 间切换。切换是通过Xn还是CN对UE来说是透明的。
- 为了保持 SDAP 和 PDCP 配置用于按顺序且无损的 RAT 间切换，使用无线承载配置的增量配置。

9.3.1.3 测量

NR 中的 RAT 间测量仅限于 E-UTRA。

9.3.2 从5GC到EPC

9.3.2.1 小区重选

小区重选的特点如下：

- 支持NR RRC_IDLE和E-UTRA RRC_IDLE之间的小区重选；
- 支持从NR RRC_INACTIVE到E-UTRA RRC_IDLE的小区重选。

9.3.2.2 交出

RAT 间移动性具有以下特点：

- 源 RAT 配置目标 RAT 测量和报告。

- The source RAT decides on the preparation initiation and provides the necessary information to the target RAT in the format required by the target RAT.
- Radio resources are prepared in the target RAT before the handover.
- The RRC reconfiguration message from the target RAT is delivered to the source RAT via a transparent container, and is passed to the UE by the source RAT in the handover command.
- In-sequence and lossless handovers are not supported.
- A full configuration is required to reset the radio bearers.
- Security procedures for handover to E-UTRA/EPC should follow legacy inter-RAT handover procedures.

9.3.2.3 Measurements

Inter RAT measurements in NR are limited to E-UTRA.

9.3.2.4 Data Forwarding

The inter-System data forwarding follows the following key principles:

- Only indirect data forwarding is supported.
- PDU session information at the serving NG-RAN node contains mapping information per QoS Flow to a corresponding E-RAB.
- At handover preparation, the source NG-RAN node shall decide which mapped E-RABs are proposed to be subject to data forwarding and provide this information in the source-to-target container to the target eNB.
- The target eNB assigns forwarding TEID/TNL address(es) for the E-RAB(s) for which it accepts data forwarding.
- A single data forwarding tunnel is established between the source NG-RAN node and UPF per PDU session for which at least data for a single QoS Flow is subject to data forwarding. For the QoS flow(s) accepted for data forwarding, the NG-RAN node initiates data forwarding to the UPF by the corresponding PDU session data forwarding tunnel(s). Then the UPF maps data received from the per PDU session data forwarding tunnel(s) to the mapped EPS bearer(s).

9.3.3 From EPC to 5GC

9.3.3.1 Data Forwarding

The inter-System data forwarding from EPS to 5GS follows the following key principles:

- Only indirect data forwarding is supported.
- The target NG-RAN node receives in the Handover Request message the mapping between E-RAB ID(s) and QoS Flow ID(s). It decides whether to accept the data forwarding for E-RAB IDs proposed for forwarding within the source to target container. It assigns a TEID/TNL address for each PDU session for which at least one QoS flow is involved in the accepted forwarding.
- The target NG-RAN node sends the Handover Request Acknowledge message in which it indicates the list of PDU sessions and QoS flows for which it has accepted the forwarding.
- The source eNB receives in the Handover Command message the list of E-RAB IDs for which the target NG-RAN node has accepted the forwarding of corresponding PDU sessions and QoS flows.
- For each E-RAB accepted for data forwarding, the source eNB forwards data to the SGW in the corresponding E-RAB tunnel and the SGW forwards the received data to the UPF in the E-RAB tunnel. Then the UPF maps the data received from an E-RAB tunnel to the corresponding mapped PDU session tunnel. The target NG-RAN node prioritizes the forwarded packets over the fresh packets for those QoS flows which are involved in the accepted forwarding.

- 源RAT决定准备启动并以目标RAT所需的格式向目标RAT提供必要的信息。
- 在切换之前，在目标 RAT 中准备无线资源。
- 来自目标RAT的RRC重配置消息通过透明容器传递到源RAT，并由源RAT在切换命令中传递到UE。
- 不支持顺序和无损切换。
- 重置无线电承载需要完整的配置。
- 切换到 E-UTRA/EPC 的安全程序应遵循传统的 RAT 间切换程序。

9.3.2.3 测量

NR 中的 RAT 间测量仅限于 E-UTRA。

9.3.2.4 数据转发

系统间数据转发遵循以下主要原则：

- 仅支持间接数据转发。
- 服务 NG-RAN 节点处的 PDU 会话信息包含每个 QoS 流到相应 E-RAB 的映射信息。
- 在切换准备时，源 NG-RAN 节点应决定建议哪些映射的 E-RAB 进行数据转发，并将源到目标容器中的此信息提供给目标 eNB。
- 目标eNB为其接受数据转发的E-RAB分配转发TEID/TNL地址。
- 每个 PDU 会话在源 NG-RAN 节点和 UPF 之间建立单个数据转发隧道，对于该隧道，至少单个 QoS 流的数据受到数据转发。
  对于接受数据转发的QoS流，NG-RAN节点通过相应的PDU会话数据转发隧道发起向UPF的数据转发。然后，UPF将从每PDU会话数据转发隧道接收的数据映射到映射的EPS承载。

9.3.3 从EPC到5GC

9.3.3.1 数据转发

EPS到5GS的系统间数据转发遵循以下关键原则：

- 仅支持间接数据转发。
- 目标 NG-RAN 节点在切换请求消息中接收 E-RAB ID 和 QoS 流 ID 之间的映射。它决定是否接受建议在源容器内转发到目标容器的 E-RAB ID 的数据转发。
  它为每个 PDU 会话分配一个 TEID/TNL 地址，对于该 PDU 会话，在接受的转发中至少涉及一个 QoS 流。
- 目标 NG-RAN 节点发送切换请求确认消息，其中指示它已接受转发的 PDU 会话和 QoS 流的列表。
- 源 eNB 在切换命令消息中接收目标 NGRAN 节点已接受相应 PDU 会话和 QoS 流转发的 E-RAB ID 列表。
- 对于每个接受数据转发的E-RAB，源eNB在对应的E-RAB隧道中将数据转发给SGW，SGW将接收到的数据在E-RAB隧道中转发给UPF。
  然后UPF将从E-RAB隧道接收到的数据映射到相应的映射的PDU会话隧道。对于接受转发中涉及的 QoS 流，目标 NG-RAN 节点将转发的数据包优先于新鲜数据包。

9.4 Roaming and Access Restrictions

The roaming and access restriction information for a UE includes information on restrictions to be applied for subsequent mobility action during CM-CONNECTED state. It may be provided by the AMF and also may be updated by the AMF later.

It includes the forbidden RAT, the forbidden area and the service area restrictions as specified in 3GPP TS 23.501 [3]. It also includes serving PLMN and may include a list of equivalent PLMNs.

Upon receiving the roaming and access restriction information for a UE, if applicable, the gNB should use it to determine whether to apply restriction handling for subsequent mobility action, e.g., handover, redirection.

If the roaming and access restriction information is not available for a UE at the gNB, the gNB shall consider that there is no restriction for subsequent mobility actions.

Only if received over NG or Xn signalling, the roaming and access restriction information shall be propagated over Xn by the source gNB during Xn handover. If the Xn handover results in a change of serving PLMN (to an equivalent PLMN), the source gNB shall replace the serving PLMN with the identity of the target PLMN and move the serving PLMN to the equivalent PLMN list, before propagating the roaming and access restriction information.

10 Scheduling

10.1 Basic Scheduler Operation

In order to utilise radio resources efficiently, MAC in gNB includes dynamic resource schedulers that allocate physical layer resources for the downlink and the uplink. In this subclause, an overview of the scheduler is given in terms of scheduler operation, signalling of scheduler decisions, and measurements.

Scheduler Operation:

- Taking into account the UE buffer status and the QoS requirements of each UE and associated radio bearers, schedulers assign resources between UEs;
- Schedulers may assign resources taking account the radio conditions at the UE identified through measurements made at the gNB and/or reported by the UE;
- Schedulers assign radio resources in a unit of slot (e.g. one mini-slot, one slot, or multiple slots);
- Resource assignment consists of radio resources (resource blocks).

Signalling of Scheduler Decisions:

- UEs identify the resources by receiving a scheduling (resource assignment) channel.

Measurements to Support Scheduler Operation:

- Uplink buffer status reports (measuring the data that is buffered in the logical channel queues in the UE) are used to provide support for QoS-aware packet scheduling.
- Power headroom reports (measuring the difference between the nominal UE maximum transmit power and the estimated power for uplink transmission) are used to provide support for power aware packet scheduling.

10.2 Downlink Scheduling

In the downlink, the gNB can dynamically allocate resources to UEs via the C-RNTI on PDCCH(s). A UE always monitors the PDCCH(s) in order to find possible assignments 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.

The gNB may pre-empt an ongoing PDSCH transmission to one UE with a latency-critical transmission to another UE. The gNB can configure UEs to monitor interrupted transmission indications using INT-RNTI on a PDCCH. If a UE receives the interrupted transmission indication, the UE may assume that no useful information to that UE was carried by the resource elements included in the indication, even if some of those resource elements were already scheduled to this UE.

9.4 漫游和访问限制

UE的漫游和接入限制信息包括关于在CM-CONNECTED状态期间应用于后续移动性动作的限制的信息。它可能由AMF提供，也可能由AMF稍后更新。

它包括 3GPP TS 23.501 [3] 中规定的禁止 RAT、禁止区域和服务区域限制。它还包括服务 PLMN，并且可能包括等效 PLMN 的列表。

在接收到 UE 的漫游和接入限制信息后（如果适用），gNB 应使用它来确定是否对后续移动操作（例如切换、重定向）应用限制处理。

如果漫游和接入限制信息对于gNB处的UE不可用，则gNB应当认为对于后续移动性动作没有限制。

仅当通过 NG 或 Xn 信令接收时，漫游和接入限制信息才应在 Xn 切换期间由源 gNB 通过 Xn 传播。
如果 Xn 切换导致服务 PLMN 发生更改（更改为等效 PLMN），则源 gNB 应使用目标 PLMN 的标识替换服务 PLMN，并将服务 PLMN 移动到等效 PLMN 列表，然后再传播漫游和接入限制信息。

10 调度

10.1 基本调度程序操作

为了有效地利用无线资源，gNB中的MAC包括动态资源调度器，其为下行链路和上行链路分配物理层资源。
在本子条款中，从调度器操作、调度器决策的信令和测量方面给出了调度器的概述。

调度程序操作：

- 考虑到UE缓冲区状态以及每个UE和相关无线承载的QoS要求，调度器在UE之间分配资源；
- 调度器可以考虑通过在 gNB 处进行的测量和/或由 UE 报告的测量来识别的 UE 处的无线电状况来分配资源；
- 调度器以时隙为单位分配无线电资源（例如，一个迷你时隙、一个时隙或多个时隙）；
- 资源分配由无线电资源（资源块）组成。

调度程序决策的信号发送：

- UE通过接收调度（资源分配）信道来识别资源。

支持调度程序操作的测量：

- 上行链路缓冲区状态报告（测量 UE 逻辑信道队列中缓冲的数据）用于为 QoS 感知的数据包调度提供支持。
- 功率余量报告（测量标称UE最大发射功率与上行链路传输的估计功率之间的差异）用于为功率感知分组调度提供支持。

10.2 下行调度

在下行链路中，gNB 可以通过 PDCCH 上的 C-RNTI 向 UE 动态分配资源。 UE 始终监视 PDCCH，以便在启用其下行链路接收（配置时由 DRX 管理的活动）时找到可能的分配。
配置 CA 后，相同的 C-RNTI 应用于所有服务小区。

gNB 可以用对另一个 UE 的延迟关键型传输来抢占对一个 UE 正在进行的 PDSCH 传输。 gNB 可以将 UE 配置为使用 PDCCH 上的 INT-RNTI 来监控中断传输指示。
如果UE接收到中断的传输指示，则UE可以假定该指示中所包括的资源元素没有携带对该UE有用的信息，即使那些资源元素中的一些资源元素已经被调度给该UE。

In addition, with Semi-Persistent Scheduling (SPS), the gNB can allocate downlink resources for the initial HARQ transmissions to UEs: RRC defines the periodicity of the configured downlink assignments while PDCCH addressed to CS-RNTI can either signal and activate the configured downlink assignment, or deactivate it; i.e. a PDCCH addressed to CS-RNTI indicates that the downlink assignment can be implicitly reused according to the periodicity defined by RRC, until deactivated.

NOTE: when required, retransmissions are explicitly scheduled on PDCCH(s).

When a configured downlink assignment is active, if the UE cannot find its C-RNTI on the PDCCH(s), a downlink transmission according to the configured downlink assignment is assumed. Otherwise, if the UE finds its C-RNTI on the PDCCH(s), the PDCCH allocation overrides the configured downlink assignment.

When CA is configured, at most one configured downlink assignment can be signalled per serving cell. When BA is configured, at most one configured downlink assignment can be signalled per BWP. On each serving cell, there can be only one configured downlink assignment active at a time, and multiple configured downlink assignment can be simultaneously active on different serving cells only. Activation and deactivation of configured downlink assignments are independent among the serving cells.

10.3 Uplink Scheduling

In the uplink, the gNB can dynamically allocate resources to UEs via the C-RNTI on PDCCH(s). A UE always monitors the PDCCH(s) in order to find possible grants 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.

In addition, with Configured Grants, the gNB can allocate uplink resources for the initial HARQ transmissions to UEs. Two types of configured uplink grants are defined:

- With Type 1, RRC directly provides the configured uplink grant (including the periodicity).
- With Type 2, RRC defines the periodicity of the configured uplink grant while PDCCH addressed to CS-RNTI can either signal and activate the configured uplink grant, or deactivate it; i.e. a PDCCH addressed to CS-RNTI indicates that the uplink grant can be implicitly reused according to the periodicity defined by RRC, until deactivated.

When a configured uplink grant is active, if the UE cannot find its C-RNTI/CS-RNTI on the PDCCH(s), an uplink transmission according to the configured uplink grant can be made. Otherwise, if the UE finds its C-RNTI/CS-RNTI on the PDCCH(s), the PDCCH allocation overrides the configured uplink grant.

Retransmissions other than repetitions are explicitly allocated via PDCCH(s).

When CA is configured, at most one configured uplink grant can be signalled per serving cell. When BA is configured, at most one configured uplink grant can be signalled per BWP. On each serving cell, there can be only one configured uplink grant active at a time. A configured uplink grant for one serving cell can either be of Type 1 or Type 2. For Type 2, activation and deactivation of configured uplink grants are independent among the serving cells. When SUL is configured, a configured uplink grant can only be signalled for one of the 2 ULs of the cell.

10.4 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.

Uplink buffer status reports (BSR) are needed to provide support for QoS-aware packet scheduling. In NR, uplink buffer status reports refer to the data that is buffered in for a group of logical channel (LCG) in the UE. Eight LCGs and two formats are used for reporting in uplink:

- A short format to report only one BSR (of one LCG);
- A flexible long format to report several BSRs (up to all eight LCGs).

Uplink buffer status reports are transmitted using MAC signalling.

Power headroom reports (PHR) are needed to provide support for power-aware packet scheduling. In NR, three types of reporting are supported: one for PUSCH transmission, one for PUSCH and PUCCH transmission and a third one for

此外，通过半静态调度 (SPS)，gNB 可以为 UE 的初始 HARQ 传输分配下行链路资源：RRC 定义配置的下行链路分配的周期，而寻址到 CS-RNTI 的 PDCCH 可以发送信号并激活配置的下行链路分配，或停用它； IE。
寻址到 CS-RNTI 的 PDCCH 指示可以根据 RRC 定义的周期隐式重用下行链路分配，直到停用。

笔记： 当需要时，在 PDCCH 上明确调度重传。

当配置的下行链路分配处于活动状态时，如果UE在PDCCH上找不到其C-RNTI，则假定根据配置的下行链路分配进行下行链路传输。
否则，如果 UE 在 PDCCH 上找到其 C-RNTI，则 PDCCH 分配会覆盖配置的下行链路分配。

当配置 CA 时，每个服务小区最多可以用信号通知一个配置的下行链路分配。当配置 BA 时，每个 BWP 最多可以用信号通知一个配置的下行链路分配。
在每个服务小区上，一次只能有一个配置的下行链路分配处于活动状态，并且多个配置的下行链路分配只能在不同的服务小区上同时处于活动状态。
配置的下行链路分配的激活和去激活在服务小区之间是独立的。

10.3 上行调度

在上行链路中，gNB 可以通过 PDCCH 上的 C-RNTI 向 UE 动态分配资源。 UE 始终监视 PDCCH，以便在其下行链路接收启用时（配置时由 DRX 管理的活动）找到上行链路传输的可能授权。
配置 CA 后，相同的 C-RNTI 应用于所有服务小区。
此外，通过配置授权，gNB 可以为 UE 的初始 HARQ 传输分配上行链路资源。定义了两种类型的已配置上行链路授权：

- 对于类型1，RRC直接提供配置的上行链路授权（包括周期）。
- 对于类型 2，RRC 定义了配置的上行链路授权的周期，而寻址到 CS-RNTI 的 PDCCH 可以发送信号并激活配置的上行链路授权，或者停用它； IE。
  寻址到CS-RNTI的PDCCH指示上行链路授权可以根据RRC定义的周期隐式地重用，直到被去激活。

当配置的上行链路授权激活时，如果UE在PDCCH上找不到其C-RNTI/CS-RNTI，则可以根据配置的上行链路授权进行上行链路传输。
否则，如果 UE 在 PDCCH 上找到其 C-RNTI/CS-RNTI，则 PDCCH 分配会覆盖配置的上行链路授权。

除了重复之外的重传是经由PDCCH显式分配的。

配置 CA 时，每个服务小区最多可以用信号发送一个配置的上行链路授权。配置 BA 时，每个 BWP 最多可以发送一个配置的上行链路授权。在每个服务小区上，一次只能有一个配置的上行链路授权处于活动状态。
为一个服务小区配置的上行链路授权可以是类型1或类型2。对于类型2，配置的上行链路授权的激活和去激活在服务小区之间是独立的。
当配置 SUL 时，只能为小区的 2 个 UL 之一用信号发送配置的上行链路授权。

10.4 支持调度程序操作的测量

需要测量报告才能使调度器能够在上行链路和下行链路中运行。这些包括传输量和 UE 无线电环境的测量。

需要上行链路缓冲区状态报告 (BSR) 来为 QoS 感知的数据包调度提供支持。在NR中，上行链路缓冲器状态报告是指UE中的一组逻辑信道(LCG)缓冲的数据。八个 LCG 和两种格式用于上行链路报告：

- 仅报告一个 BSR（一个 LCG）的短格式;
- 用于报告多个 BSR（最多所有八个 LCG）的灵活长格式。

上行链路缓冲器状态报告使用MAC信令传输。

需要功率余量报告 (PHR) 来为功率感知数据包调度提供支持。在 NR 中，支持三种类型的报告：一种用于 PUSCH 传输，一种用于 PUSCH 和 PUCCH 传输，第三种用于 PUSCH 传输。

SRS transmission. In case of CA, when no transmission takes place on an activated SCell, a reference power is used to provide a virtual report. Power headroom reports are transmitted using MAC signalling.

10.5 Rate Control

10.5.1 Downlink

In downlink, for GBR flows, the gNB guarantees the GFBR and ensures that the MFBR is not exceeded while for non-GBR flows, it ensures that the UE-AMBR is not exceeded (see subclause 12). When configured for a QoS flow, the gNB also ensures that the MDBV is not exceeded.

10.5.2 Uplink

The UE has an uplink rate control function which manages the sharing of uplink resources between logical channels. RRC controls the uplink rate control function by giving each logical channel a priority, a prioritised bit rate (PBR), and a buffer size duration (BSD). The values signalled need not be related to the ones signalled via NG to the gNB. In addition, mapping restrictions can be configured (see subclause 6.2.1).

The uplink rate control function ensures that the UE serves the logical channel(s) in the following sequence:

1. All relevant logical channels in decreasing priority order up to their PBR;

2. All relevant logical channels in decreasing priority order for the remaining resources assigned by the grant.

NOTE 1: In case the PBRs are all set to zero, the first step is skipped and the logical channels are served in strict priority order: the UE maximises the transmission of higher priority data.

NOTE 2: The mapping restrictions tell the UE which logical channels are relevant for the grant received. If no mapping restrictions are configured, all logical channels are considered.

NOTE 3: Through radio protocol configuration and scheduling, the gNB can guarantee the GFBR(s) and ensure that neither the MFBR(s) nor the UE-AMBR are exceeded in uplink (see subclause 12).

NOTE 4: The mapping restrictions allows the gNB to fulfill the MDBV requirements through scheduling at least for the case where logical channels are mapped to separate serving cells.

If more than one logical channels have the same priority, the UE shall serve them equally.

10.6 Activation/Deactivation Mechanism

To enable reasonable UE battery consumption when CA is configured, an activation/deactivation mechanism of Cells is supported. When a Cell is deactivated, the UE does not need to receive the corresponding PDCCH or PDSCH, cannot transmit in the corresponding uplink, nor is it required to perform CQI measurements. Conversely, when a Cell is active, the UE shall receive PDSCH and PDCCH (if the UE is configured to monitor PDCCH from this SCell) and is expected to be able to perform CQI measurements. NG-RAN ensures that while PUCCH SCell (a Secondary Cell configured with PUCCH) is deactivated, SCells of secondary PUCCH group (a group of SCells whose PUCCH signalling is associated with the PUCCH on the PUCCH SCell) should not be activated. NG-RAN ensures that SCells mapped to PUCCH SCell are deactivated before the PUCCH SCell is changed or removed.

At reconfiguration without mobility control information:

- SCells added to the set of serving cells are initially deactivated;

- SCells which remain in the set of serving cells (either unchanged or reconfigured) do not change their activation status (*activated* or *deactivated*).

At reconfiguration with mobility control information (i.e. handover):

- SCells are deactivated.

To enable reasonable UE battery consumption when BA is configured, only one UL BWP for each uplink carrier and one DL BWP or only one DL/UL BWP pair can be active at a time in an active serving cell, all other BWPs that the UE is configured with being deactivated. On deactivated BWPs, the UE does not monitor the PDCCH, does not transmit on PUCCH, PRACH and UL-SCH.

SRS传输。在CA的情况下，当在激活的SCell上没有发生传输时，参考功率用于提供虚拟报告。功率余量报告使用 MAC 信令传输。

10.5 速率控制

10.5.1 下行

在下行链路中，对于GBR流，gNB保证GFBR并确保不超过MFBR，而对于非GBR流，它确保不超过UE-AMBR（参见子条款12）。当配置 QoS 流时，gNB 还确保不超过 MDBV。

10.5.2 上行链路

UE具有上行链路速率控制功能，其管理逻辑信道之间的上行链路资源的共享。 RRC 通过为每个逻辑信道赋予优先级、优先比特率 (PBR) 和缓冲区大小持续时间 (BSD) 来控制上行链路速率控制功能。
发送的值不需要与通过 NG 发送给 gNB 的值相关。此外，还可以配置映射限制（参见第 6.2.1 节）。

上行链路速率控制功能确保 UE 按以下顺序服务逻辑信道：

1. 所有相关逻辑通道按优先级递减顺序直至其 PBR；
2. 对于授权所分配的剩余资源，所有相关逻辑信道均按优先级降序排列。

注 1：如果 PBR 全部设置为零，则跳过第一步，并按严格的优先级顺序服务逻辑信道：UE 最大化更高优先级数据的传输。

注2：映射限制告诉UE哪些逻辑信道与接收到的授权相关。如果没有配置映射限制，则考虑所有逻辑通道。

注 3：通过无线协议配置和调度，gNB 可以保证 GFBR 并确保上行链路中的 MFBR 和 UE-AMBR 均不超过（参见子条款 12）。

注 4：映射限制允许 gNB 至少在逻辑信道映射到单独的服务小区的情况下通过调度来满足 MDBV 要求。

如果多个逻辑信道具有相同的优先级，则UE应当平等地为它们提供服务。

10.6 激活/停用机制

为了在配置CA时实现合理的UE电池消耗，支持小区的激活/去激活机制。
当小区被去激活时，UE不需要接收相应的PDCCH或PDSCH，不能在相应的上行链路上进行传输，也不需要进行CQI测量。
相反，当小区处于活动状态时，UE 应接收 PDSCH 和 PDCCH（如果 UE 配置为监视来自该 SCell 的 PDCCH），并且预计能够执行 CQI 测量。
NG-RAN 确保当 PUCCH SCell（配置有 PUCCH 的辅助小区）被去激活时，辅助 PUCCH 组（其 PUCCH 信令与 PUCCH SCell 上的 PUCCH 相关联的一组 SCell）的 SCell 不应被激活。
NG-RAN 确保映射到 PUCCH SCell 的 SCell 在 PUCCH SCell 更改或删除之前被停用。

在没有移动性控制信息的情况下重新配置时：

- 添加到服务小区集合的 SCell 最初被停用；
- 保留在服务小区集合中的SCell（未更改或重新配置）不会改变其激活状态（激活或去激活）。

在使用移动性控制信息重新配置时（即切换）：

- SCell 被停用。

为了在配置 BA 时实现合理的 UE 电池消耗，在活动服务小区中，每个上行链路载波只能有一个 UL BWP 和一个 DL BWP 或只能有一对 DL/UL BWP，而 UE 所在的所有其他 BWP 一次只能处于活动状态。配置为停用。
在去激活的 BWP 上，UE 不监视 PDCCH，也不在 PUCCH、PRACH 和 UL-SCH 上进行传输。

10.7 E-UTRA-NR Physical Layer Resource Coordination

An NR cell may use spectrum that overlaps or is adjacent to spectrum in use for E-UTRA cells. In this case network signalling enables coordination of TDM and FDM physical layer resources between MAC in the gNB and the corresponding entity in the ng-eNB.

11 UE Power Saving

The PDCCH monitoring activity of the UE in RRC connected mode is governed by DRX and BA.

When DRX is configured, the UE does not have to continuously monitor PDCCH. DRX is characterized by the following:

- **on-duration**: duration that the UE waits for, after waking up, to receive PDCCHs. If the UE successfully decodes a PDCCH, the UE stays awake and starts the inactivity timer;
- **inactivity-timer**: duration that the UE waits to successfully decode a PDCCH, from the last successful decoding of a PDCCH, failing which it can go back to sleep. 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);
- **retransmission-timer**: duration until a retransmission can be expected;
- **cycle**: specifies the periodic repetition of the on-duration followed by a possible period of inactivity (see figure 11-1 below);
- **active-time**: total duration that the UE monitors PDCCH. 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 when the UE is performing continuous reception while waiting for a retransmission opportunity.

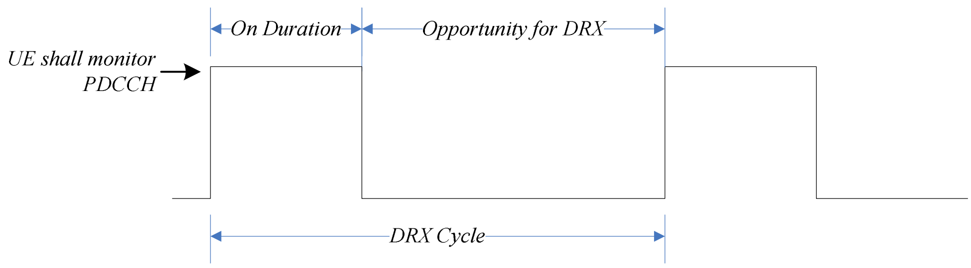


Figure 11-1: DRX Cycle

When BA is configured, the UE only has to monitor PDCCH on the one active BWP i.e. it does not have to monitor PDCCH on the entire DL frequency of the cell. A BWP inactivity timer (independent from the DRX inactivity-timer described above) is used to switch the active BWP to the default one: the timer is restarted upon successful PDCCH decoding and the switch to the default BWP takes place when it expires.

12 QoS

12.1 Overview

The **5G QoS model** is based on QoS Flows (see 3GPP TS 23.501 [3]) and supports both QoS Flows that require guaranteed flow bit rate (GBR QoS Flows) and QoS Flows that do not require guaranteed flow bit rate (non-GBR QoS Flows). At NAS level (see 3GPP TS 23.501 [3]), the QoS flow is thus the finest granularity of QoS differentiation in a PDU session. A QoS flow is identified within a PDU session by a QoS Flow ID (QFI) carried in an encapsulation header over NG-U.

The **QoS architecture** in NG-RAN, both for NR connected to 5GC and for E-UTRA connected to 5GC, is depicted in the Figure 12-1 and described in the following:

- For each UE, 5GC establishes one or more PDU Sessions;

10.7 E-UTRA-NR物理层资源协调

NR小区可以使用与E-UTRA小区使用的频谱重叠或相邻的频谱。在这种情况下，网络信令能够协调 gNB 中的 MAC 与 ng-eNB 中的相应实体之间的 TDM 和 FDM 物理层资源。

11 UE省电

RRC 连接模式下 UE 的 PDCCH 监视活动由 DRX 和 BA 控制。

当配置DRX时，UE不必持续监视PDCCH。 DRX具有以下特点：

- on-duration：UE醒来后等待接收PDCCH的时长。如果UE成功解码PDCCH，则UE保持唤醒状态并启动不活动定时器；
- inactivity-timer：从上次成功解码PDCCH开始，UE等待成功解码PDCCH的持续时间，失败则可以返回休眠。UE应在仅针对第一次传输（即不用于重传）的PDCCH的单次成功解码之后重新启动不活动定时器；
- 重传定时器：预计重传之前的持续时间；
- 周期：指定开启持续时间的周期性重复，随后可能是不活动的时间段（参见下图 11-1）；
- active-time：UE监听PDCCH的总时长。这包括DRX周期的“开启持续时间”、UE在不活动定时器尚未到期时执行连续接收的时间、以及UE在等待重传机会的同时执行连续接收的时间。

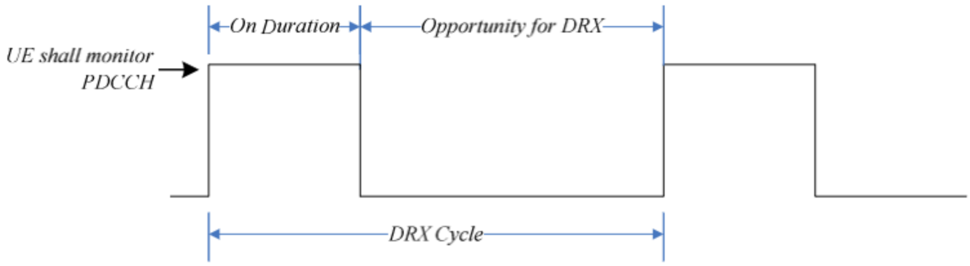


图 11-1：DRX 周期

当配置 BA 时，UE 仅需要监视一个活动 BWP 上的 PDCCH，即，它不必监视小区的整个 DL 频率上的 PDCCH。BWP 不活动定时器（独立于上述 DRX 不活动定时器）用于将活动 BWP 切换到默认 BWP：定时器在 PDCCH 解码成功后重新启动，并且在定时器到期时切换到默认 BWP。

12 QoS

12.1 概述

5G QoS 模型基于 QoS 流（参见 3GPP TS 23.501 [3]），支持需要保证流比特率的 QoS 流（GBR QoS 流）和不需要保证流比特率的 QoS 流（非 GBR QoS）流）。
因此，在 NAS 级别（参见 3GPP TS 23.501 [3]），QoS 流是 PDU 会话中 QoS 区分的最细粒度。 QoS 流在 PDU 会话中由 NG-U 封装标头中携带的 QoS 流 ID（QFI）进行标识。
NG-RAN 中的 QoS 架构（对于连接到 5GC 的 NR 和连接到 5GC 的 E-UTRA）如图 12-1 所示，并描述如下：

- 对于每个UE，5GC建立一个或多个PDU Session；

- For each UE, the NG-RAN establishes at least one Data Radio Bearers (DRB) together with the PDU Session and additional DRB(s) for QoS flow(s) of that PDU session can be subsequently configured (it is up to NG-RAN when to do so);
- The NG-RAN maps packets belonging to different PDU sessions to different DRBs;
- NAS level packet filters in the UE and in the 5GC associate UL and DL packets with QoS Flows;
- AS-level mapping rules in the UE and in the NG-RAN associate UL and DL QoS Flows with DRBs.

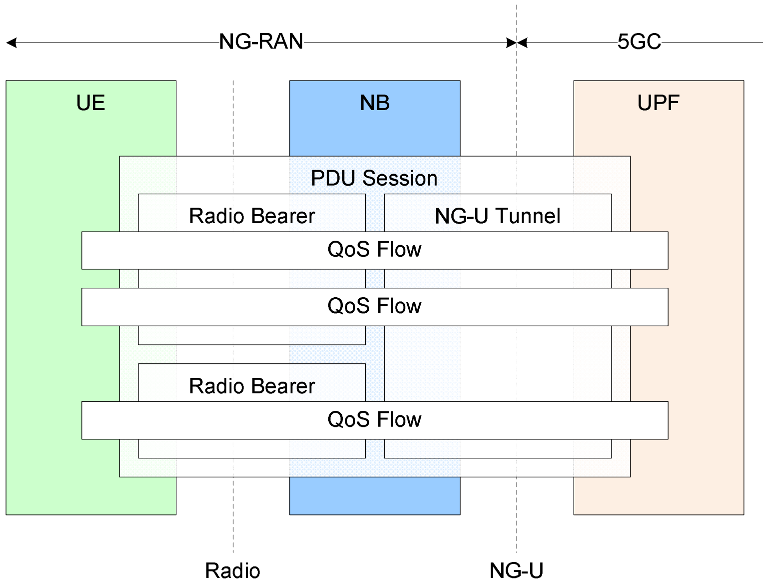


Figure 12-1: QoS architecture

NG-RAN and 5GC ensure quality of service (e.g. reliability and target delay) by mapping packets to appropriate QoS Flows and DRBs. Hence there is a 2-step mapping of IP-flows to QoS flows (NAS) and from QoS flows to DRBs (Access Stratum).

At **NAS level**, a QoS flow is characterised by a QoS profile provided by 5GC to NG-RAN and QoS rule(s) provided by 5GC to the UE. The QoS profile is used by NG-RAN to determine the treatment on the radio interface while the QoS rules dictates the mapping between uplink User Plane traffic and QoS flows to the UE. A QoS flow may either be GBR or Non-GBR depending on its profile. The QoS profile of a QoS flow contains QoS parameters, for instance (see 3GPP TS 23.501 [3]):

- For each QoS flow:
  - A 5G QoS Identifier (5QI);
  - An Allocation and Retention Priority (ARP).
- In case of a GBR QoS flow only:
  - Guaranteed Flow Bit Rate (GFBR) for both uplink and downlink;
  - Maximum Flow Bit Rate (MFBR) for both uplink and downlink;
  - Maximum Packet Loss Rate for both uplink and downlink.
- In case of Non-GBR QoS only:
  - Reflective QoS Attribute (RQA): the RQA, when included, indicates that some (not necessarily all) traffic carried on this QoS flow is subject to reflective quality of service (RQoS) at NAS.

In addition, an Aggregate Maximum Bit Rate is associated to each PDU session (Session-AMBR) and to each UE (UE-AMBR). The Session-AMBR limits the aggregate bit rate that can be expected to be provided across all Non-GBR QoS Flows for a specific PDU Session. The UE-AMBR limits the aggregate bit rate that can be expected to be provided across all Non-GBR QoS Flows of a UE.

- 对于每个 UE，NG-RAN 与 PDU 会话一起建立至少一个数据无线承载（DRB），并且可以随后配置用于该 PDU 会话的 QoS 流的附加 DRB（由 NG-RAN 决定） RAN 何时这样做）；

- NG-RAN将属于不同PDU会话的数据包映射到不同的DRB；
- UE 和 5GC 中的 NAS 级数据包过滤器将 UL 和 DL 数据包与 QoS 流相关联；
- UE 和 NG-RAN 中的 AS 级映射规则将 UL 和 DL QoS 流与 DRB 相关联。

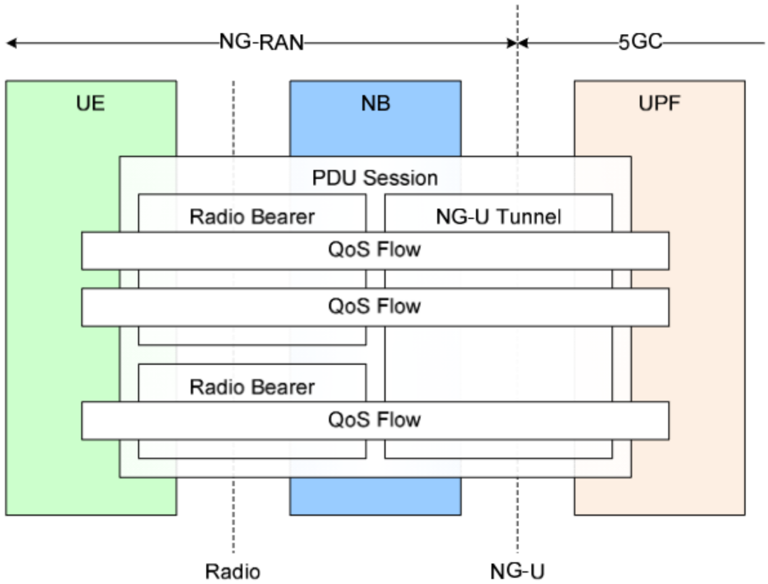


图12-1：QoS架构

NG-RAN 和 5GC 通过将数据包映射到适当的 QoS 流和 DRB 来确保服务质量（例如可靠性和目标延迟）。因此，存在 IP 流到 QoS 流（NAS）以及从 QoS 流到 DRB（接入层）的两步映射。

在 NAS 级别，QoS 流的特征是 5GC 向 NG-RAN 提供的 QoS 配置文件以及 5GC 向 UE 提供的 QoS 规则。
NG-RAN 使用 QoS 配置文件来确定无线接口上的处理方式，而 QoS 规则规定上行链路用户平面流量和到 UE 的 QoS 流之间的映射。 QoS 流可以是 GBR 或非 GBR，具体取决于其配置文件。
QoS 流的 QoS 配置文件包含 QoS 参数，例如（参见 3GPP TS 23.501 [3]）：

- 对于每个 QoS 流：
  - 5G QoS 标识符（5QI）；
  - 分配和保留优先级（ARP）。
- 仅在 GBR QoS 流的情况下：
  - 上行链路和下行链路的保证流比特率（GFBR）；
  - 上行链路和下行链路的最大流比特率（MFBR）；
  - 上行链路和下行链路的最大丢包率。
- 仅在非 GBR QoS 的情况下：
  - 反射 QoS 属性（RQA）：当包含 RQA 时，表明该 QoS 流上承载的某些（不一定是全部）流量受 NAS 处的反射服务质量（RQoS）的影响。

此外，聚合最大比特率与每个 PDU 会话（Session-AMBR）和每个 UE（UEAMBR）相关联。会话 AMBR 限制了特定 PDU 会话的所有非 GBR QoS 流中预期提供的聚合比特率。
UE-AMBR 限制了预期在 UE 的所有非 GBR QoS 流上提供的聚合比特率。

The 5QI is associated to QoS characteristics giving guidelines for setting node specific parameters for each QoS Flow. Standardized or pre-configured 5G QoS characteristics are derived from the 5QI value and are not explicitly signalled. Signalled QoS characteristics are included as part of the QoS profile. The QoS characteristics consist for instance of (see 3GPP TS 23.501 [3]):

- Resource Type (GBR, delay critical GBR or Non-GBR);
- Priority level;
- Packet Delay Budget;
- Packet Error Rate;
- Averaging window;
- Maximum Data Burst Volume.

At **Access Stratum** level, the data radio bearer (DRB) defines the packet treatment on the radio interface (Uu). A DRB serves packets with the same packet forwarding treatment. The QoS flow to DRB mapping by NG-RAN is based on QFI and the associated QoS profiles (i.e. QoS parameters and QoS characteristics). Separate DRBs may be established for QoS flows requiring different packet forwarding treatment, or several QoS Flows belonging to the same PDU session can be multiplexed in the same DRB.

In the uplink, the mapping of QoS Flows to DRBs is controlled by mapping rules which are signalled in two different ways:

- Reflective mapping: for each DRB, the UE monitors the QFI(s) of the downlink packets and applies the same mapping in the uplink; that is, for a DRB, the UE maps the uplink packets belonging to the QoS flows(s) corresponding to the QFI(s) and PDU Session observed in the downlink packets for that DRB. To enable this reflective mapping, the NG-RAN marks downlink packets over Uu with QFI.
- Explicit Configuration: QoS flow to DRB mapping rules can be explicitly signalled by RRC.

The UE always applies the latest update of the mapping rules regardless of whether it is performed via reflecting mapping or explicit configuration.

When a QoS flow to DRB mapping rule is updated, the UE sends an end marker on the old bearer.

In the downlink, the QFI is signalled by NG-RAN over Uu for the purpose of RQoS and if neither NG-RAN, nor the NAS (as indicated by the RQA) intend to use reflective mapping for the QoS flow(s) carried in a DRB, no QFI is signalled for that DRB over Uu. In the uplink, NG-RAN can configure the UE to signal QFI over Uu.

For each PDU session, a default DRB may be configured: if an incoming UL packet matches neither an RRC configured nor a reflective mapping rule, the UE then maps that packet to the default DRB of the PDU session.

Within each PDU session, it is up to NG-RAN how to map multiple QoS flows to a DRB. The NG-RAN may map a GBR flow and a non-GBR flow, or more than one GBR flow to the same DRB, but mechanisms to optimise these cases are not within the scope of standardization.

As specified in 3GPP TS 23.501 [3], the 5GC may associate a GBR QoS flow with notification control to request from the NG-RAN to notify the 5GC either when the GFBR can no longer be fulfilled or when the GFBR can be fulfilled again.

13 Security

13.1 Overview and Principles

The following principles apply to NR connected to 5GC security, see 3GPP TS 33.501 [5]:

- For user data (DRBs), ciphering provides user data confidentiality and integrity protection provides user data integrity;
- For RRC signalling (SRBs), ciphering provides signalling data confidentiality and integrity protection signalling data integrity;

5QI 与 QoS 特性相关联，为每个 QoS 流设置节点特定参数提供指导。标准化或预配置的 5G QoS 特性是从 5QI 值导出的，并且没有明确地用信号通知。
发信号通知的 QoS 特性作为 QoS 配置文件的一部分包含在内。 QoS 特性包括（参见 3GPP TS 23.501 [3]）：

- 资源类型（GBR、延迟关键 GBR 或非 GBR）；
- 优先级；
- 数据包延迟预算；
- 数据包错误率；
- 平均窗口；
- 最大数据突发量。

在接入层级别，数据无线承载 (DRB) 定义无线接口 (Uu) 上的数据包处理。 DRB 以相同的数据包转发处理来服务数据包。 NG-RAN 的 QoS 流到 DRB 的映射基于 QFI 和关联的 QoS 配置文件（即 QoS 参数和 QoS 特性）。可以为需要不同报文转发处理的QoS流建立单独的DRB，或者可以将属于同一PDU会话的多个QoS流复用在同一DRB中。

在上行链路中，QoS 流到 DRB 的映射由映射规则控制，这些规则以两种不同的方式发出信号：

- 反射映射：对于每个DRB，UE监视下行链路分组的QFI并在上行链路中应用相同的映射；也就是说，对于DRB，UE映射属于与在该DRB的下行链路分组中观察到的QFI和PDU会话相对应的QoS流的上行链路分组。
  为了启用这种反射映射，NG-RAN 使用 QFI 标记 Uu 上的下行链路数据包。

- 显式配置：RRC 可以显式地用信号通知 QoS 流到 DRB 映射规则。

无论是通过反射映射还是显式配置执行，UE始终应用映射规则的最新更新。

当 QoS 流到 DRB 映射规则更新时，UE 在旧承载上发送结束标记。

在下行链路中，出于 RQoS 的目的，NG-RAN 通过 Uu 发信号通知 QFI，并且如果 NG-RAN 和 NAS（如 RQA 所示）都不打算对 QoS 流中携带的 QoS 流使用反射映射， DRB，没有通过 Uu 为该 DRB 发送 QFI 信号。
在上行链路中，NG-RAN 可以配置 UE 通过 Uu 发送 QFI。

对于每个 PDU 会话，可以配置默认 DRB：如果传入 UL 数据包既不匹配配置的 RRC 也不匹配反射映射规则，则 UE 会将该数据包映射到 PDU 会话的默认 DRB。

在每个 PDU 会话中，NG-RAN 如何将多个 QoS 流映射到 DRB 取决于 NG-RAN。 NG-RAN可以将GBR流和非GBR流或多于一个GBR流映射到同一DRB，但是优化这些情况的机制不在标准化范围内。

正如 3GPP TS 23.501 [3] 中所规定的，5GC 可以将 GBR QoS 流与通知控制相关联，以请求 NG-RAN 在 GFBR 不再满足或可以再次满足 GFBR 时通知 5GC。

13 安全

13.1 概述和原理

以下原则适用于连接到 5GC 安全的 NR，请参阅 3GPP TS 33.501 [5]：

- 对于用户数据（DRB），加密提供用户数据机密性，完整性保护提供用户数据完整性；

- 对于RRC信令（SRB），加密提供信令数据机密性和完整性保护；

NOTE: Ciphering and integrity protections are optionally configured except for RRC signalling for which integrity protection is always configured. Ciphering and integrity protection can be configured per DRB but all DRBs belonging to a PDU session for which the User Plane Security Enforcement information indicates that UP integrity protection is required (see 3GPP TS 23.502 [22]), are configured with integrity protection.

- For key management and data handling, any entity processing cleartext shall be protected from physical attacks and located in a secure environment;
- The gNB (AS) keys are cryptographically separated from the 5GC (NAS) keys;
- Separate AS and NAS level Security Mode Command (SMC) procedures are used;
- A sequence number (COUNT) is used as input to the ciphering and integrity protection and a given sequence number must only be used once for a given key (except for identical re-transmission) on the same radio bearer in the same direction.

The keys are organised and derived as follows:

- Key for AMF:
  - K_{AMF} is a key derived by ME and SEAF from K_{SEAF}.
- Keys for NAS signalling:
  - K_{NASint} is a key derived by ME and AMF from K_{AMF}, which shall only be used for the protection of NAS signalling with a particular integrity algorithm;
  - K_{NASenc} is a key derived by ME and AMF from K_{AMF}, which shall only be used for the protection of NAS signalling with a particular encryption algorithm.

Key for gNB:

- K_{gNB} is a key derived by ME and AMF from K_{AMF}. K_{gNB} is further derived by ME and source gNB when performing horizontal or vertical key derivation.

Keys for UP traffic:

- K_{UPenc} is a key derived by ME and gNB from K_{gNB}, which shall only be used for the protection of UP traffic between ME and gNB with a particular encryption algorithm;
- K_{UPint} is a key derived by ME and gNB from K_{gNB}, which shall only be used for the protection of UP traffic between ME and gNB with a particular integrity algorithm.

Keys for RRC signalling:

- K_{RRCint} is a key derived by ME and gNB from K_{gNB}, which shall only be used for the protection of RRC signalling with a particular integrity algorithm;
- K_{RRCenc} is a key derived by ME and gNB from K_{gNB}, which shall only be used for the protection of RRC signalling with a particular encryption algorithm.

Intermediate keys:

- NH is a key derived by ME and AMF to provide forward security.
- $K_{gNB}*$ is a key derived by ME and gNB when performing a horizontal or vertical key derivation.

The primary authentication enables mutual authentication between the UE and the network and provide an anchor key called K_{SEAF}. From K_{SEAF}, K_{AMF} is created during e.g. primary authentication or NAS key re-keying and key refresh events. Based on K_{AMF}, K_{NASint} and K_{NASenc} are then derived when running a successful NAS SMC procedure.

Whenever an initial AS security context needs to be established between UE and gNB, AMF and the UE derive a K_{gNB} and a Next Hop parameter (NH). The K_{gNB} and the NH are derived from the K_{AMF}. A NH Chaining Counter (NCC) is associated with each K_{gNB} and NH parameter. Every K_{gNB} is associated with the NCC corresponding to the NH value from which it was derived. At initial setup, the K_{gNB} is derived directly from K_{AMF}, and is then considered to be associated with a virtual NH parameter with NCC value equal to zero. At initial setup, the derived NH value is

笔记： 加密和完整性保护是可选配置的，但始终配置完整性保护的 RRC 信令除外。
可以为每个 DRB 配置加密和完整性保护，但属于用户平面安全执行信息指示需要 UP 完整性保护的 PDU 会话的所有 DRB 都配置有完整性保护。

- 对于密钥管理和数据处理，任何处理明文的实体均应受到保护，免受物理攻击并位于安全的环境中；
- gNB（AS）密钥与 5GC（NAS）密钥以加密方式分开；
- 使用单独的 AS 和 NAS 级安全模式命令（SMC）程序；
- 序列号（COUNT）用作加密和完整性保护的输入，并且给定序列号对于同一方向上相同无线电承载上的给定密钥只能使用一次（相同的重传除外）。

键的组织和派生如下：

- AMF 的关键：
  - K 是 ME 和 SEAF 从 K 派生的密钥。
- NAS 信令按键：
  - K NASint 是 ME 和 AMF 从 K 导出的密钥，仅用于保护具有特定完整性算法的 NAS 信令；
  - K NASenc 是 ME 和 AMF 从 K 导出的密钥，仅用于保护具有特定加密算法的 NAS 信令。

gNB 的密钥：

  - K 是 ME 和 AMF 从 K 导出的密钥。 K 是由 ME 和源 gNB 在执行水平或垂直密钥推导时进一步推导的。

UP 流量的关键：

  - K 是 ME 和 gNB 从 K 导出的密钥，仅用于使用特定加密算法保护 ME 和 gNB 之间的 UP 流量；
  - K 是 ME 和 gNB 从 K 导出的密钥，仅用于通过特定完整性算法保护 ME 和 gNB 之间的 UP 流量。

RRC信令的关键：

  - K RRCint 是 ME 和 gNB 从 K 导出的密钥，仅用于保护具有特定完整性算法的 RRC 信令；
  - K RRCenc 是ME和gNB从K导出的密钥，其仅用于保护具有特定加密算法的RRC信令。

中间键：

  - NH 是由 ME 和 AMF 派生的密钥，用于提供前向安全性。
  - K * 是ME和gNB在执行水平或垂直密钥导出时导出的密钥。

主要认证允许UE和网络之间的相互认证并提供称为K的锚密钥。从 K ， K 是在例如主要身份验证或 NAS 密钥重新生成密钥和密钥刷新事件。
当运行成功的 NAS SMC 过程时，基于 K ，然后导出 K NASint 和 K NASenc 。

每当需要在 UE 和 gNB 之间建立初始 AS 安全上下文时，AMF 和 UE 都会导出 K 和下一跳参数（NH）。 K 和 NH 源自 K 。 NH 链接计数器（NCC）与每个 K 和 NH 参数相关联。
每个 K 都与 NCC 相关联，NCC 对应于从中导出它的 NH 值。在初始设置时，K 直接从 K 导出，然后被视为与 NCC 值等于 0 的虚拟 NH 参数相关联。
在初始设置时，导出的 NH 值为

associated with the NCC value one. On handovers, the basis for the K_{gNB} that will be used between the UE and the target gNB, called K_{gNB}*, is derived from either the currently active K_{gNB} or from the NH parameter. If K_{gNB}* is derived from the currently active K_{gNB}, this is referred to as a horizontal key derivation and is indicated to UE with an NCC that does not increase. If the K_{gNB}* is derived from the NH parameter, the derivation is referred to as a vertical key derivation and is indicated to UE with an NCC increase. Finally, K_{RRCint}, K_{RRCenc}, K_{UPint} and K_{UPenc} are derived based on K_{gNB} after a new K_{gNB} is derived. This is depicted on Figure 13.1-1 below:

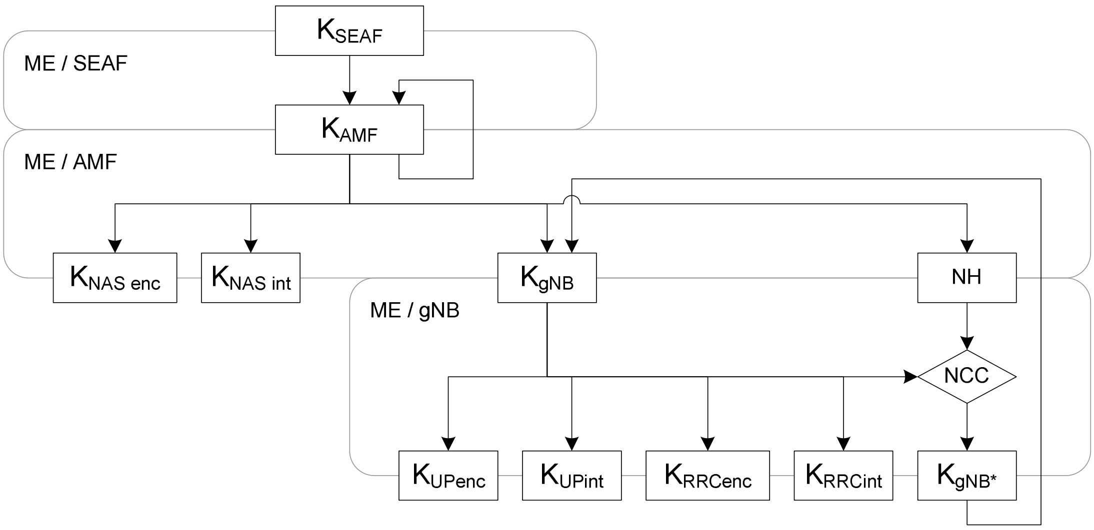


Figure 13.1-1: 5G Key Derivation

With such key derivation, a gNB with knowledge of a K_{gNB}, shared with a UE, is unable to compute any previous K_{gNB} that has been used between the same UE and a previous gNB, therefore providing backward security. Similarly, a gNB with knowledge of a K_{gNB}, shared with a UE, is unable to predict any future K_{gNB} that will be used between the same UE and another gNB after n or more handovers (since NH parameters are only computable by the UE and the AMF).

The AS SMC procedure is for RRC and UP security algorithms negotiation and RRC security activation. When AS security context is to be established in the gNB, the AMF sends the UE 5G security capabilities to the gNB. The gNB chooses the ciphering algorithm which has the highest priority from its configured list and is also present in the UE 5G security capabilities. The gNB also chooses the integrity algorithm which has the highest priority from its configured list and is also present in the UE 5G security capabilities. The chosen algorithms are indicated to the UE in the AS SMC and this message is integrity protected. RRC downlink ciphering (encryption) at the gNB starts after sending the AS SMC message. RRC uplink deciphering (decryption) at the gNB starts after receiving and successful verification of the integrity protected AS security mode complete message from the UE. The UE verifies the validity of the AS SMC message from the gNB by verifying the integrity of the received message. RRC uplink ciphering (encryption) at the UE starts after sending the AS security mode complete message. RRC downlink deciphering (decryption) at the UE shall start after receiving and successful verification of the AS SMC message. The RRC Connection Reconfiguration procedure used to add DRBs shall be performed only after RRC security has been activated as part of the AS SMC procedure.

The maximum supported data rate for integrity protected DRBs is a UE capability indicated at NAS layer, with a minimum value of 64 kbps and a maximum value of the highest data rate supported by the UE. In case of failed integrity check (i.e. faulty or missing MAC-I), the concerned PDU shall be discarded by the receiving PDCP entity.

Key refresh is possible for K_{gNB}, $K_{RRC\text{-}enc}$, $K_{RRC\text{-}int}$, $K_{UP\text{-}enc}$, and $K_{UP\text{-}int}$ and can be initiated by the gNB when a PDCP COUNTs are about to be re-used with the same Radio Bearer identity and with the same K_{gNB}. Key re-keying is also possible for the K_{gNB}, $K_{RRC\text{-}enc}$, $K_{RRC\text{-}int}$, $K_{UP\text{-}enc}$, and $K_{UP\text{-}int}$ and can be initiated by the AMF when a 5G AS security context different from the currently active one shall be activated.

13.2 Security Termination Points

The table below describes the security termination points.

与 NCC 值 1 相关。在切换时，UE 和目标 gNB 之间使用的 K 的基础（称为 K *）是从当前活动的 K 或 NH 参数导出的。
如果K*是从当前活动的K导出的，则这被称为水平密钥导出并且用不增加的NCC向UE指示。
如果K*是从NH参数导出的，则该导出被称为垂直密钥导出并且以NCC增加来指示给UE。最后推导出新的K后，在K的基础上推导出 K、K RRCenc 、K 、K 。如下图 13.1-1 所示：

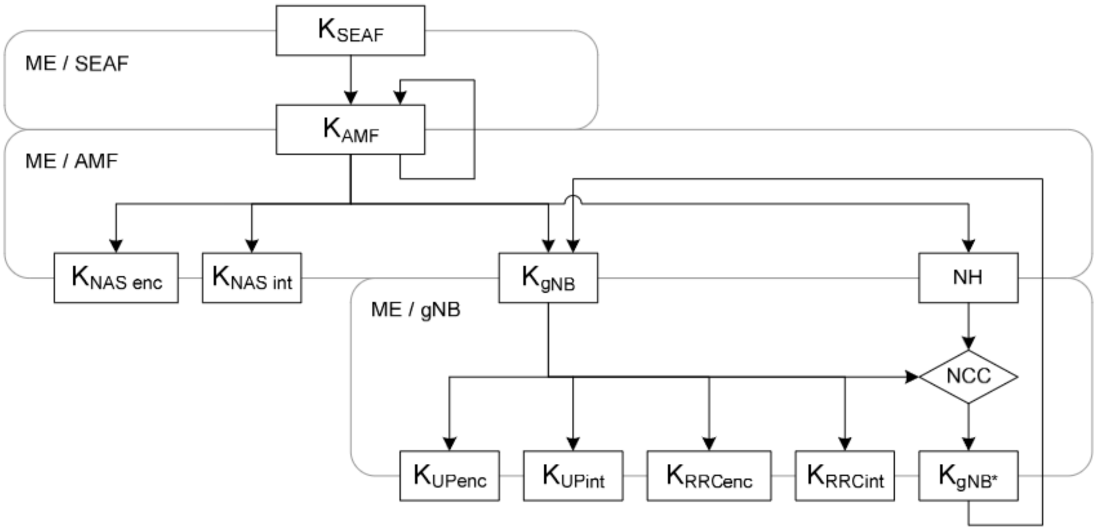


图 13.1-1：5G 密钥派生

通过这种密钥推导，知道与 UE 共享的 K 的 gNB 无法计算在同一 UE 和先前 gNB 之间使用的任何先前 K，因此提供了后向安全性。
类似地，知道与 UE 共享的 K 的 gNB 无法预测在 n 次或多次切换之后同一 UE 和另一个 gNB 之间将使用的任何未来 K（因为 NH 参数只能由 UE 和 UE 计算） AMF）。

AS SMC过程用于RRC和UP安全算法协商以及RRC安全激活。当要在 gNB 中建立 AS 安全上下文时，AMF 向 gNB 发送 UE 5G 安全能力。
gNB 从其配置列表中选择具有最高优先级且也存在于 UE 5G 安全能力中的加密算法。
gNB 还会从其配置列表中选择具有最高优先级且也存在于 UE 5G 安全功能中的完整性算法。所选择的算法在 AS SMC 中向 UE 指示，并且该消息受到完整性保护。
发送 AS SMC 消息后，gNB 处的 RRC 下行链路加密（加密）开始。在接收并成功验证来自 UE 的完整性保护 AS 安全模式完成消息后，gNB 处的 RRC 上行链路解密（解密）开始。
UE通过验证接收到的消息的完整性来验证来自gNB的AS SMC消息的有效性。在发送AS安全模式完成消息后，UE处的RRC上行链路加密（加密）开始。
UE 处的 RRC 下行链路解密（解密）应在收到并成功验证 AS SMC 消息后开始。
用于添加 DRB 的 RRC 连接重新配置过程仅应在 RRC 安全已作为 AS SMC 过程的一部分激活后执行。

完整性保护的DRB支持的最大数据速率是NAS层指示的UE能力，最小值为64kbps，最大值为UE支持的最高数据速率。如果完整性检查失败（即
错误或丢失的 MAC-I），相关的 PDU 将被接收 PDCP 实体丢弃。

K、K RRC-enc、K RRC-int、K UP-enc 和 K UP-int 可以进行密钥刷新，并且可以在 PDCP COUNT 即将与同一无线承载重用时由 gNB 发起身份并具有相同的 K 。 K、K RRC-enc、K RRC-int、K UP-enc 和 K UP-int 也可以进行密钥重新生成，并且当 5G AS 安全上下文与当前活动的安全上下文不同时，可由 AMF 发起应被激活。

13.2 安全终止点

下表描述了安全终止点。

Table 13.2-1 Security Termination Points

	Ciphering	Integrity Protection
NAS Signalling	AMF	AMF
RRC Signalling	gNB	gNB
User Plane Data	gNB	gNB

13.3 State Transitions and Mobility

As a general principle, on RRC_IDLE to RRC_CONNECTED transitions, RRC protection keys and UP protection keys are generated while keys for NAS protection as well as higher layer keys are assumed to be already available. These higher layer keys may have been established as a result of an AKA run, or as a result of a transfer from another AMF during handover or idle mode mobility see 3GPP TS 23.502 [22]).

On RRC_CONNECTED to RRC_IDLE transitions, the gNBs deletes the keys it stores for that UE such that state information for idle mode UEs only has to be maintained in AMF. It is also assumed that gNB 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 gNB and UE delete NH, K_{RRCint}, K_{RRCenc}, K_{UPint} and K_{UPenc} and related NCC;
- AMF and UE keeps K_{AMF}, K_{NASint} and K_{NASenc} stored.

On handovers with vertical key derivation the NH is further bound to the target PCI and its frequency ARFCN-DL before it is taken into use as the K_{gNB} in the target gNB. On handovers with horizontal key derivation the currently active K_{gNB} is further bound to the target PCI and its frequency ARFCN-DL before it is taken into use as the K_{gNB} in the target gNB (see subclause 13.1).

It is not required to change the AS security algorithms during intra-gNB-CU handover. If the UE does not receive an indication of new AS security algorithms during an intra-gNB-CU handover, the UE shall continue to use the same algorithms as before the handover (see 3GPP TS 38.331 [12]).

14 UE Capabilities

The UE capabilities in NR do not rely on UE categories: UE categories associated to fixed peak data rates are only defined for marketing purposes and not signalled to the network. Instead, the network determines the UL and DL data rate supported by a UE from the supported band combinations and from the baseband capabilities (modulation scheme, MIMO layers, …).

To limit signalling overhead, the gNB can request the UE to provide NR capabilities for a restricted set of band combinations. When responding, the UE can skip a subset of the requested band combinations when the corresponding UE capabilities are the same.

15 Self-Configuration and Self-Optimisation

Self-Configuration and Self-Optimisation are not complete and are targeted for completion in June 2018.

15.1 Definitions

Void.

15.2 UE Support for self-configuration and self-optimisation

Void.

表 13.2-1 安全终止点

	加密	完整性保护
NAS 信令	AMF	AMF
RRC信令	gNB	gNB
用户平面数据	gNB	gNB

13.3 状态转换和移动性

作为一般原则，在 RRC_IDLE 到 RRC_CONNECTED 转换时，生成 RRC 保护密钥和 UP 保护密钥，同时假设用于 NAS 保护的密钥以及更高层密钥已经可用。
这些高层密钥可能是 AKA 运行的结果，或者是切换或空闲模式移动期间从另一个 AMF 传输的结果（请参阅 3GPP TS 23.502 [22]）。

在 RRC_CONNECTED 到 RRC_IDLE 转换时，gNB 删除其为该 UE 存储的密钥，以便仅需要在 AMF 中维护空闲模式 UE 的状态信息。
还假设gNB不再存储有关相应UE的状态信息并从其存储器中删除当前密钥。特别是，在连接到空闲转换时：

- gNB和UE删除NH、K、K、K和K以及相关NCC；
- AMF 和 UE 保存 K 、K NASint 和 K NASenc 存储。

在通过垂直密钥导出进行切换时，NH 在用作目标 gNB 的 Kin 之前，会进一步绑定到目标 PCI 及其频率 ARFCN-DL。
在使用水平密钥导出的切换中，当前活动的 K 在用作目标 gNB 的 Kin 之前，进一步绑定到目标 PCI 及其频率 ARFCN-DL（参见第 13.1 节）。

gNB-CU内切换期间不需要改变AS安全算法。
如果 UE 在 gNB-CU 内切换期间没有收到新 AS 安全算法的指示，则 UE 应继续使用与切换之前相同的算法（参见 3GPP TS 38.331 [12]）。

14 终端能力

NR 中的 UE 功能不依赖于 UE 类别：与固定峰值数据速率相关的 UE 类别仅出于营销目的而定义，不会向网络发送信号。
相反，网络根据支持的频段组合和基带功能（调制方案、MIMO 层等）确定 UE 支持的 UL 和 DL 数据速率。
为了限制信令开销，gNB 可以请求 UE 为一组受限的频带组合提供 NR 功能。当响应时，当相应的UE能力相同时，UE可以跳过所请求的频带组合的子集。

15 自配置和自优化

自配置和自优化尚未完成，预计于 2018 年 6 月完成。

15.1 定义

空白。

15.2 UE支持自配置和自优化

空白。

15.3 Self-configuration

15.3.1 Dynamic configuration of the NG-C interface

15.3.1.1 Prerequisites

The following prerequisites are assumed:

- An initial remote IP end point to be used for SCTP initialisation is provided to the NG-RAN node for each AMF the NG-RAN node is supposed to connect to.

15.3.1.2 SCTP initialization

NG-RAN establishes the first SCTP (IETF RFC 4960 [23]) using a configured IP address.

NOTE: The NG-RAN node may use different source and/or destination IP end point(s) if the SCTP establishment towards one IP end point fails. How the NG-RAN node gets the remote IP end point(s) and its own IP address are outside the scope of this specification.

15.3.1.3 Application layer initialization

Once SCTP connectivity has been established, the NG-RAN node and the AMF shall exchange application level configuration data over NGAP with the NG Setup procedure, which is needed for these two nodes to interwork correctly on the NG interface.

- The NG-RAN node provides the relevant configuration information to the AMF, which includes list of supported TA(s), etc;
- The AMF provides the relevant configuration information to the NG-RAN node, which includes PLMN ID, etc.;
- When the application layer initialization is successfully concluded, the dynamic configuration procedure is completed and the NG-C interface is operational.

After the application layer initialization is successfully completed, the AMF may add or update or remove SCTP endpoints to be used for NG-C signalling between the AMF and the NG-RAN node pair as specified in 3GPP TS 23.501 [3].

15.3.2 Dynamic Configuration of the Xn interface

15.3.2.1 Prerequisites

The following prerequisites are necessary:

- An initial remote IP end point to be used for SCTP initialisation is provided to the NG-RAN node.

15.3.2.2 SCTP initialization

NG-RAN establishes the first SCTP (IETF RFC 4960 [23]) using a configured IP address.

NOTE: The NG-RAN node may use different source and/or destination IP end point(s) if the SCTP establishment towards one IP end point fails.

15.3.2.3 Application layer initialization

Once SCTP connectivity has been established, the NG-RAN node and its candidate peer NG-RAN node are in a position to exchange application level configuration data over XnAP needed for the two nodes to interwork correctly on the Xn interface.

- The NG-RAN node provides the relevant configuration information to the candidate NG-RAN node, which includes served cell information.
- The candidate NG-RAN node provides the relevant configuration information to the initiating NG-RAN node, which includes served cell information.

15.3 自配置

15.3.1 NG-C接口的动态配置

15.3.1.1 先决条件

假设满足以下先决条件：

- 对于 NG-RAN 节点应该连接到的每个 AMF，向 NG-RAN 节点提供用于 SCTP 初始化的初始远程 IP 端点。

15.3.1.2 SCTP初始化

NG-RAN 使用配置的 IP 地址建立第一个 SCTP（IETF RFC 4960 [23]）。

笔记： 如果朝向一个 IP 端点的 SCTP 建立失败，NG-RAN 节点可以使用不同的源和/或目的地 IP 端点。 NG-RAN 节点如何获取远程 IP 端点及其自己的 IP 地址超出了本规范的范围。

15.3.1.3 应用层初始化

一旦建立了 SCTP 连接，NG-RAN 节点和 AMF 将通过 NGAP 与 NG 设置过程交换应用级配置数据，这是这两个节点在 NG 接口上正确互操作所必需的。

- NG-RAN节点向AMF提供相关配置信息，包括支持的TA列表等；

- AMF向NG-RAN节点提供相关配置信息，包括PLMN ID等；
- 当应用层初始化成功结束时，动态配置过程完成并且NG-C接口可操作。

成功完成应用层初始化后，AMF 可以添加、更新或删除用于 AMF 与 NG-RAN 节点对之间的 NG-C 信令的 SCTP 端点，如 3GPP TS 23.501 [3] 中所指定。

15.3.2 Xn 接口的动态配置

15.3.2.1 先决条件

需要满足以下先决条件：

- 用于 SCTP 初始化的初始远程 IP 端点被提供给 NG-RAN 节点。

15.3.2.2 SCTP初始化

NG-RAN 使用配置的 IP 地址建立第一个 SCTP（IETF RFC 4960 [23]）。

笔记： 如果朝向一个 IP 端点的 SCTP 建立失败，NG-RAN 节点可以使用不同的源和/或目的地 IP 端点。

15.3.2.3 应用层初始化

一旦建立了 SCTP 连接，NG-RAN 节点及其候选对等 NG-RAN 节点就可以通过 XnAP 交换两个节点在 Xn 接口上正确互通所需的应用程序级配置数据。

- NG-RAN节点向候选NG-RAN节点提供相关配置信息，其中包括服务小区信息。

- 候选NG-RAN节点向发起NG-RAN节点提供相关配置信息，其中包括所服务的小区信息。

- When the application layer initialization is successfully concluded, the dynamic configuration procedure is completed and the Xn interface is operational.

- The NG-RAN node shall keep neighbouring NG-RAN nodes updated with the complete list of served cells, or, if requested by the peer NG-RAN node, by a limited list of served cells, while the Xn interface is operational.

15.3.3 Automatic Neighbour Cell Relation Function

15.3.3.1 General

The purpose of ANR function is to relieve the operator from the burden of manually managing NCRs. Figure 15.3.3.1-1 shows ANR and its environment:

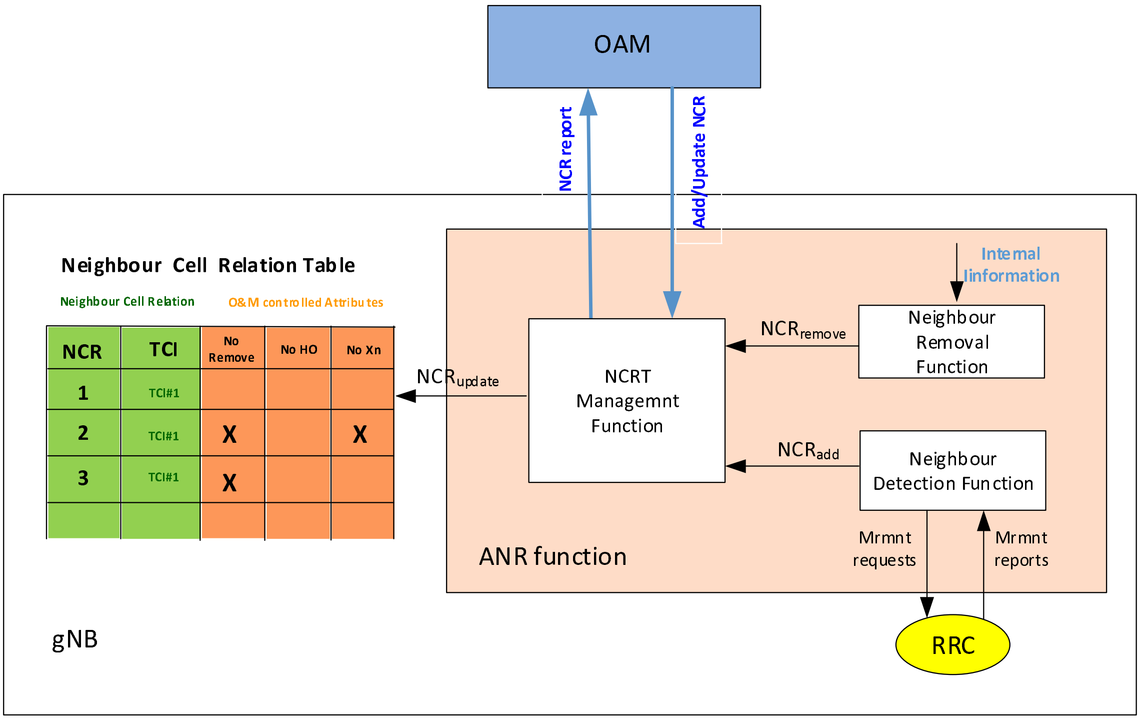


Figure 15.3.3.1-1: Interaction between gNB and OAM due to ANR

The ANR function resides in the gNB and manages the NCRT. Located within ANR, the Neighbour Detection Function finds new neighbours and adds them to the NCRT. ANR also contains the Neighbour Removal Function which removes outdated NCRs. The Neighbour Detection Function and the Neighbour Removal Function are implementation specific.

An existing NCR from a source cell to a target cell means that gNB controlling the source cell:

a) Knows the global and physical IDs (e.g. NR CGI/NR PCI, ECGI/PCI) of the target cell.

b) Has an entry in the NCRT for the source cell identifying the target cell.

c) Has the attributes in this NCRT entry defined, either by OAM or set to default values.

NCRs are cell-to-cell relations, while an Xn link is set up between two gNBs. Neighbour Cell Relations are unidirectional, while an Xn link is bidirectional.

NOTE: The neighbour information exchange, which occurs during the Xn Setup procedure or in the gNB Configuration Update procedure, may be used for ANR purpose.

The ANR function also allows OAM to manage the NCRT. OAM can add and delete NCRs. It can also change the attributes of the NCRT. The OAM system is informed about changes in the NCRT.

- 当应用层初始化成功结束时，动态配置过程完成并且Xn接口可操作。

- 当 Xn 接口运行时，NG-RAN 节点应使用完整的服务小区列表来更新相邻的 NG-RAN 节点，或者，如果对等 NG-RAN 节点请求，则使用有限的服务小区列表来更新。

15.3.3 自动邻区关联功能

15.3.3.1 一般的

ANR功能的目的是减轻操作员手动管理NCR的负担。图15.3.3.1-1显示了ANR及其环境：

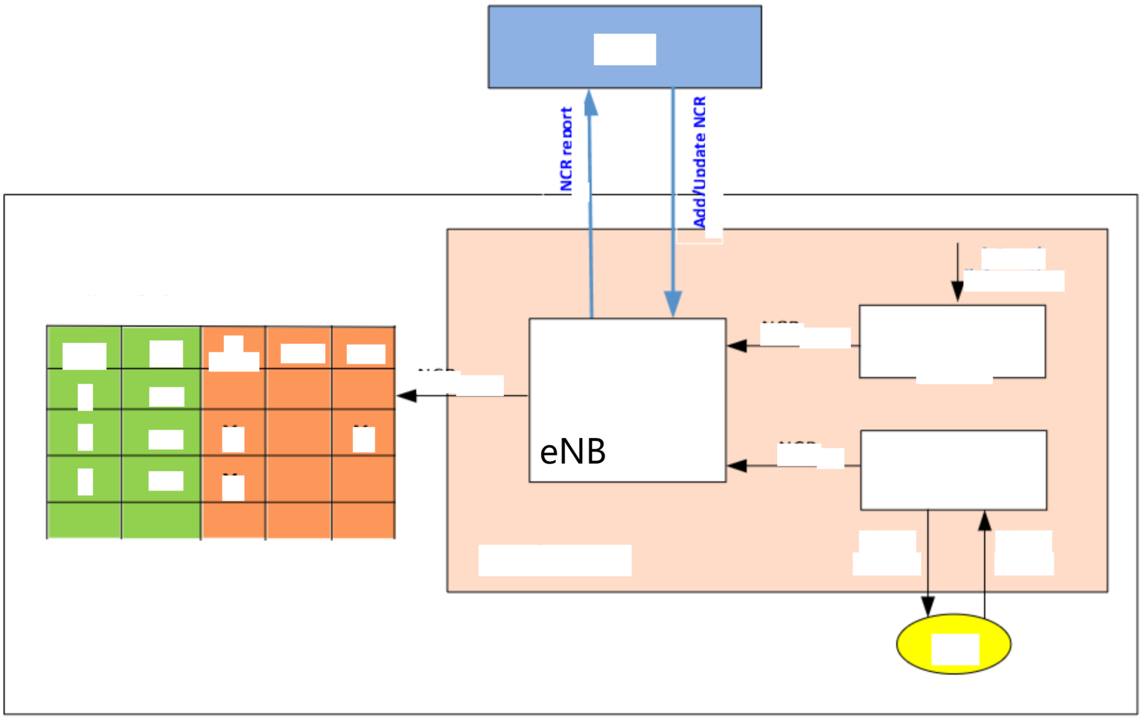


图15.3.3.1-1：ANR导致的gNB和OAM之间的交互

ANR功能驻留在gNB中并管理NCRT。邻居检测功能位于 ANR 内，可查找新邻居并将其添加到 NCRT。 ANR 还包含邻居删除功能，可删除过时的 NCR。
邻居检测功能和邻居删除功能是特定于实现的。

从源小区到目标小区的现有NCR意味着gNB控制源小区：

a) 了解目标小区的全局和物理 ID（例如 NR CGI/NR PCI、ECGI/PCI）。

b) 在 NCRT 中有一个条目，用于标识目标小区的源小区。

c) 此 NCRT 条目中的属性由 OAM 定义或设置为默认值。

NCR 是小区到小区的关系，而 Xn 链路是在两个 gNB 之间建立的。相邻小区关系是单向的，而 Xn 链路是双向的。

笔记： 在 Xn 设置过程或 gNB 配置更新过程中发生的邻居信息交换可以用于 ANR 目的。

ANR功能还允许OAM管理NCRT。 OAM 可以添加和删除NCR。它还可以更改 NCRT 的属性。 OAM 系统会获知 NCRT 的变化。

15.3.3.2 Intra-system – intra NR Automatic Neighbour Cell Relation Function

ANR relies on NCGI (see subclause 8.2).

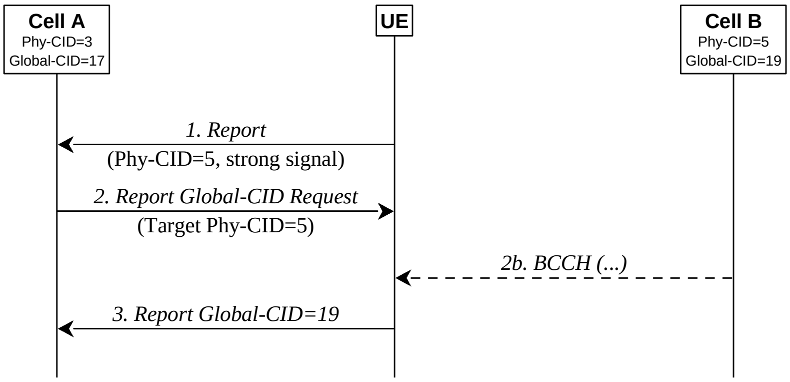


Figure 15.3.3.2-1: Automatic Neighbour Relation Function

Figure 15.3.3.2-1 depicts an example where the gNB serving cell A has an ANR function. In RRC_CONNECTED, the gNB instructs each UE to perform measurements on neighbour cells. The gNB may use different policies for instructing the UE to do measurements, and when to report them to the gNB. This measurement procedure is as specified in TS 38.331[12].

1. The UE sends a measurement report regarding cell B. This report contains Cell B's PCI, but not its NCGI.

When the gNB receives a UE measurement report containing the PCI, the following sequence may be used.

2. The gNB instructs the UE, using the newly discovered PCI as parameter, to read the all the broadcast NCGI(s), TAC(s), RANAC(s), PLMN ID(s) and NR frequency band(s) of the related neighbour cell. To do so, the gNB may need to schedule appropriate idle periods to allow the UE to read the NCGI from the broadcast channel of the detected neighbour cell. How the UE reads the NCGI is specified in TS 38.331.

3. When the UE has found out the new cell's NCGI(s), the UE reports all the broadcast NCGI(s) to the serving cell gNB. In addition, the UE reports all the tracking area code(s), RANAC(s), PLMN IDs and NR frequency band(s) that have been read by the UE.

4. The gNB decides to add this neighbour relation, and can use PCI and NCGI(s) to:

   a. Lookup a transport layer address to the new gNB.

   b. Update the Neighbour Cell Relation List.

   c. If needed, setup a new Xn interface towards this gNB.

15.3.3.3 Intra-system – intra E-UTRA Automatic Neighbour Cell Relation Function

Void.

15.3.3.4 Intra-system – inter RAT Automatic Neighbour Cell Relation Function

Void.

15.3.3.5 Inter-system Automatic Neighbour Cell Relation Function

For Inter-RAT ANR, each cell contains an Inter Frequency Search list. This list contains all frequencies that shall be searched.

15.3.3.2 系统内-NR内自动邻区关联功能

ANR 依赖于 NCGI（参见第 8.2 款）。

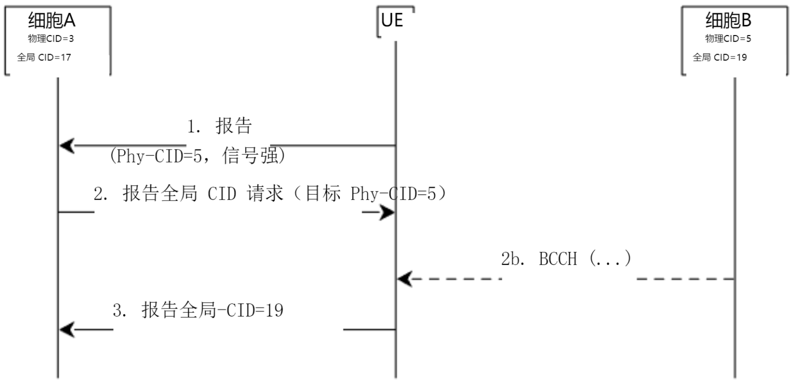


图 15.3.3.2-1：自动邻居关系功能

图15.3.3.2-1描述了gNB服务小区A具有ANR功能的示例。在RRC_CONNECTED中，gNB指示每个UE对相邻小区执行测量。gNB 可以使用不同的策略来指示 UE 进行测量以及何时将测量结果报告给 gNB。该测量程序如 TS 38.331[12] 中所规定。

1. UE发送关于小区B的测量报告。该报告包含小区B的PCI，但不包含其NCGI。

当gNB接收到包含PCI的UE测量报告时，可以使用以下序列。

2. gNB指示UE使用新发现的PCI作为参数，读取相关的所有广播NCGI、TAC、RANAC、PLMN ID和NR频带。邻居小区。为此，gNB 可能需要调度适当的空闲周期以允许 UE 从检测到的相邻小区的广播信道读取 NCGI。 UE如何读取NCGI在TS 38.331中指定。

3. 当UE发现新小区的NCGI时，UE向服务小区gNB报告所有广播NCGI。另外，UE报告UE已经读取的所有跟踪区域代码、RANAC、PLMN ID和NR频带。

4. gNB 决定添加此邻居关系，并且可以使用 PCI 和 NCGI 来：

   a. 查找新 gNB 的传输层地址。

   b.更新邻居小区关系列表。

   c. 如果需要，请为此 gNB 设置新的 Xn 接口。

15.3.3.3 系统内-E-UTRA自动邻区关联功能

空白。

15.3.3.4 系统内-RAT间自动邻区关联功能

空白。

15.3.3.5 系统间自动邻区关联功能

对于Inter-RAT ANR，每个小区包含一个频间搜索列表。该列表包含应搜索的所有频率。

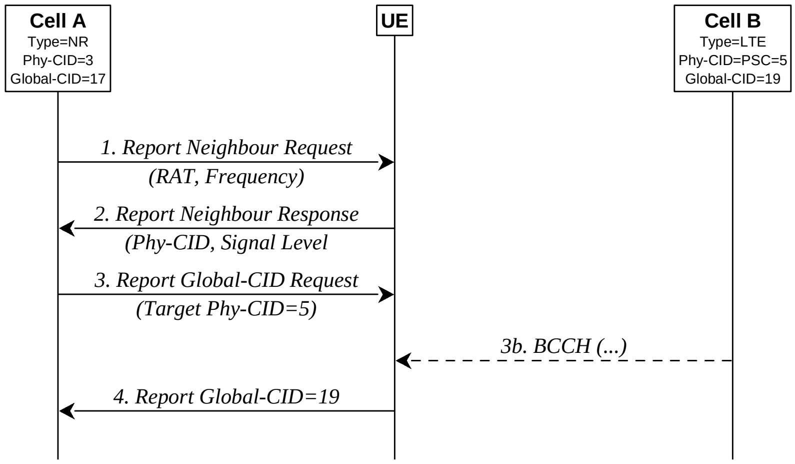


Figure 15.3.3.5-1: Automatic Neighbour Relation Function in case of E-UTRAN detected cell

Figure 15.3.3.5-1 depicts an example where the gNB serving cell A has an ANR function. In RRC_CONNECTED, the gNB can instruct a UE to perform measurements and detect cells on other RATs. The gNB may use different policies for instructing the UE to do measurements, and when to report them to the gNB.

1 The gNB instructs a UE to look for neighbour cells in the target RATs. To do so the gNB may need to schedule appropriate idle periods to allow the UE to scan all cells in the target RATs.

2 The UE reports the PCI and carrier frequency of the detected cells in the target RATs.

When the gNB receives UE reports containing PCIs of cell(s) the following sequence may be used.

3 The gNB instructs the UE, using the newly discovered PCI as parameter, to read the ECGI, the TAC and all available PLMN ID(s) of the newly detected cell in case of E-UTRA detected cells. The UE ignores transmissions from the serving cell while finding the requested information transmitted in the broadcast channel of the detected inter-system/inter-frequency neighbour cell. To do so, the gNB may need to schedule appropriate idle periods to allow the UE to read the requested information from the broadcast channel of the detected inter-RAT neighbour cell.

4 After the UE has read the requested information in the new cell, it reports the detected ECGI, TAC, and available PLMN ID(s) to the serving cell gNB.

5 The gNB updates its inter-RAT NCRT.

15.3.4 Xn-C TNL address discovery

If the NG-RAN node is aware of the RAN node ID of the candidate NG-RAN node (e.g. via the ANR function) but not of a TNL address suitable for SCTP connectivity, then the NG-RAN node can utilize the 5GC (an AMF it is connected to) to determine the TNL address as follows:

- The NG-RAN node sends the UPLINK RAN CONFIGURATION TRANSFER message to the AMF to request the TNL address of the candidate NG-RAN node, and includes relevant information such as the source and target RAN node ID.

- The AMF relays the request by sending the DOWNLINK RAN CONFIGURATION TRANSFER message to the candidate NG-RAN node identified by the target RAN node ID.

- The candidate NG-RAN node responds by sending the UPLINK RAN CONFIGURATION TRANSFER message containing one or more TNL addresses to be used for SCTP connectivity with the initiating NG-RAN node, and includes other relevant information such as the source and target RAN node ID.

- The AMF relays the response by sending the DOWNLINK CONFIGURATION TRANSFER message to the initiating NG-RAN node identified by the target RAN node ID.

NOTE: In this version of the specification, it is assumed that the NG-RAN node is able to determine the gNB ID length of the candidate gNB (e.g. based on OAM configuration).

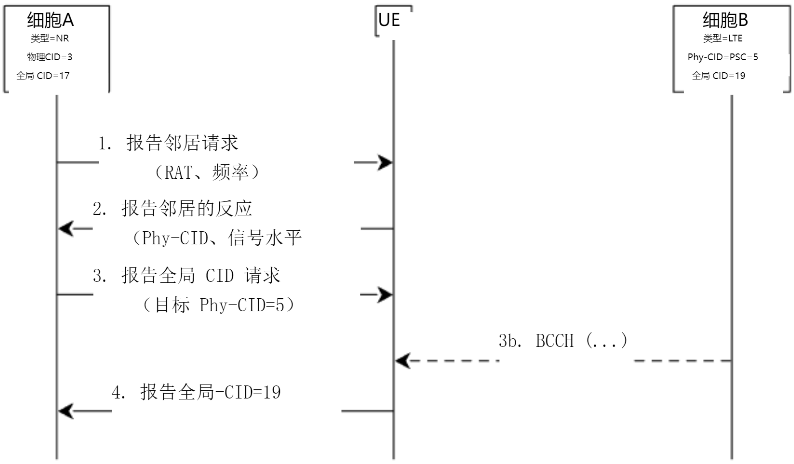


图 15.3.3.5-1：E-UTRAN 检测到小区时的自动邻居关系功能

图15.3.3.5-1描述了gNB服务小区A具有ANR功能的示例。在RRC_CONNECTED中，gNB可以指示UE执行测量并检测其他RAT上的小区。
gNB 可以使用不同的策略来指示 UE 进行测量以及何时将测量结果报告给 gNB。

1 gNB 指示 UE 在目标 RAT 中寻找相邻小区。为此，gNB 可能需要调度适当的空闲周期以允许 UE 扫描目标 RAT 中的所有小区。

2 UE报告目标RAT中检测到的小区的PCI和载波频率。

当 gNB 接收到包含小区 PCI 的 UE 报告时，可以使用以下序列。

3 gNB 使用新发现的 PCI 作为参数来指示 UE 读取 ECGI、TAC 以及在 E-UTRA 检测到的小区的情况下新检测到的小区的所有可用 PLMN ID。
UE忽略来自服务小区的传输，同时找到在检测到的系统间/频率间相邻小区的广播信道中发送的所请求的信息。
为此，gNB 可能需要调度适当的空闲周期，以允许 UE 从检测到的 InterRAT 相邻小区的广播信道中读取请求的信息。

4 UE在新小区中读取请求的信息后，向服务小区gNB报告检测到的ECGI、TAC和可用的PLMN ID。

5 gNB 更新其 RAT 间 NCRT。

15.3.4 Xn-C TNL 地址发现

如果 NG-RAN 节点知道候选 NG-RAN 节点的 RAN 节点 ID（例如，通过 ANR 功能），但不知道适合 SCTP 连接的 TNL 地址，则 NG-RAN 节点可以利用 5GC（它连接到的 AMF）来确定 TNL 地址，如下所示：

- NG-RAN节点向AMF发送UPLINK RAN CONFIGURATION TRANSFER消息，请求候选NG-RAN节点的TNL地址，并包含源、目标RAN节点ID等相关信息。

- AMF 通过向目标 RAN 节点 ID 标识的候选 NG-RAN 节点发送 DOWNLINK RAN CONFIGURATION TRANSFER 消息来中继该请求。

- 候选 NG-RAN 节点通过发送 UPLINK RAN CONFIGURATION TRANSFER 消息进行响应，该消息包含一个或多个用于与发起 NG-RAN 节点进行 SCTP 连接的 TNL 地址，并包括其他相关信息，例如源和目标 RAN 节点 ID。

- AMF 通过将下行链路配置传输消息发送到由目标 RAN 节点 ID 标识的发起 NG-RAN 节点来中继响应。

笔记： 在此版本的规范中，假设 NG-RAN 节点能够确定候选 gNB 的 gNB ID 长度（例如，基于 OAM 配置）。

16 Verticals Support

16.1 URLLC

16.1.1 Overview

The support of Ultra-Reliable and Low Latency Communications (URLLC) services is facilitated by the introduction of the mechanisms described in the following subclauses. Please note however that those mechanisms need not be limited to the provision of URLLC services.

16.1.2 LCP Restrictions

With LCP restrictions in MAC, RRC can restrict the mapping of a logical channel to a subset of the configured cells, numerologies, PUSCH transmission durations and control whether a logical channel can utilise the resources allocated by a Type 1 Configured Grant (see subclause 10.3). With such restrictions, it then becomes possible to reserve, for instance, the numerology with the largest subcarrier spacing and/or shortest PUSCH transmission duration for URLLC services.

16.1.3 Packet Duplication

When duplication is configured for a radio bearer by RRC, a secondary RLC entity and a secondary logical channel are added to the radio bearer to handle the duplicated PDCP PDUs. Duplication at PDCP therefore consists in submitting the same PDCP PDUs twice: once to the primary RLC entity and a second time to the secondary RLC entity. With two independent transmission paths, packet duplication therefore increases reliability and reduces latency and is especially beneficial for URLLC services.

NOTE: PDCP control PDUs are not duplicated and always submitted to the primary RLC entity.

When duplication is activated, the original PDCP PDU and the corresponding duplicate shall not be transmitted on the same carrier. The two different logical channels can either belong to the same MAC entity (CA) or to different ones (DC). In the former case, logical channel mapping restrictions are used in MAC to ensure that the logical channel carrying the original PDCP PDUs and logical channel carrying the corresponding duplicates are not sent on the same carrier.

When an RLC entity acknowledges the transmission of a PDCP PDU, the PDCP entity shall indicate to the other RLC entity to discard it; and when the secondary RLC entity reaches the maximum number of retransmissions for a PDCP PDU, the UE informs the gNB but does not trigger RLF.

When configuring duplication for a DRB, RRC also sets the initial state (either activated or deactivated). After the configuration, the state can then be dynamically controlled by means of a MAC control element and in DC, the UE applies the MAC CE commands regardless of their origin (MCG or SCG). When duplication is deactivated for a DRB, the secondary RLC entity is not re-established, the HARQ buffers are not flushed but the corresponding logical channel mapping restrictions – if any – are lifted, and the transmitting PDCP entity should indicate to the secondary RLC entity to discard all duplicated PDCP PDUs.

When duplication is configured for an SRB the state is always active and cannot be dynamically controlled.

When activating duplication for a DRB, NG-RAN should ensure that at least one serving cell is activated for each logical channel of the DRB; and when the deactivation of SCells leaves no serving cells activated for a logical channel of the DRB, NG-RAN should ensure that duplication is also deactivated.

16.2 IMS Voice

16.2.1 Support for MMTEL IMS voice and video enhancements

16.2.1.1 RAN-assisted codec adaptation

RAN-assisted codec adaptation provides a means for the gNB to send codec adaptation indication with recommended bit rate to assist the UE to select or adapt to a codec rate for MMTEL voice or MMTEL video. The RAN-assisted codec adaptation mechanism supports the uplink/downlink bit rate increase or decrease. For a bearer associated with

16 垂直行业支持

16.1 URLLC

16.1.1 概述

通过引入以下子条款中描述的机制促进了对超可靠和低延迟通信（URLLC）服务的支持。但请注意，这些机制不必限于提供 URLLC 服务。

16.1.2 LCP 限制

通过 MAC 中的 LCP 限制，RRC 可以限制逻辑信道到配置小区、参数、PUSCH 传输持续时间的子集的映射，并控制逻辑信道是否可以利用由类型 1 配置授权分配的资源（参见子条款 10.3） 。
通过这样的限制，例如可以为URLLC服务保留具有最大子载波间隔和/或最短PUSCH传输持续时间的数字。

16.1.3 数据包复制

当RRC为无线承载配置复制时，辅助RLC实体和辅助逻辑信道被添加到无线承载以处理复制的PDCP PDU。
因此，PDCP 的复制包括两次提交相同的 PDCP PDU：一次向主 RLC 实体提交，第二次向次要 RLC 实体提交。
通过两条独立的传输路径，数据包复制可提高可靠性并减少延迟，对于 URLLC 服务尤其有利。

笔记： PDCP 控制 PDU 不重复，并且始终提交给主 RLC 实体。

当激活复制时，原始 PDCP PDU 和相应的副本不得在同一载波上传输。两个不同的逻辑信道可以属于相同的MAC实体(CA)或不同的MAC实体(DC)。
在前一种情况下，在MAC中使用逻辑信道映射限制来确保承载原始PDCP PDU的逻辑信道和承载相应副本的逻辑信道不在同一载波上发送。

当RLC实体确认PDCP PDU的传输时，该PDCP实体应指示其他RLC实体丢弃它；当辅RLC实体达到PDCP PDU的最大重传次数时，UE通知gNB，但不触发RLF。

当为 DRB 配置复制时，RRC 还会设置初始状态（激活或去激活）。
配置完成后，可以通过 MAC 控制元素动态控制状态，并且在 DC 中，UE 应用 MAC CE 命令，无论其来源（MCG 或 SCG）如何。
当针对 DRB 去激活复制时，辅助 RLC 实体不会重新建立，HARQ 缓冲区不会刷新，但相应的逻辑信道映射限制（如果有）会解除，并且发送 PDCP 实体应向辅助 RLC 实体指示丢弃所有重复的 PDCP PDU。

当为SRB配置复制时，状态始终处于活动状态并且无法动态控制。

NG-RAN在激活DRB复制时，应确保该DRB的每个逻辑信道至少激活一个服务小区；当 SCell 的去激活没有留下任何为 DRB 的逻辑信道激活的服务小区时，NG-RAN 应确保复制也被去激活。

16.2 IMS语音

16.2.1 支持 MMTEL IMS 语音和视频增强功能

16.2.1.1 RAN 辅助编解码器适配

RAN辅助编解码器适配为gNB提供了一种发送具有推荐比特率的编解码器适配指示的手段，以帮助UE选择或适配MMTEL语音或MMTEL视频的编解码器速率。
RAN辅助编解码适配机制支持上下行比特率增减。对于与关联的承载者

configuration of MBR greater than GBR, the recommended uplink/downlink bit rate is within boundaries set by the MBR and GBR of the concerned bearer.

For uplink or downlink bit rate adaptation, gNB may send a recommended bit rate to the UE to inform the UE on the currently recommended transport bit rate on the local uplink or downlink, which the UE may use in combination with other information to adapt the bit rate, e.g. the UE may send a bit rate request to the peer UE via application layer messages as specified in 3GPP TS 26.114 [24], which the peer UE may use in combination with other information to adapt the codec bit rate. The recommended bit rate is in kbps at the physical layer at the time when the decision is made.

The recommended bit rate for UL and DL is conveyed as a MAC Control Element (CE) from the gNB to the UE as outlined in Figure 16.2.1.1-1.

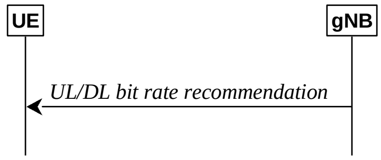


Figure 16.2.1.1-1: UL or DL bit rate recommendation

Based on the recommended bit rate from the gNB, a UE may initiate an end-to-end bit rate adaptation with its peer (UE or MGW). The UE may also send a query message to its local gNB to check if a bit rate recommended by its peer can be provided by the gNB. The UE is not expected to go beyond the recommended bit rate from the gNB.

The recommended bit rate query message is conveyed as a MAC CE from the UE to the gNB as outlined in Figure 16.2.1.1-2.

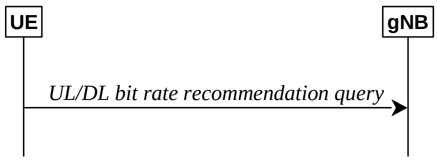


Figure 16.2.1.1-2: UL or DL bit rate recommendation query

A prohibit timer can be configured per logical channel by the network to limit UEs sending frequent query MAC CEs. Independent prohibit timers are used for each direction (uplink and downlink) to prohibit the UE from retransmitting exactly the same query MAC CE to the gNB during the configured time.

16.2.1.2 MMTEL voice quality/coverage enhancements

The air interface delay budget can be relaxed to increase the robustness of the transmission for coverage enhancement. Such relaxation may be achieved when a UE in good coverage indicates a preference to the gNB to reduce the local air interface delay by sending a *DelayBudgetReport* message to decrease the DRX cycle length, so that the E2E delay and jitter can be reduced. When the UE detects changes such as end-to-end MMTEL voice quality or local radio quality, the UE may inform the gNB its new preference by sending *DelayBudgetReport* messages with updated contents.

16.3 Network Slicing

16.3.1 General Principles and Requirements

In this sub clause, the general principles and requirements related to the realization of network slicing in the NG-RAN for NR connected to 5GC and for E-UTRA connected to 5GC are given.

A network slice always consists of a RAN part and a CN part. The support of network slicing relies on the principle that traffic for different slices is handled by different PDU sessions. Network can realise the different network slices by scheduling and also by providing different L1/L2 configurations. The UE provides assistance information for network slice selection in RRC message, if it has been provided by NAS. While the network can support large number of slices (hundreds), the UE need not support more than 8 slices simultaneously.

Network Slicing is a concept to allow differentiated treatment depending on each customer requirements. With slicing, it is possible for Mobile Network Operators (MNO) to consider customers as belonging to different tenant types with

当MBR配置大于GBR时，推荐的上下行比特率在相关承载的MBR和GBR设置的范围内。

对于上行链路或下行链路比特率适配，gNB可以向UE发送推荐比特率，以通知UE当前在本地上行链路或下行链路上推荐的传输比特率，UE可以结合其他信息来使用该比特率来适配比特率率，例如
UE 可以通过 3GPP TS 26.114 [24] 中指定的应用层消息向对等 UE 发送比特率请求，对等 UE 可以结合其他信息使用该消息来调整编解码器比特率。
做出决定时建议的物理层比特率以 kbps 为单位。

UL 和 DL 的推荐比特率作为 MAC 控制元素 (CE) 从 gNB 传送到 UE，如图 16.2.1.1-1 所示。

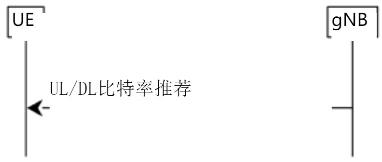


图16.2.1.1-1：UL或DL比特率建议

基于 gNB 推荐的比特率，UE 可以发起与其对等方（UE 或 MGW）的端到端比特率适配。 UE还可以向其本地gNB发送查询消息以检查gNB是否可以提供其对等体推荐的比特率。
UE 预计不会超出 gNB 推荐的比特率。

推荐的比特率查询消息作为 MAC CE 从 UE 传送到 gNB，如图所示
16.2.1.1-2.

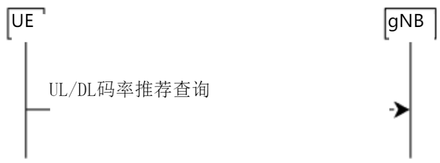


图16.2.1.1-2：UL或DL比特率推荐查询

网络可以为每个逻辑信道配置禁止定时器，以限制UE发送频繁的查询MAC CE。
每个方向（上行链路和下行链路）使用独立的禁止定时器，以禁止 UE 在配置的时间内向 gNB 重传完全相同的查询 MAC CE。

16.2.1.2 MMTEL 语音质量/覆盖范围增强

可以放宽空中接口延迟预算，以提高传输的鲁棒性，从而增强覆盖范围。
当覆盖良好的UE指示gNB优先通过发送DelayBudgetReport消息来减少本地空口延迟以减少DRX周期长度时，可以实现这种放松，从而可以减少E2E延迟和抖动。
当UE检测到诸如端到端MMTEL语音质量或本地无线电质量之类的变化时，UE可以通过发送具有更新内容的DelayBudgetReport消息来通知gNB其新的偏好。

16.3 网络切片

16.3.1 一般原则和要求

在本子条款中，给出了与连接到5GC的NR和连接到5GC的E-UTRA在NG-RAN中实现网络切片相关的一般原则和要求。

网络切片始终由 RAN 部分和 CN 部分组成。网络切片的支持依赖于不同切片的流量由不同的 PDU 会话处理的原则。
网络可以通过调度以及提供不同的L1/L2配置来实现不同的网络切片。 UE 在 RRC 消息中提供网络切片选择的辅助信息（如果 NAS 已提供）。
虽然网络可以支持大量切片（数百个），但 UE 不需要同时支持超过 8 个切片。

网络切片是一个允许根据每个客户的要求进行差异化处理的概念。通过切片，移动网络运营商 (MNO) 可以将客户视为属于不同的租户类型

each having different service requirements that govern in terms of what slice types each tenant is eligible to use based on Service Level Agreement (SLA) and subscriptions.

NSSAI (Network Slice Selection Assistance Information) includes one or more S-NSSAIs (Single NSSAI). Each network slice is uniquely identified by a S-NSSAI, as defined in 3GPP TS 23.501 [3].

The following key principles apply for support of Network Slicing in NG-RAN:

RAN awareness of slices

- NG-RAN supports a differentiated handling of traffic for different network slices which have been pre-configured. How NG-RAN supports the slice enabling in terms of NG-RAN functions (i.e. the set of network functions that comprise each slice) is implementation dependent.

Selection of RAN part of the network slice

- NG-RAN supports the selection of the RAN part of the network slice, by assistance information provided by the UE or the 5GC which unambiguously identifies one or more of the pre-configured network slices in the PLMN.

Resource management between slices

- NG-RAN supports policy enforcement between slices as per service level agreements. It should be possible for a single NG-RAN node to support multiple slices. The NG-RAN should be free to apply the best RRM policy for the SLA in place to each supported slice.

Support of QoS

- NG-RAN supports QoS differentiation within a slice.

RAN selection of CN entity

- For initial attach, the UE may provide assistance information to support the selection of an AMF. If available, NG-RAN uses this information for routing the initial NAS to an AMF. If the NG-RAN is unable to select an AMF using this information or the UE does not provide any such information the NG-RAN sends the NAS signalling to one of the default AMFs.

- For subsequent accesses, the UE provides a Temp ID, which is assigned to the UE by the 5GC, to enable the NG-RAN to route the NAS message to the appropriate AMF as long as the Temp ID is valid (NG-RAN is aware of and can reach the AMF which is associated with the Temp ID). Otherwise, the methods for initial attach applies.

Resource isolation between slices

- the NG-RAN supports resource isolation between slices. NG-RAN resource isolation may be achieved by means of RRM policies and protection mechanisms that should avoid that shortage of shared resources in one slice breaks the service level agreement for another slice. It should be possible to fully dedicate NG-RAN resources to a certain slice. How NG-RAN supports resource isolation is implementation dependent.

Slice Availability

- Some slices may be available only in part of the network. The NG-RAN supported S-NSSAI(s) is configured by OAM. Awareness in the NG-RAN of the slices supported in the cells of its neighbours may be beneficial for inter-frequency mobility in connected mode. It is assumed that the slice availability does not change within the UE's registration area.

- The NG-RAN and the 5GC are responsible to handle a service request for a slice that may or may not be available in a given area. Admission or rejection of access to a slice may depend by factors such as support for the slice, availability of resources, support of the requested service by NG-RAN.

Support for UE associating with multiple network slices simultaneously

- In case a UE is associated with multiple slices simultaneously, only one signalling connection is maintained and for intra-frequency cell reselection, the UE always tries to camp on the best cell. For inter-frequency cell reselection, dedicated priorities can be used to control the frequency on which the UE camps.

Granularity of slice awareness

每个租户都有不同的服务要求，这些要求根据服务级别协议 (SLA) 和订阅来管理每个租户有资格使用的切片类型。

NSSAI（网络切片选择辅助信息）包括一个或多个S-NSSAI（单个NSSAI）。每个网络切片均由 S-NSSAI 唯一标识，如 3GPP TS 23.501 [3] 中所定义。

以下关键原则适用于支持 NG-RAN 中的网络切片：

切片的 RAN 感知

- NG-RAN支持对预先配置的不同网络切片进行差异化的流量处理。 NG-RAN 如何支持 NG-RAN 功能（即组成每个切片的网络功能集）方面的切片启用取决于实现。

网络切片RAN部分的选择

- NG-RAN 支持通过 UE 或 5GC 提供的辅助信息来选择网络切片的 RAN 部分，该辅助信息明确标识 PLMN 中的一个或多个预配置网络切片。

切片之间的资源管理

- NG-RAN 支持根据服务级别协议在切片之间执行策略。单个 NG-RAN 节点应该可以支持多个切片。 NG-RAN 应该可以自由地将 SLA 的最佳 RRM 策略应用于每个支持的切片。

支持服务质量

- NG-RAN 支持切片内的 QoS 区分。

CN实体的RAN选择

- 对于初始附着，UE可以提供辅助信息来支持AMF的选择。如果可用，NG-RAN 使用此信息将初始 NAS 路由到 AMF。
  如果 NG-RAN 无法使用此信息选择 AMF，或者 UE 未提供任何此类信息，则 NG-RAN 会将 NAS 信令发送到默认 AMF 之一。

- 对于后续接入，UE 提供由 5GC 分配给 UE 的临时 ID，以便只要临时 ID 有效（NG-RAN 知道），NG-RAN 就可以将 NAS 消息路由到适当的 AMF并且可以到达与临时 ID 关联的 AMF）。
  否则，应用初始附加的方法。

切片之间的资源隔离

- NG-RAN支持切片之间的资源隔离。 NG-RAN 资源隔离可以通过 RRM 策略和保护机制来实现，这些策略和保护机制应避免一个切片中共享资源的短缺破坏另一切片的服务水平协议。
  应该可以将 NG-RAN 资源完全专用于某个切片。 NG-RAN 如何支持资源隔离取决于实现。

切片可用性

- 某些切片可能仅在部分网络中可用。 NG-RAN 支持的 S-NSSAI 由 OAM 配置。 NG-RAN 对其邻居小区支持的切片的感知可能有利于连接模式下的频率间移动性。
  假设分片可用性在UE的注册区域内没有改变。

- NG-RAN 和 5GC 负责处理对给定区域中可能可用或不可用的切片的服务请求。
  允许或拒绝对切片的接入可能取决于诸如对切片的支持、资源的可用性、NG-RAN对所请求的服务的支持等因素。

支持UE同时关联多个网络切片

- 如果UE同时与多个切片相关联，则仅维持一个信令连接，并且对于同频小区重选，UE总是尝试驻留在最佳小区上。
  对于异频小区重选，可以使用专用优先级来控制UE驻留的频率。

切片感知的粒度

- Slice awareness in NG-RAN is introduced at PDU session level, by indicating the S-NSSAI corresponding to the PDU Session, in all signalling containing PDU session resource information.

Validation of the UE rights to access a network slice

- It is the responsibility of the 5GC to validate that the UE has the rights to access a network slice. Prior to receiving the Initial Context Setup Request message, the NG-RAN may be allowed to apply some provisional/local policies, based on awareness of which slice the UE is requesting access to. During the initial context setup, the NG-RAN is informed of the slice for which resources are being requested.

16.3.2 CN Instance and NW Slice Selection

16.3.2.1 CN-RAN interaction and internal RAN aspects

NG-RAN selects AMF based on a Temp ID or assistance information provided by the UE over RRC. The mechanisms used in the RRC protocol are described in the next sub clause.

Table 16.3.2.1-1 AMF selection based on Temp ID and assistance information

Temp ID	Assistance Info	AMF Selection by NG-RAN
not available or invalid	not available	One of the default AMFs is selected (NOTE)
not available or invalid	present	Selects AMF which supports UE requested slices
valid	not available, or present	Selects AMF per CN identity information in Temp ID
NOTE: The set of default AMFs is configured in the NG-RAN nodes via OAM.		

16.3.2.2 Radio Interface Aspects

The UE conveys the slice assistance information over RRC in the explicitly indicated format by the upper layer. The slice assistance information consists of one or a list of S-NSSAIs, where an S-NSSAI is a combination of:

- mandatory SST (Slice/Service Type) field, which identifies the slice type and consists of 8 bits (with range is 0-255);

- optional SD (Slice Differentiator) field, which differentiates among Slices with same SST field and consist of 24 bits.

The list shall convey at most 8 S-NSSAI.

16.3.3 Resource Isolation and Management

Resource isolation enables specialized customization and avoids one slice affecting another slice.

Hardware/software resource isolation is up to implementation. Each slice may be assigned with either shared or dedicated radio resource up to RRM implementation and SLA.

To enable differentiated handling of traffic for network slices with different SLA:

- NG-RAN is configured with a set of different configurations for different network slices by OAM;

- To select the appropriate configuration for the traffic for each network slice, NG-RAN receives relevant information indicating which of the configurations applies for this specific network slice.

16.3.4 Signalling Aspects

16.3.4.1 General

In this sub clause, signalling flows related to the realization of network slicing in the NG-RAN are given.

16.3.4.2 CN Instance and NW Slice Selection

RAN selects the AMF based on a Temp ID or assistance information provided by the UE.

- NG-RAN 中的切片感知是在 PDU 会话级别引入的，通过在包含 PDU 会话资源信息的所有信令中指示与 PDU 会话相对应的 S-NSSAI。

验证UE访问网络切片的权限

- 5GC 负责验证 UE 是否有权访问网络切片。
  在接收初始上下文设置请求消息之前，可以允许 NG-RAN 基于对 UE 请求接入哪个切片的了解来应用一些临时/本地策略。
  在初始上下文设置期间，NG-RAN 被告知正在请求资源的切片。

16.3.2 CN实例和NW切片选择

16.3.2.1 CN-RAN 交互和内部 RAN 方面

NG-RAN 根据 UE 通过 RRC 提供的临时 ID 或辅助信息来选择 AMF。 RRC 协议中使用的机制将在下一个子条款中描述。

表16.3.2.1-1 基于Temp ID和辅助信息的AMF选择

临时 ID	协助信息	NG-RAN 选择 AMF
不可用或无效	不可用	选择默认 AMF 之一（注意）
不可用或无效	存在	选择支持UE请求的切片的AMF
有效的	不可用或存在	根据 Temp 中的 CN 身份信息选择 AMF ID
笔记: 默认 AMF 集是通过 OAM 在 NG-RAN 节点中配置的。		

16.3.2.2 无线电接口方面

UE以上层明确指示的格式通过RRC传送切片辅助信息。分片辅助信息由一个或一系列 S-NSSAI 组成，其中 S-NSSAI 是以下各项的组合：

- 强制SST（Slice/Service Type）字段，标识分片类型，由8位组成（范围为0255）；

- 可选的SD（Slice Differentiator）字段，用于区分具有相同SST字段的Slice，由24位组成。

该列表最多应传送 8 个 S-NSSAI。

16.3.3 资源隔离与管理

资源隔离支持专门定制，并避免一个切片影响另一个切片。

硬件/软件资源隔离取决于实现。每个切片都可以分配有共享或专用无线资源，具体取决于 RRM 实施和 SLA。

要对具有不同 SLA 的网络切片启用流量的差异化处理：

- NG-RAN通过OAM为不同的网络切片配置一组不同的配置；

- 为了为每个网络切片的流量选择适当的配置，NG-RAN 接收指示哪些配置适用于该特定网络切片的相关信息。

16.3.4 信令方面

16.3.4.1 一般的

在本子条款中，给出了与NG-RAN中网络切片的实现相关的信令流程。

16.3.4.2 CN实例和NW切片选择

RAN 根据 UE 提供的临时 ID 或辅助信息来选择 AMF。

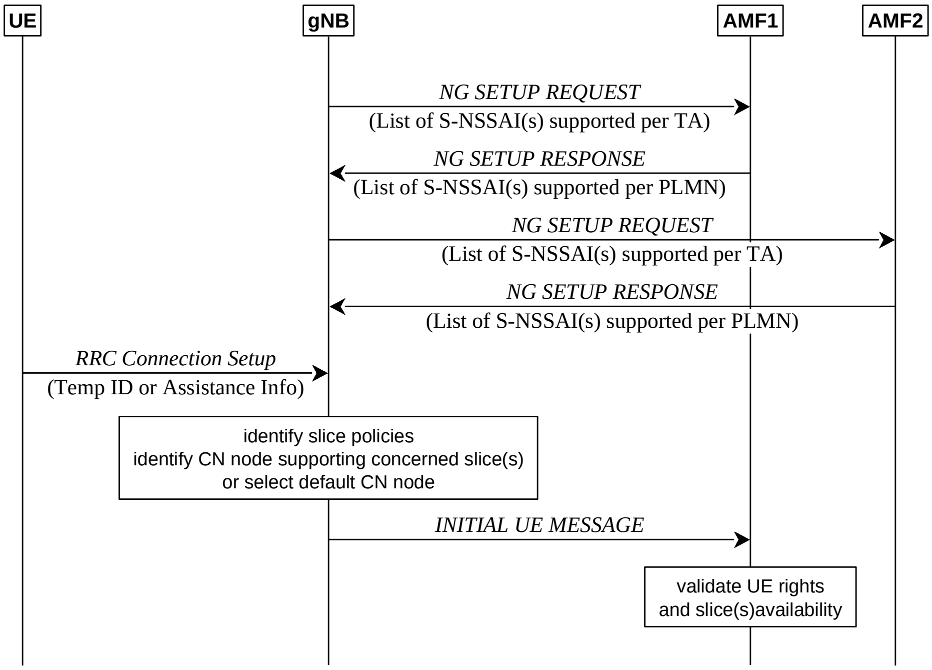


Figure 16.3.4.2-1: AMF instance selection

In case a Temp ID is not available, the NG-RAN uses the assistance information provided by the UE at RRC connection establishment to select the appropriate AMF instance (the information is provided after MSG3 of the random access procedure). If such information is also not available, the NG-RAN routes the UE to one of the configured default AMF instances.

The NG-RAN uses the list of supported S-NSSAI(s) previously received in the NG Setup Response message when selecting the AMF with the assistance information. This list may be updated via the AMF Configuration Update message.

16.3.4.3 UE Context Handling

Following the initial access, the establishment of the RRC connection and the selection of the correct AMF, the AMF establishes the complete UE context by sending the Initial Context Setup Request message to the NG-RAN over NG-C. The message contains the Allowed NSSAI and additionally contains the S-NSSAI(s) as part of the PDU session(s) resource description when present in the message. Upon successful establishment of the UE context and allocation of PDU session resources to the relevant NW slice(s) when present, the NG-RAN responds with the Initial Context Setup Response message.

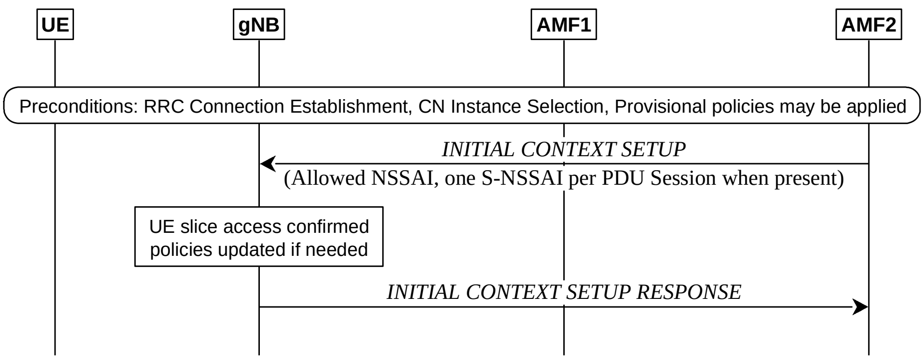


Figure 16.3.4.3-1: Network Slice-aware Initial Context Setup

16.3.4.4 PDU Session Handling

When new PDU sessions need to be established or existing ones modified or released, the 5GC requests the NG-RAN to allocate/release resources relative to the relevant PDU sessions by means of the PDU Session Resource Setup/Modify/Release procedures over NG-C. One S-NSSAI is added per PDU session, so NG-RAN is enabled to apply policies at PDU session level according to the SLA represented by the network slice, while still being able to apply (for example) differentiated QoS within the slice.

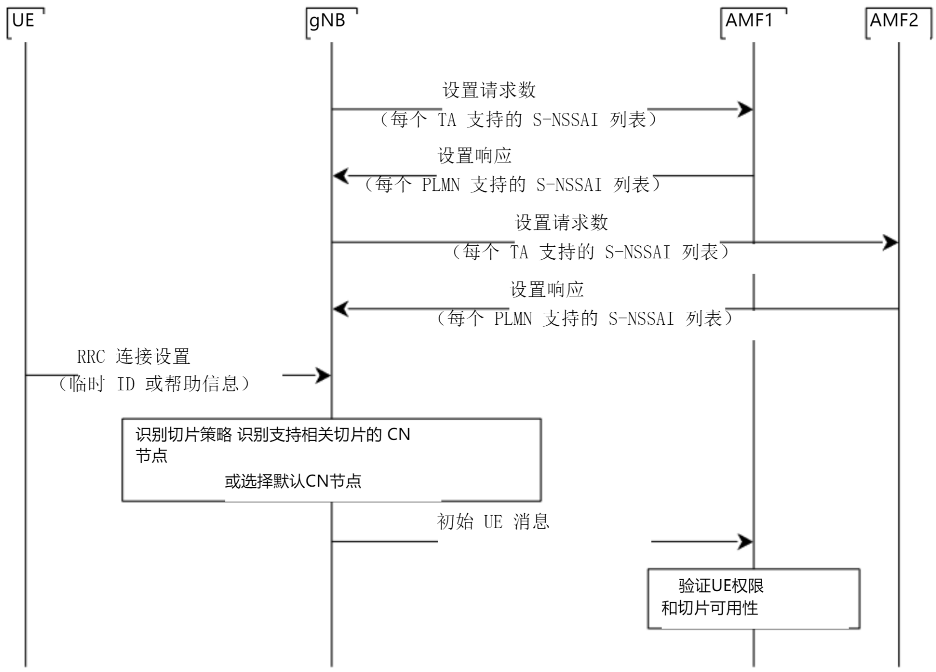


图16.3.4.2-1：AMF实例选择

如果临时 ID 不可用，NG-RAN 将使用 UE 在 RRC 连接建立时提供的辅助信息来选择适当的 AMF 实例（该信息在随机接入过程的 MSG3 之后提供）。
如果此类信息也不可用，NG-RAN 会将 UE 路由到配置的默认 AMF 实例之一。

当选择具有辅助信息的 AMF 时，NG-RAN 使用先前在 NG 设置响应消息中接收到的支持的 S-NSSAI 列表。该列表可以通过 AMF 配置更新消息进行更新。

16.3.4.3 UE上下文处理

在初始接入、RRC 连接建立和正确 AMF 选择之后，AMF 通过 NG-C 向 NG-RAN 发送初始上下文设置请求消息来建立完整的 UE 上下文。
该消息包含允许的 NSSAI，并且还包含 S-NSSAI，作为消息中存在的 PDU 会话资源描述的一部分。
当成功建立 UE 上下文并将 PDU 会话资源分配给相关 NW 切片（如果存在）时，NG-RAN 将使用初始上下文设置响应消息进行响应。

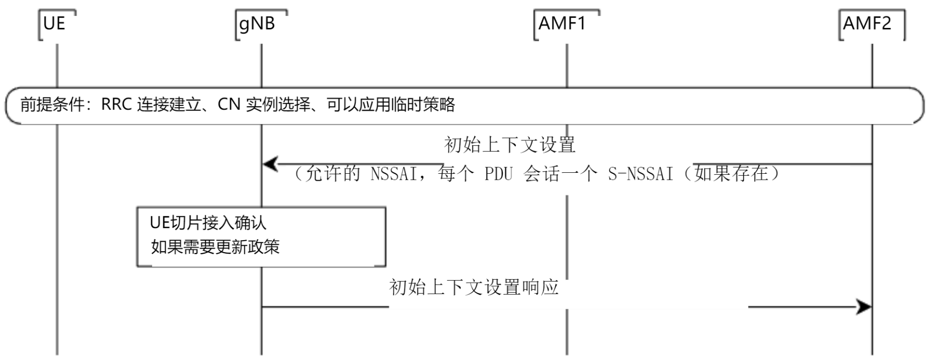


图 16.3.4.3-1：网络切片感知初始上下文设置

16.3.4.4 PDU 会话处理

当需要建立新的 PDU 会话或修改或释放现有的 PDU 会话时，5GC 请求 NG-RAN 通过 NG-C 上的 PDU 会话资源设置/修改/释放过程来分配/释放与相关 PDU 会话相关的资源。
每个 PDU 会话添加一个 S-NSSAI，因此 NG-RAN 能够根据网络切片表示的 SLA 在 PDU 会话级别应用策略，同时仍然能够在切片内应用（例如）差异化 QoS。

NG-RAN confirms the establishment/modification/release of the resources for a PDU session associated to a certain NW slice by responding with the PDU Session Resource Setup/Modify/Release Response message over the NG-C interface.

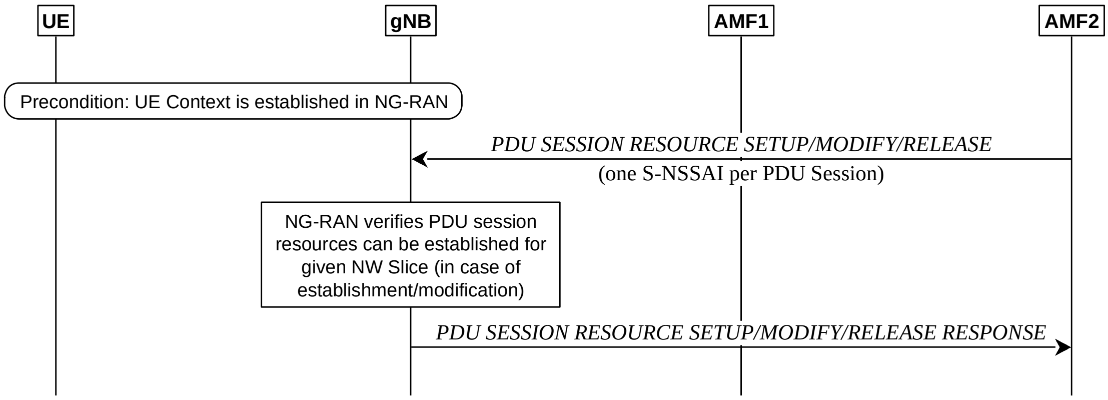


Figure 16.3.4.4-1: Network Slice-aware PDU Session Resource Setup/Modify/Release

16.3.4.5 Mobility

To make mobility slice-aware in case of Network Slicing, S-NSSAI is introduced as part of the PDU session information that is transferred during mobility signalling. This enables slice-aware admission and congestion control.

Both NG and Xn handovers are allowed regardless of the slice support of the target NG-RAN node i.e. even if the target NG-RAN node does not support the same slices as the source NG-RAN node. An example for the case of active mode mobility across different Registration Areas, is shown in Figure 16.3.4.5-1 for the case of 5GC involved handover and in Figure 16.3.4.5-2 for the case of Xn based handover.

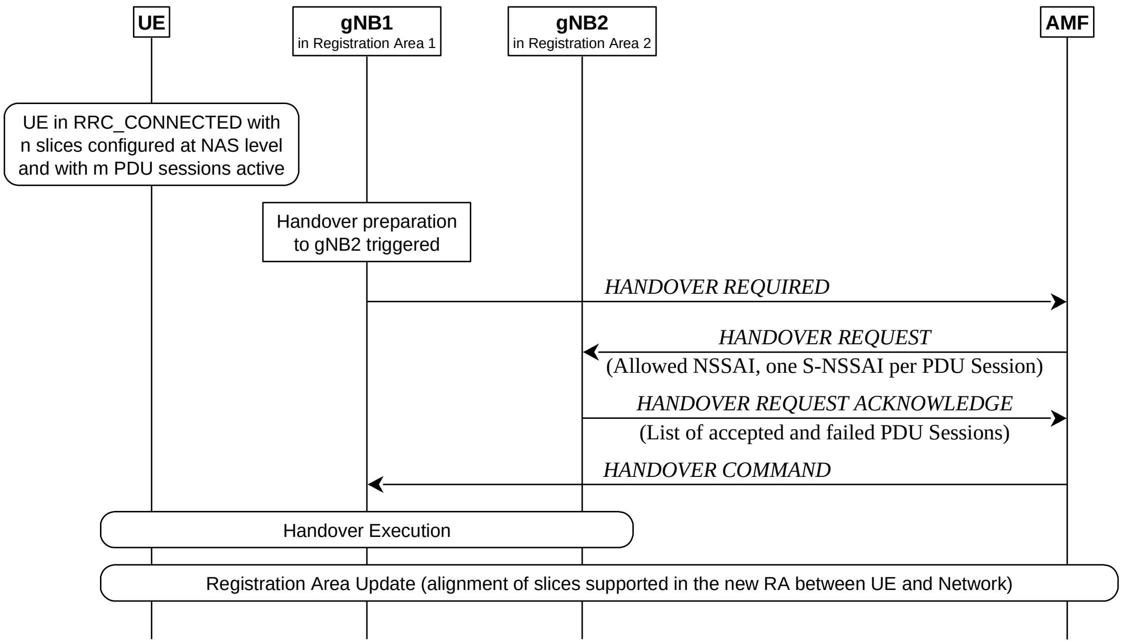


Figure 16.3.4.5-1: CN based mobility across different Registration Areas

NG-RAN 通过 NG-C 接口上的 PDU 会话资源设置/修改/释放响应消息进行响应，确认与某个 NW 切片关联的 PDU 会话的资源的建立/修改/释放。

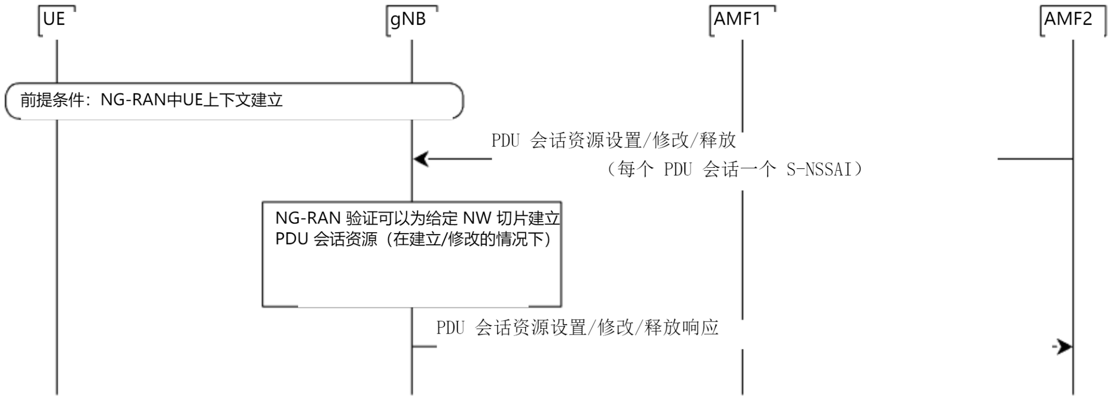


图 16.3.4.4-1：网络切片感知 PDU 会话资源设置/修改/释放

16.3.4.5 移动性

为了在网络切片的情况下实现移动性切片感知，引入了 S-NSSAI 作为在移动性信令期间传输的 PDU 会话信息的一部分。这使得切片感知准入和拥塞控制成为可能。

无论目标 NG-RAN 节点的分片支持如何，都允许 NG 和 Xn 切换，即即使目标 NG-RAN 节点不支持与源 NG-RAN 节点相同的分片。

图 16.3.4.5-1 显示了跨不同注册区域的主动模式移动性情况的示例（涉及 5GC 的切换），图 16.3.4.5-2 显示了基于 Xn 的切换的情况。

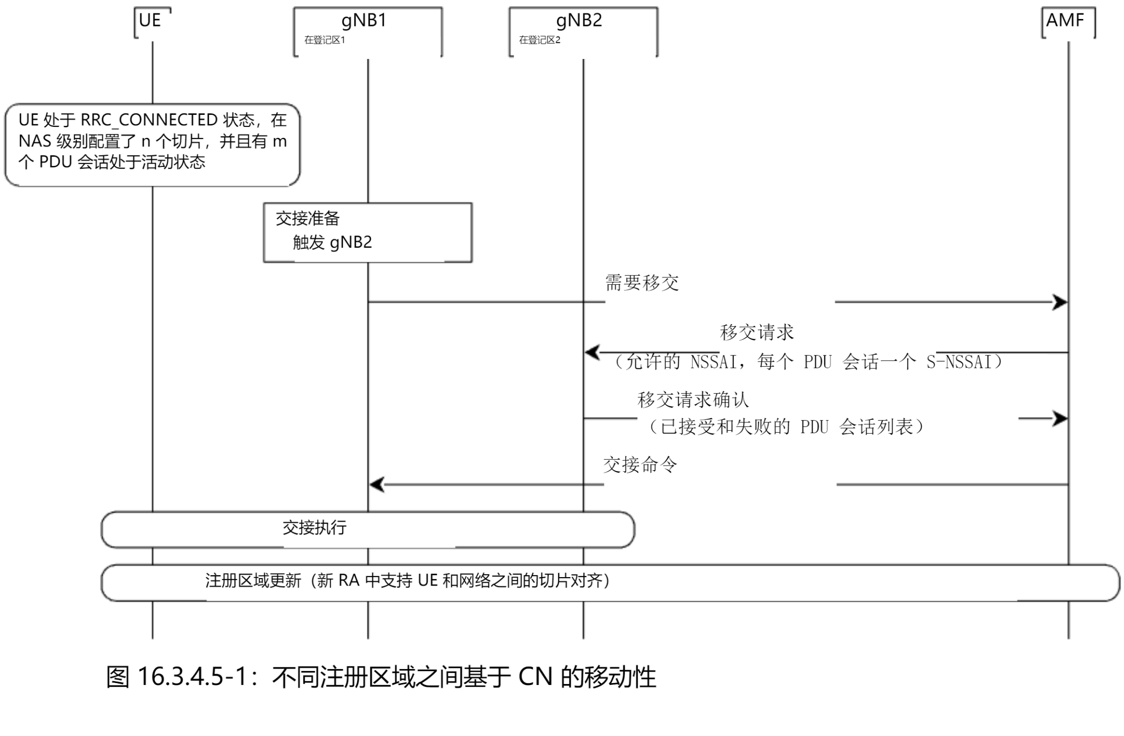


图 16.3.4.5-1：不同注册区域之间基于 CN 的移动性

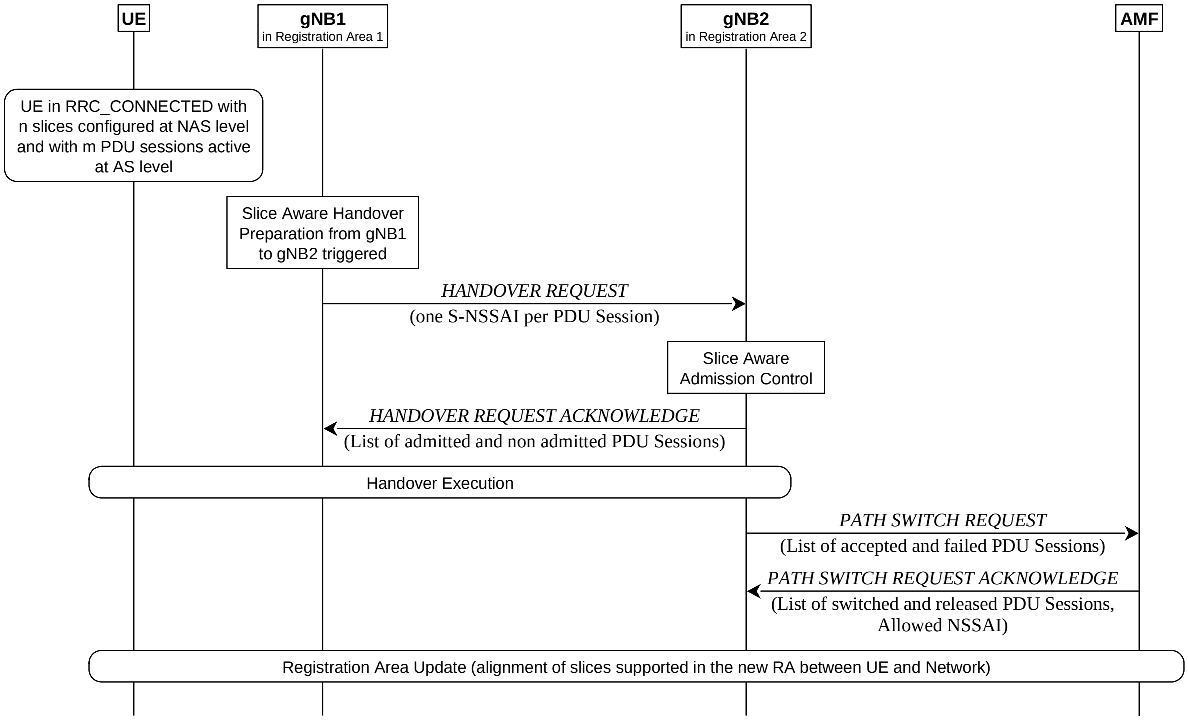


Figure 16.3.4.5-2: Xn based mobility across different Registration Areas

16.4 Public Warning System

NR connected to 5GC provides support for public warning systems (PWS) through means of system information broadcast capability. NR is responsible for scheduling and broadcasting of the warning messages as well as for paging the UE to provide indication that the warning message is being broadcast:

- Earthquake and Tsunami Warning System: ETWS is a public warning system developed to meet the regulatory requirements for warning notifications related to earthquake and/or tsunami events (see 3GPP TS 22.168 [14]). ETWS warning notifications can either be a primary notification (short notification) or secondary notification (providing detailed information).

- Commercial Mobile Alert System: CMAS is a public warning system developed for the delivery of multiple, concurrent warning notifications (see 3GPP TS 22.268 [15]).

Different SIBs are defined for ETWS primary notification, ETWS secondary notification and CMAS notification. Paging is used to inform UEs about ETWS indication and CMAS indication. UE monitors ETWS/CMAS indication in its own paging occasion for RRC_IDLE and RRC_INACTIVE. UE monitors ETWS/CMAS indication in any paging occasion for RRC Connected. Paging indicating ETWS/CMAS notification triggers acquisition of system information (without delaying until the next modification period).

16.5 Emergency Services

16.5.1 Overview

NG-RAN provides support for Emergency Services either directly or through fallback mechanisms towards E-UTRA. The support of Emergency Services is broadcast in system information (see 3GPP TS 36.331 [12]).

16.5.2 IMS Emergency call

An IMS Emergency call support indication is provided to inform the UE that emergency bearer services are supported. In normal service state the UE is informed if the PLMN supports emergency services through an Emergency Service Support indicator in the Attach and TAU procedures (see 3GPP TS 23.501 [3]). In limited service state and for emergency services other than eCall over IMS, a UE is informed about if a cell supports emergency services over NG-RAN from a broadcast indication (*ims-Emergency*). The broadcast indicator is set to "support" if any AMF in a non-shared environment or at least one of the PLMN's in a shared environment supports IMS emergency bearer services.

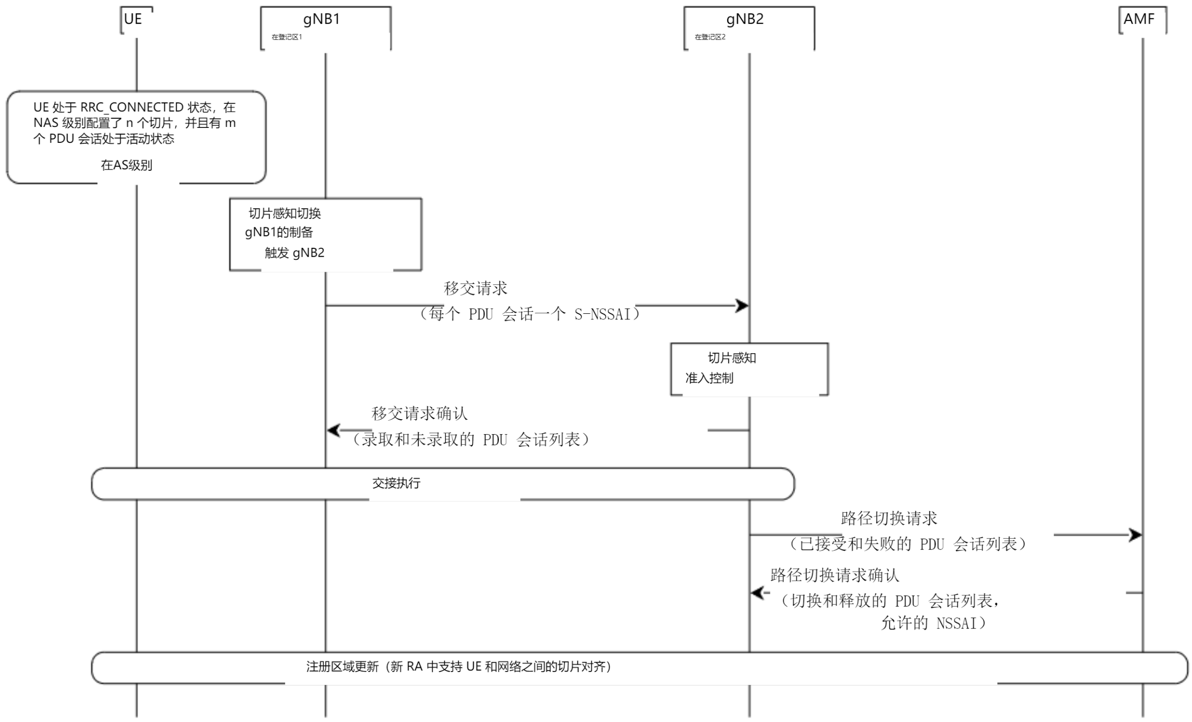


图 16.3.4.5-2：不同注册区域之间基于 Xn 的移动性

16.4 公共警报系统

与5GC连接的NR通过系统信息广播能力为公共预警系统（PWS）提供支持。
NR 负责调度和广播警告消息，以及寻呼 UE 以提供正在广播警告消息的指示：

- 地震和海啸预警系统：ETWS 是一个公共预警系统，旨在满足与地震和/或海啸事件相关的预警通知的监管要求（请参阅 3GPP TS 22.168 [14]）。
  ETWS 警告通知可以是主要通知（简短通知）或次要通知（提供详细信息）。

- 商业移动警报系统：CMAS 是一个公共警报系统，旨在发送多个并发警报通知（请参阅 3GPP TS 22.268 [15]）。

为ETWS主要通知、ETWS辅助通知和CMAS通知定义了不同的SIB。寻呼用于向UE通知ETWS指示和CMAS指示。 UE 在其自己的寻呼时机中监视 ETWS/CMAS 指示以获取 RRC_IDLE 和 RRC_INACTIVE。
UE 在 RRC 连接的任何寻呼时机中监视 ETWS/CMAS 指示。指示 ETWS/CMAS 通知的寻呼触发系统信息的获取（不会延迟到下一个修改周期）。

16.5 紧急服务

16.5.1 概述

NG-RAN 直接或通过 E-UTRA 的回退机制提供对紧急服务的支持。
紧急服务的支持在系统信息中广播（参见 3GPP TS 36.331 [12]）。

16.5.2 IMS紧急呼叫

提供IMS紧急呼叫支持指示以通知UE支持紧急承载服务。
在正常服务状态下，通过附着和 TAU 过程中的紧急服务支持指示符通知 UE PLMN 是否支持紧急服务（参见 3GPP TS 23.501 [3]）。
在有限服务状态下，对于除 IMS 上的 eCall 之外的紧急服务，UE 通过广播指示（ims-Emergency）获知小区是否支持 NGRAN 上的紧急服务。
如果非共享环境中的任何AMF或者共享环境中的至少一个PLMN支持IMS紧急承载服务，则广播指示符被设置为“支持”。

16.5.3 eCall over IMS

NG-RAN broadcast an indication to indicate support of eCall over IMS (*eCallOverIMS*). UEs that are in limited service state need to consider both *eCallOverIMS* and *ims-Emergency* to determine if eCall over IMS is possible.

16.5.4 Fallback

RAT fallback towards E-UTRA connected to 5GC is performed when NR does not support Emergency Services and System fallback towards E-UTRA connected to EPS is performed when 5GC does not support Emergency Services. Depending on factors such as CN interface availability, network configuration and radio conditions, the fallback procedure results in either CONNECTED state mobility (handover procedure) or IDLE state mobility (redirection) - see 3GPP TS 23.501 [3] and 3GPP TS 36.331 [12].

16.5.3 通过 IMS 的 eCall

NG-RAN 广播指示以指示支持基于 IMS 的 eCall (eCallOverIMS)。处于有限服务状态的 UE 需要同时考虑 eCallOverIMS 和 ims-Emergency，以确定是否可以通过 IMS 进行 eCall。

16.5.4 倒退

当 NR 不支持紧急服务时，RAT 回退到连接到 5GC 的 E-UTRA；当 5GC 不支持紧急服务时，系统回退到连接到 EPS 的 E-UTRA。
根据 CN 接口可用性、网络配置和无线电条件等因素，回退过程会导致 CONNECTED 状态移动性（切换过程）或 IDLE 状态移动性（重定向） - 请参阅 3GPP TS 23.501 [3] 和 3GPP TS 36.331 [12] 。

Annex A (informative): QoS Handling in RAN

A.1 PDU Session Establishment

The following figure shows an example message flow for a PDU session establishment. NAS procedures details between gNB and 5GC can be found in 3GPP TS 23.501 [3], TS 23.502 [22] and 3GPP TS 38.413 [26].

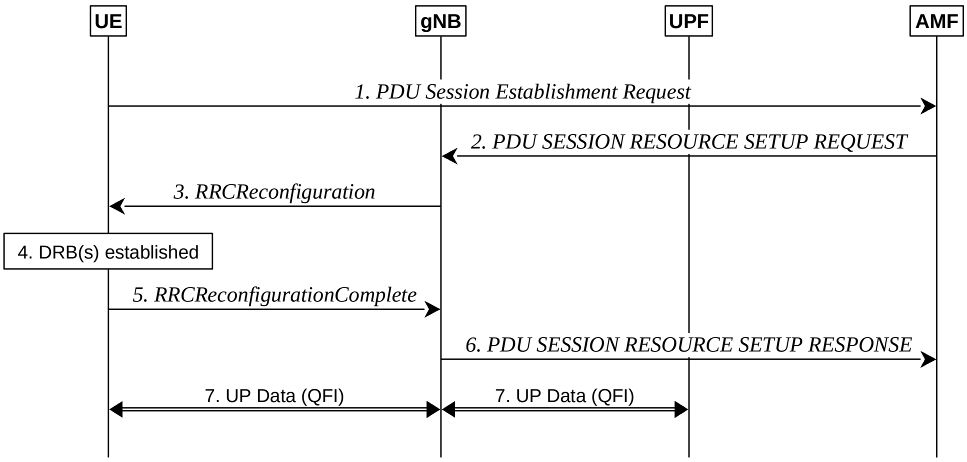


Figure A.1-1: PDU session establishment

1. UE requests a PDU session establishment to AMF.
2. AMF sends a PDU SESSION RESOURCE SETUP REQUEST message to gNB, which includes the NAS message to be sent to the UE with NAS QoS related information.
3. gNB sends an *RRCReconfiguration* message to UE including the configuration of at least one DRB and the NAS message received at Step 2.
4. UE establishes the DRB(s) for the new PDU session and creates the QFI to DRB mapping rules.
5. UE sends an *RRCReconfiguration Complete* message to gNB.
6. gNB sends a PDU SESSION RESOURCE SETUP RESPONSE message to AMF.
7. User Plane Data can then be exchanged between UE and gNB over DRB(s) according to the mapping rules and between UPF and gNB over the tunnel for the PDU session. QFI marking over Uu is optional (see subclause 12) while QFI marking over NG-U is always present.

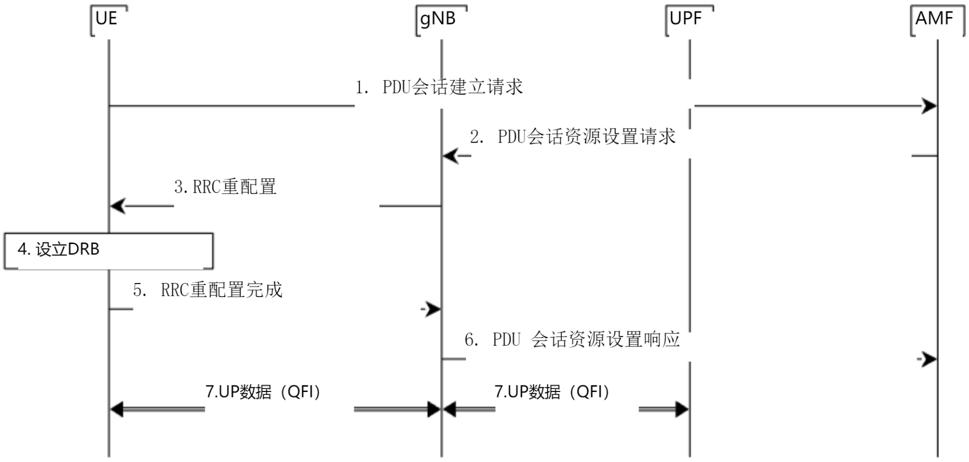
A.2 New QoS Flow with RQoS

The following figure shows an example message flow when RQoS is used for a new QoS flow. In this example, the gNB receives from UPF a first downlink packet associated with a QFI for which the QoS parameters are known from the PDU session establishment, but for which there is no association to any DRB yet in AS.

附录 A（资料性）：
RAN 中的 QoS 处理

A.1 PDU会话建立

下图显示了 PDU 会话建立的示例消息流。 gNB 和 5GC 之间的 NAS 过程细节可以在 3GPP TS 23.501 [3]、TS 23.502 [22] 和 3GPP TS 38.413 [26] 中找到。



图A.1-1：PDU会话建立

1. UE 向 AMF 请求建立 PDU 会话。
2. AMF 向 gNB 发送 PDU SESSION RESOURCE SETUP REQUEST 消息，其中包含要发送给 UE 的 NAS 消息以及 NAS QoS 相关信息。
3. gNB 向 UE 发送 RRCReconfiguration 消息，其中包括至少一个 DRB 的配置以及在步骤 2 中接收到的 NAS 消息。
4. UE 为新的 PDU 会话建立 DRB，并创建 QFI 到 DRB 映射规则。
5. UE向gNB发送RRC重配置完成消息。
6. gNB 向 AMF 发送 PDU SESSION RESOURCE SETUP RESPONSE 消息。
7. 然后，用户平面数据可以根据映射规则通过 DRB 在 UE 和 gNB 之间交换，并通过 PDU 会话的隧道在 UPF 和 gNB 之间交换。 Uu 上的 QFI 标记是可选的（参见第 12 款），而 NG-U 上的 QFI 标记始终存在。

A.2 具有 RQoS 的新 QoS 流程

下图显示了将 RQoS 用于新 QoS 流时的示例消息流。
在此示例中，gNB 从 UPF 接收与 QFI 关联的第一下行链路数据包，该 QFI 的 QoS 参数从 PDU 会话建立中已知，但尚未与 AS 中的任何 DRB 关联。

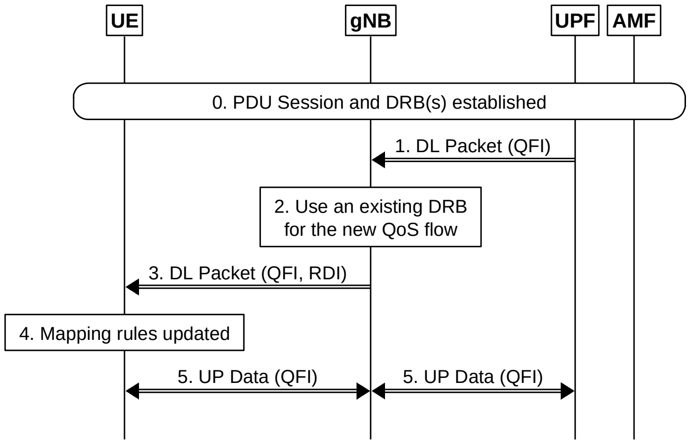


Figure A.2-1: DL data with new QFI sent over existing DRB

0. PDU session and DRB(s) have been already established.

1. gNB receives a downlink packet with a new QFI from UPF.

2. gNB decides to send the new QoS flow over an existing DRB.

NOTE: If gNB decides to send it over a new DRB, it needs to establish the DRB first.

3. gNB sends the DL packet over the selected DRB with the new QFI and RDI set in the SDAP header.

4. UE identifies the QFI and RDI in the received DL packet and the DRB on which the packet was received. The AS mapping rules are then updated accordingly.

5. User Plane Data for the new QoS flow can then be exchanged between UE and gNB over the DRB according to the updated mapping rules and between UPF and gNB over the tunnel for the PDU session.

A.3 New QoS Flow with Explicit RRC Signalling

The following figure shows an example message flow when explicit RRC signalling is used for a new QoS flow. In this example, the gNB receives from UPF a first downlink packet associated with a QFI, for which the QoS parameters are already known from the PDU session establishment, but for which there is no association to any DRB yet in AS.

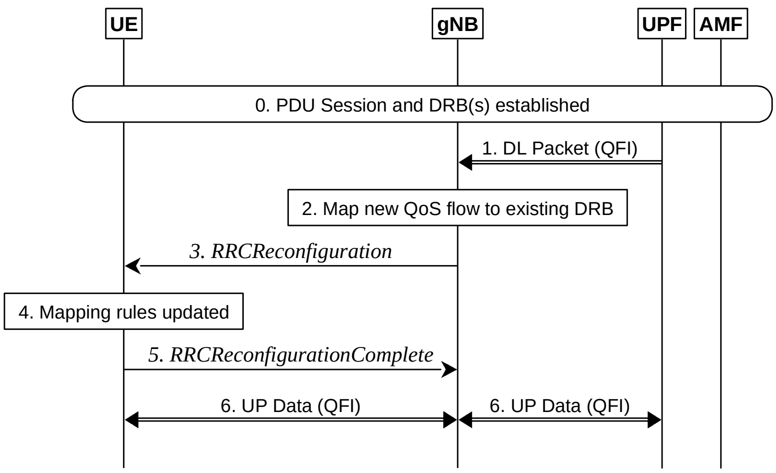


Figure A.3-1: DL data with new QFI sent over existing DRB

0. PDU session and DRB(s) have been already established.

1. gNB receives a downlink packet with a new QFI from UPF.

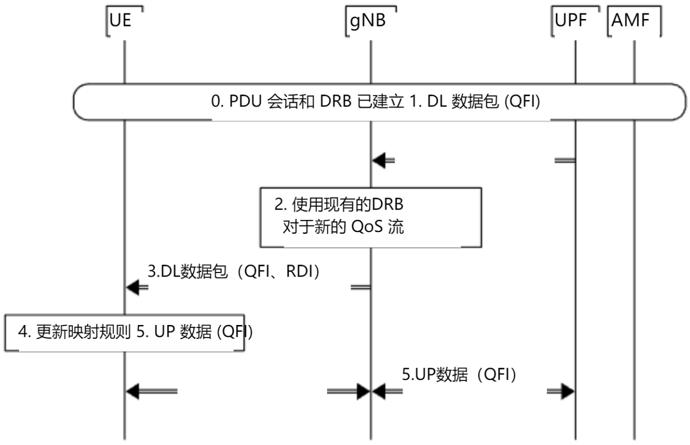


图 A.2-1：通过现有 DRB 发送具有新 QFI 的 DL 数据

0. PDU 会话和 DRB 已建立。

1. gNB 从 UPF 接收带有新 QFI 的下行数据包。

2. gNB 决定通过现有 DRB 发送新的 QoS 流。

笔记： 如果gNB决定通过新的DRB发送，则需要首先建立DRB。

3. gNB 通过选定的 DRB 发送 DL 数据包，并在 SDAP 标头中设置新的 QFI 和 RDI。

4. UE识别接收到的DL分组中的QFI和RDI以及接收分组的DRB。然后相应地更新AS映射规则。

5. 然后，新 QoS 流的用户平面数据可以根据更新的映射规则通过 DRB 在 UE 和 gNB 之间交换，并通过 PDU 会话的隧道在 UPF 和 gNB 之间交换。

A.3 具有显式 RRC 信令的新 QoS 流程

下图显示了显式 RRC 信令用于新 QoS 流时的示例消息流。
在此示例中，gNB 从 UPF 接收与 QFI 关联的第一下行链路数据包，该数据包的 QoS 参数已从 PDU 会话建立中得知，但尚未与 AS 中的任何 DRB 关联。

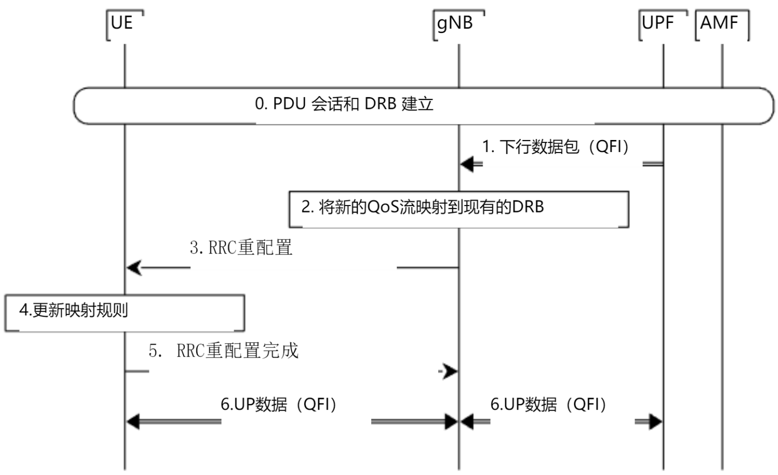


图 A.3-1：通过现有 DRB 发送具有新 QFI 的 DL 数据

0. PDU 会话和 DRB 已建立。

1. gNB 从 UPF 接收带有新 QFI 的下行数据包。

2. gNB decides to send the new QoS flow over an existing DRB using explicit RRC signalling for updating the AS mapping rules.

3. gNB sends an *RRCReconfiguration* message to UE with the new QFI to DRB mapping rule. gNB may also decide to update the DRB configuration if required to meet the QoS requirements for the new QoS Flow.

4. UE updates the QFI to DRB mapping rules and configuration (if received).

5. UE sends an *RRCReconfigurationComplete* message to gNB.

6. User Plane Data for the new QoS flow can then be exchanged between UE and gNB over the DRB according to the updated mapping rules and between UPF and gNB over the tunnel for the PDU session.

A.4 New QoS Flow with Explicit NAS Signalling

The following figure shows an example message flow when the gNB receives a new QoS flow establishment request from CN that involves NAS explicit signalling. The QoS flow establishment request provides the gNB and UE with the QoS parameters for the QFI. In this example, the gNB decides to establish a new DRB (rather than re-use an existing one) for this QoS flow and provides the mapping rule over RRC signalling. NAS procedures details between gNB and 5GC can be found in 3GPP TS 23.501 [3], 3GPP TS 23.502 [22] and 3GPP TS 38.413 [26].

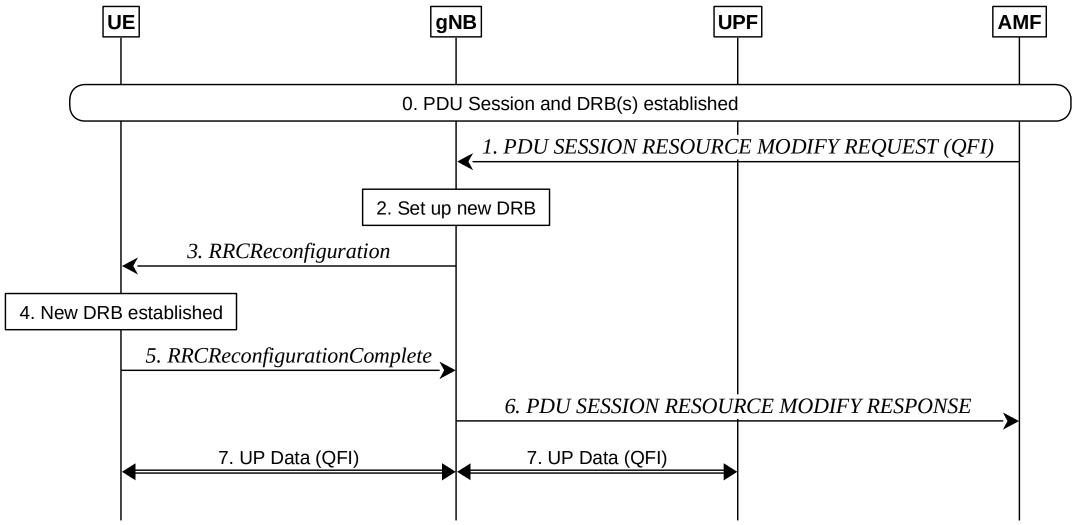


Figure A.4-1: DL data with new QoS Flow ID sent over new DRB with explicit signalling

0. PDU session DRB(s) have been already established.

1. gNB receives a PDU SESSION RESOURCE MODIFY REQUEST message from AMF for a new QoS flow.

2. If gNB cannot find an existing DRB to map this new QoS flow, it decides to establish a new DRB.

3. gNB sends an *RRCReconfiguration* message to UE including the DRB configuration with the new QFI to DRB mapping rule and the NAS message received at step 1.

4. UE establishes the DRB for the new QoS flow associated with this PDU session and updates the mapping rules.

5. UE sends an *RRCReconfigurationComplete* message to gNB.

6. gNB sends a PDU SESSION RESOURCE MODIFY RESPONSE message to AMF.

7. User Plane Data can then be exchanged between UE and gNB over DRB(s) according to the mapping rules and between UPF and gNB over the tunnel for the PDU session.

2. gNB 决定使用显式 RRC 信令通过现有 DRB 发送新的 QoS 流，以更新 AS 映射规则。

3. gNB 向 UE 发送 RRCReconfiguration 消息，其中包含新的 QFI 到 DRB 映射规则。如果需要满足新 QoS 流的 QoS 要求，gNB 还可以决定更新 DRB 配置。

4. UE 更新 QFI 到 DRB 映射规则和配置（如果收到）。

5. UE向gNB发送RRCReconfigurationComplete消息。

6. 然后，新 QoS 流的用户平面数据可以根据更新的映射规则通过 DRB 在 UE 和 gNB 之间交换，并通过 PDU 会话的隧道在 UPF 和 gNB 之间交换。

A.4 具有显式 NAS 信令的新 QoS 流程

下图显示了当 gNB 从 CN 接收到涉及 NAS 显式信令的新 QoS 流建立请求时的示例消息流。 QoS 流建立请求向 gNB 和 UE 提供 QFI 的 QoS 参数。
在此示例中，gNB 决定为此 QoS 流建立一个新的 DRB（而不是重新使用现有的 DRB），并通过 RRC 信令提供映射规则。
gNB 和 5GC 之间的 NAS 过程细节可以在 3GPP TS 23.501 [3]、3GPP TS 23.502 [22] 和 3GPP TS 38.413 [26] 中找到。

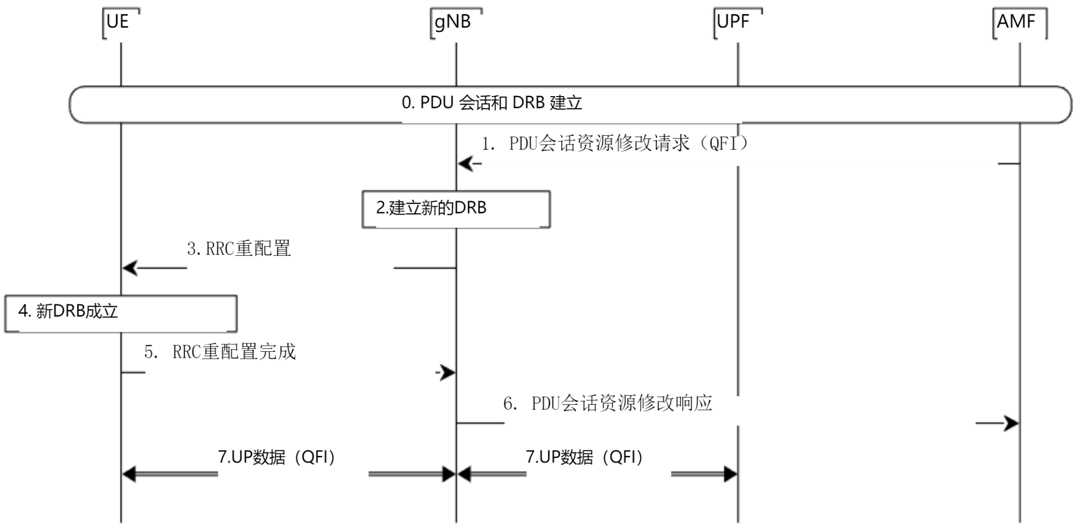


图 A.4-1：具有新 QoS 流 ID 的 DL 数据通过具有显式信令的新 DRB 发送

0. PDU 会话 DRB 已建立。

1. gNB 从 AMF 接收新 QoS 流的 PDU SESSION RESOURCE MODIFY REQUEST 消息。

2. 如果gNB无法找到现有的DRB来映射这个新的QoS流，它决定建立一个新的DRB。

3. gNB 向 UE 发送 RRCReconfiguration 消息，其中包括具有新 QFI 到 DRB 映射规则的 DRB 配置以及在步骤 1 中收到的 NAS 消息。

4. UE 为与该 PDU 会话关联的新 QoS 流建立 DRB，并更新映射规则。

5. UE向gNB发送RRCReconfigurationComplete消息。

6. gNB 向 AMF 发送 PDU SESSION RESOURCE MODIFY RESPONSE 消息。

7. 然后，用户平面数据可以根据映射规则通过 DRB 在 UE 和 gNB 之间交换，并通过 PDU 会话的隧道在 UPF 和 gNB 之间交换。

A.5 Release of QoS Flow with Explicit Signalling

The following figure shows an example message flow when the gNB receives a request to release a QoS flow from CN that involves explicit NAS signalling. NAS procedures details between gNB and 5GC can be found in 3GPP TS 23.501 [3], 3GPP TS 23.502 [22] and 3GPP TS 38.413 [26].

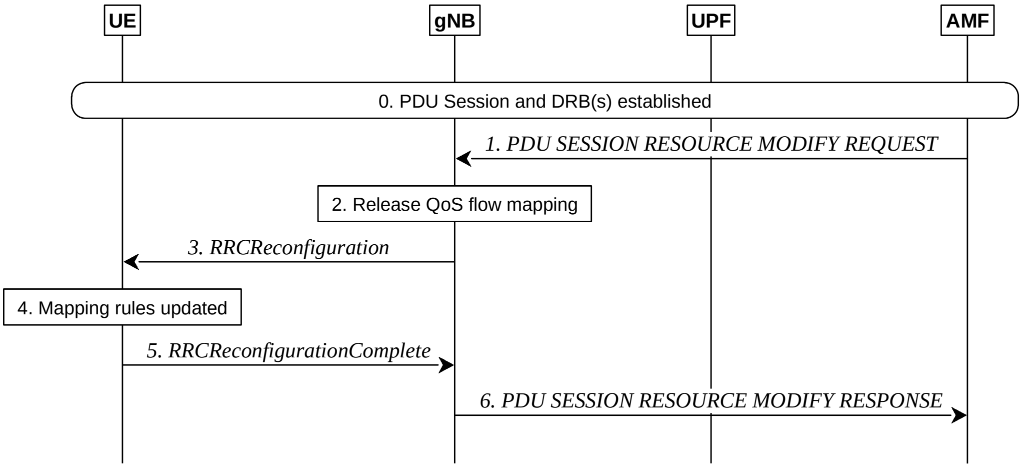


Figure A.5-1: Release of QoS Flow with Explicit Signalling

0. PDU session and DRB(s) have been already established.
1. gNB receives a PDU SESSION RESOURCE MODIFY REQUEST message from AMF to release a QoS flow.
2. The gNB decides to release corresponding the QFI to DRB mapping rule. Since the DRB also carries other QoS flows, the DRB is not released.
3. gNB sends an *RRCReconfiguration* message to UE to release the QFI to DRB mapping rule.
4. UE updates the AS QFI to DRB mapping rules to release this QFI to DRB mapping rule.
5. UE sends an *RRCReconfigurationC*omplete message to gNB.
6. gNB sends a PDU SESSION RESOURCE MODIFY RESPONSE message to AMF.

A.6 UE Initiated UL QoS Flow

The following figure shows an example message flow when the UE AS receives an UL packet for a new QoS flow for which a QFI to DRB mapping rule does not exist.

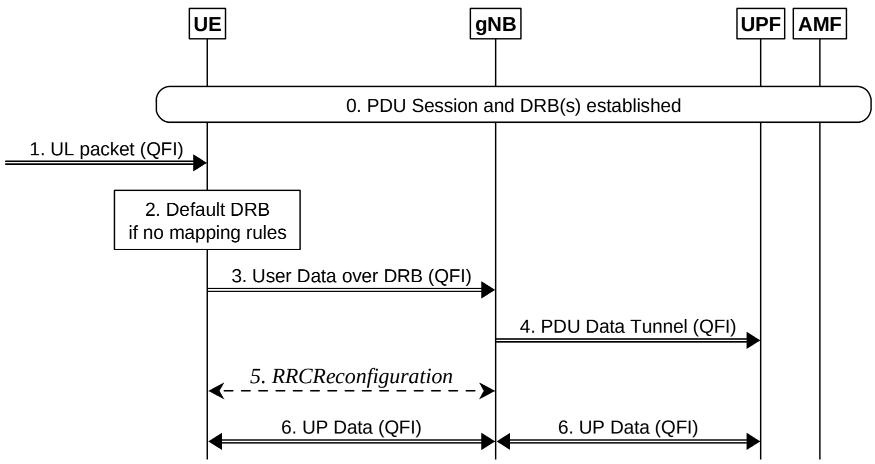


Figure A.6-1: UL packet with a new QoS flow for which a mapping does not exist in UE

A.5 通过显式信令释放 QoS 流

下图显示了当 gNB 收到来自 CN 的释放 QoS 流的请求（涉及显式 NAS 信令）时的示例消息流。 gNB 和 5GC 之间的 NAS 过程细节可以在 3GPP TS 23.501 [3]、3GPP TS 23.502 [22] 和 3GPP TS 38.413 [26] 中找到。

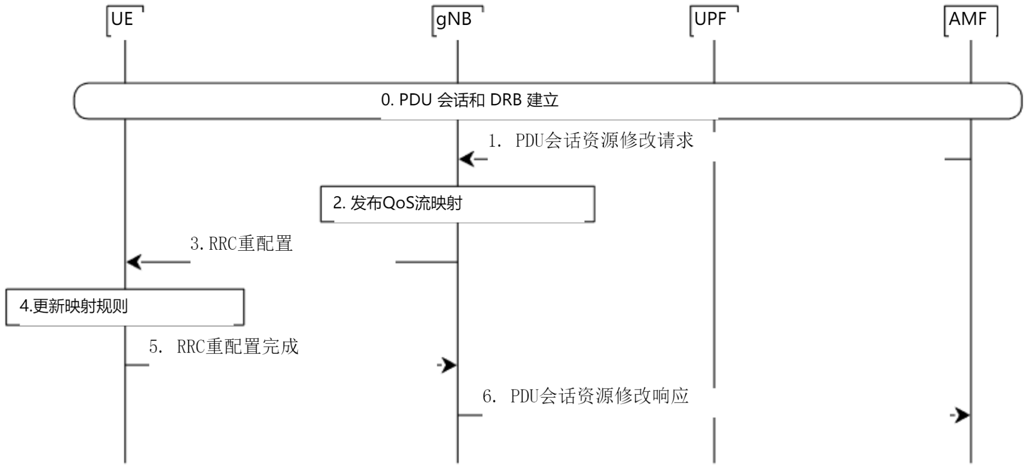


图 A.5-1：使用显式信令释放 QoS 流

0. PDU 会话和 DRB 已建立。
1. gNB 从 AMF 接收 PDU SESSION RESOURCE MODIFY REQUEST 消息以释放 QoS 流。
2. gNB决定释放相应的QFI到DRB映射规则。由于DRB还承载其他QoS流，因此不释放DRB。
3. gNB向UE发送RRCReconfiguration消息以释放QFI到DRB映射规则。
4. UE更新AS QFI到DRB映射规则以释放该QFI到DRB映射规则。
5. UE向gNB发送RRCReconfigurationComplete消息。
6. gNB 向 AMF 发送 PDU SESSION RESOURCE MODIFY RESPONSE 消息。

A.6 UE发起的UL QoS流

下图示出了当UE AS接收到不存在QFI到DRB映射规则的新QoS流的UL分组时的示例消息流。

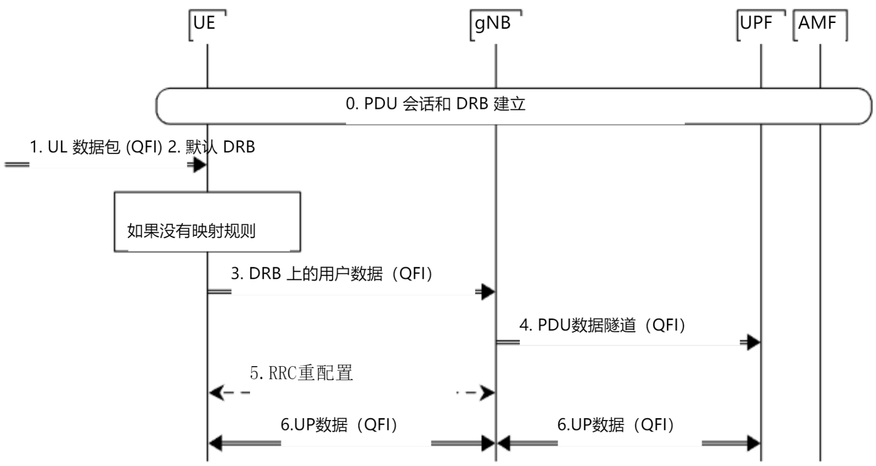


图 A.6-1：UE 中不存在映射的具有新 QoS 流的 UL 数据包

0. PDU session and DRBs (including a default DRB) have been already established.
1. UE AS receives a packet with a new QFI from UE NAS.
2. UE uses the QFI of the packet to map it to a DRB. If there is no mapping of the QFI to a DRB in the AS mapping rules for this PDU session, then the packet is assigned to the default DRB.
3. UE sends the UL packet on the default DRB. The UE includes the QFI in the SDAP header.
4. gNB sends UL packets to UPF and includes the corresponding QFI.
5. If gNB wants to use a new DRB for this QoS flow, it sets up one. It can also choose to move the QoS flow to an existing DRB using RQoS or RRC signalling (see subclauses A.2 and A.3).
6. User Plane Data for the new QoS flow can then be exchanged between UE and gNB over the DRB according to the updated mapping rules and between UPF and gNB over the tunnel for the PDU session.

0. PDU会话和DRB（包括默认DRB）已经建立。

1. UE AS从UE NAS接收带有新QFI的数据包。

2. UE 使用数据包的 QFI 将其映射到 DRB。如果此 PDU 会话的 AS 映射规则中没有 QFI 到 DRB 的映射，则数据包将被分配到默认 DRB。

3. UE 在默认 DRB 上发送 UL 数据包。 UE 将 QFI 包含在 SDAP 标头中。

4. gNB 向 UPF 发送 UL 数据包，并包含相应的 QFI。

5. 如果 gNB 希望为此 QoS 流使用新的 DRB，则会设置一个。它还可以选择使用 RQoS 或 RRC 信令将 QoS 流移至现有 DRB（参见子条款 A.2 和 A.3）。

6. 然后，新 QoS 流的用户平面数据可以根据更新的映射规则通过 DRB 在 UE 和 gNB 之间交换，并通过 PDU 会话的隧道在 UPF 和 gNB 之间交换。

Annex B (informative): Deployment Scenarios

B.1 Supplementary Uplink

To improve UL coverage for high frequency scenarios, SUL can be configured (see 3GPP TS 38.101 [18]). With SUL, the UE is configured with 2 ULs for one DL of the same cell as depicted on Figure B.1-1 below:

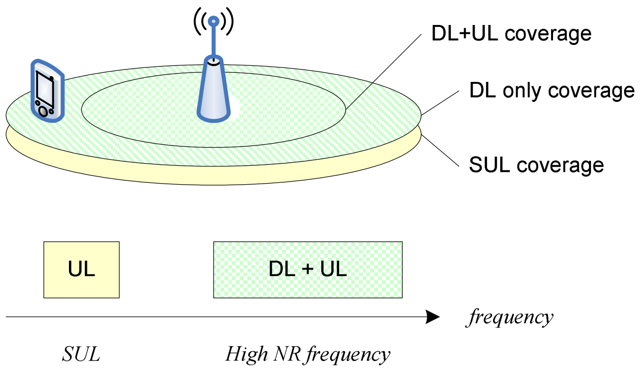


Figure B.1-1: Example of Supplementary Uplink

B.2 Multiple SSBs in a carrier

For a UE in RRC_CONNECTED, the BWPs configured by a serving cell may overlap in the frequency domain with the BWPs configured for other UEs by other cells within a carrier. Multiple SSBs may also be transmitted within the frequency span of a carrier used by the serving cell. However, from the UE perspective, each serving cell is associated to at most a single SSB. Figure B.2-1 below describes a scenario with multiple SSBs in a carrier, identifying two different cells (NCGI = 5, associated to SSB1, and NCGI = 6, associated to SSB3) with overlapping BWPs, and where RRM measurements can be configured to be performed by the UE on each of the available SSBs, i.e. SSB1, SSB2, SSB3 and SSB4.

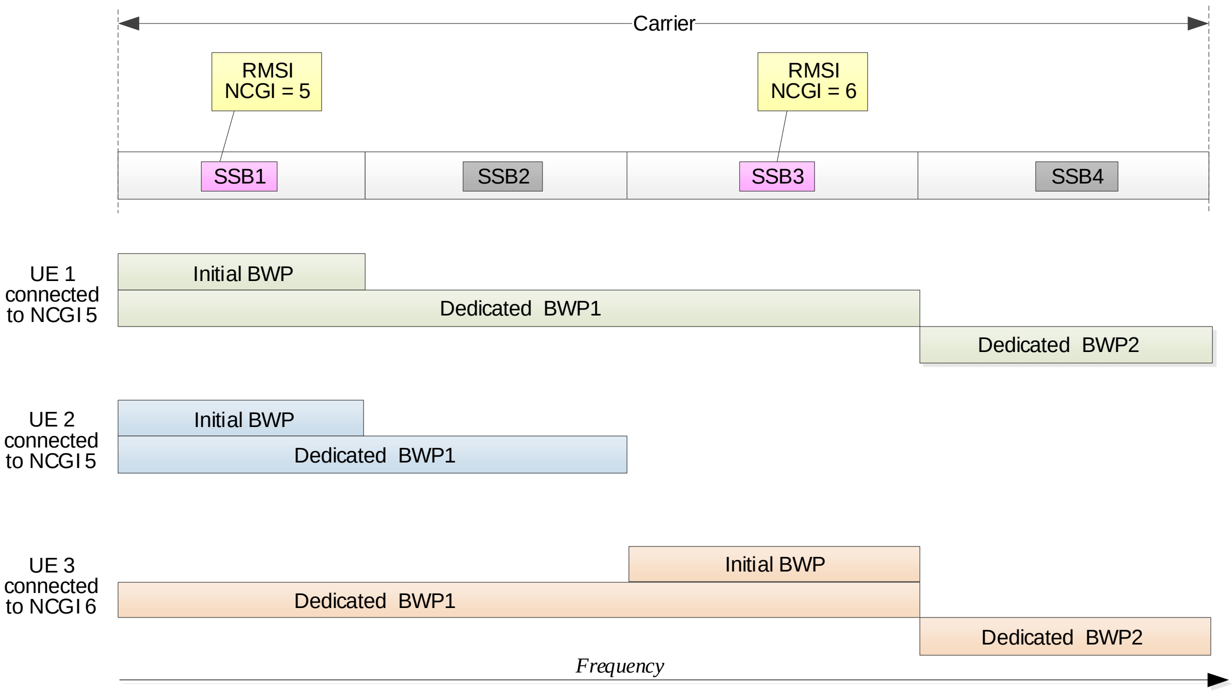


Figure B.2-1: Example of multiple SSBs in a carrier

附件 B（资料性）：部署场景

B.1 补充上行链路

为了提高高频场景的 UL 覆盖范围，可以配置 SUL（参见 3GPP TS 38.101 [18]）。对于 SUL，UE 为同一小区的一个 DL 配置 2 个 UL，如下图 B.1-1 所示：

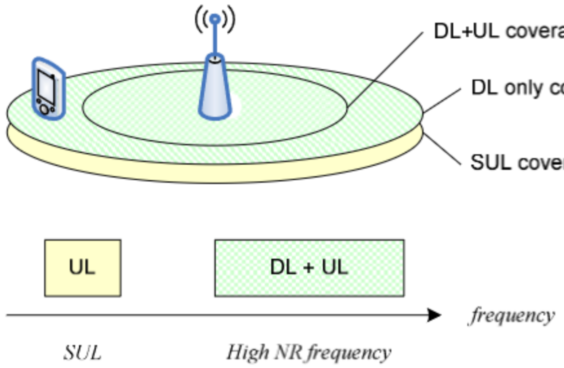


图 B.1-1：补充上行链路示例

B.2 一个载波中有多个 SSB

对于RRC_CONNECTED中的UE，服务小区配置的BWP可以与载波内其他小区为其他UE配置的BWP在频域上重叠。还可以在服务小区使用的载波的频率跨度内发送多个SSB。

然而，从UE的角度来看，每个服务小区最多关联到单个SSB。

下面的图 B.2-1 描述了一个载波中具有多个 SSB 的场景，识别具有重叠 BWP 的两个不同小区（NCGI = 5，与 SSB1 关联，NCGI = 6，与 SSB3 关联），并且可以在其中配置 RRM 测量由UE在每个可用的SSB上执行，即 SSB1、SSB2、SSB3 和 SSB4。

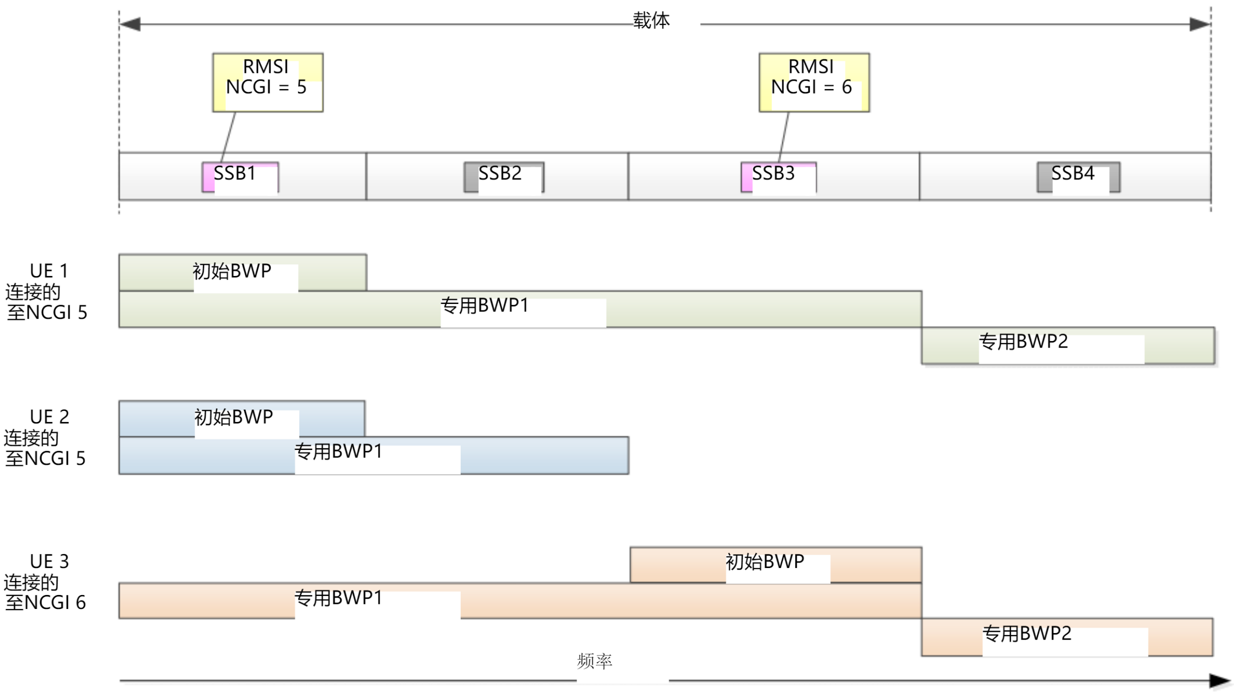


图 B.2-1：一个载波中多个 SSB 的示例

Annex C (informative): I-RNTI Reference Profiles

The I-RNTI provides the new NG-RAN node a reference to the UE context in the old NG-RAN node. How the new NG-RAN node is able to resolve the old NG-RAN ID from the I-RNTI is a matter of proper configuration in the old and new NG-RAN node.

Table C-1 below provides some typical partitioning of an 40bit I-RNTI, assuming the following content:

- **UE specific reference**: reference to the UE context within a logical NG-RAN node;
- **NG-RAN node address index**: information to identify the NG-RAN node that has allocated the UE specific part;

NOTE: **RAT-specific information** may be introduced in a later release, containing information to identify the RAT of the cell within which the UE was sent to RRC_INACTIVE. This version of the specification only supports intra-RAT mobility of UEs in RRC_INACTIVE.

- **PLMN-specific information**: information supporting network sharing deployments, providing an index to the PLMN ID part of the Global NG-RAN node identifier.

Table C-1: I-RNTI reference profiles

Profile ID	UE specific reference	NG-RAN node address index (e.g., gNB ID, eNB ID)	RAT-specific information	PLMN-specific information	Comment
1	20 bits (~1 million values)	20 bits (~1 million values)	N/A	N/A	NG-RAN node address index may be very well represented by the LSBs of the gNB ID. This profile may be applicable for any NG-RAN RAT.
2	20 bits (~1 million values)	16 bits (65.000 nodes)	N/A	4 bits (Max 16 PLMNs)	Max number of PLMN IDs broadcast in NR is 12. This profile may be applicable for any NG-RAN RAT.
3	24 bits (16 million values)	16 bits (65.000 nodes)	N/A	N/A	Reduced node address to maximise addressable UE contexts. This profile may be applicable for any NG-RAN RAT.

附录 C（资料性）：
I-RNTI 参考配置文件

I-RNTI 向新 NG-RAN 节点提供对旧 NG-RAN 节点中 UE 上下文的引用。新 NG-RAN 节点如何能够从 I-RNTI 解析旧 NG-RAN ID 取决于新旧 NG-RAN 节点中的正确配置。

下面的表 C-1 提供了 40 位 I-RNTI 的一些典型划分，假设内容如下：

- UE特定参考：对逻辑NG-RAN节点内的UE上下文的参考；
- NG-RAN节点地址索引：标识已分配UE特定部分的NG-RAN节点的信息；

笔记： RAT特定信息可以在以后的版本中引入，包含用于识别UE被发送到RRC_INACTIVE的小区的RAT的信息。该版本的规范仅支持 RRC_INACTIVE 中 UE 的 RAT 内移动性。

- PLMN特定信息：支持网络共享部署的信息，提供全局NG-RAN节点标识符的PLMN ID部分的索引。

表 C-1：I-RNTI 参考配置文件

档案编号	UE特定参考	NG-RAN节点地址索引（例如，gNB ID、eNB ID）	RAT 特定的信息	PLMN 特定的信息	评论
1	20位（约 100 万值）	20位（约 100 万值）	N/A	N/A	NG-RAN节点地址索引可能很好代表为 gNB ID 的 LSB。该配置文件可能是适用于任何 NG-跑老鼠。
2	20位（约 100 万值）	16位（65.000 个节点）	N/A	4位（最多16位 PLMN）	PLMN最大数量 NR 中广播的 ID 为 12. 该配置文件可能是适用于任何 NG-跑老鼠。
3	24位（1600 万值）	16位（65.000 个节点）	N/A	N/A	减少节点地址最大化可寻址UE上下文。该配置文件可能是适用于任何 NGRAN RAT。

Annex D (informative): Change history

附录 D（资料性）：变更历史记录

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New Version**
2017.03	RAN2 97bis	R2-1702627	-	-	-	First version.	0.1.0
2017.04	RAN2 97bis	R2-1703825	-	-	-	Editorial Updates: - Stage 2 Details of ARQ operation marked as FFS - Placeholder for CU/DU Split overview added - Outdated editor notes removed - Protocol Architecture updated - NG-RAN terminology aligned - Header placement in the L2 overview put as FFS	0.1.1
2017.04	RAN2 97bis	R2-1703952	-	-	-	Editorial Updates: - description of measurements for mobility clarified - some cell reselection details put FFS - outdated references removed	0.1.2
2017.04	RAN2 98	R2-1704296	-	-	-	Editorial updates: - NG interfaces naming aligned to RAN3 - 5GC used consistently - Statement on lossless delivery removed from 9.3.2 - Overview of PDCP function for CP detailed	0.1.3
2017.05	RAN2 98	R2-1704298	-	-	-	Agreements of RAN2#97bis captured: - overview of duplication operation - RLC modes for DRBs and SRBs - Condition for lossless mobility - L2 handling at handover - RLF triggers - Measurement details (filtering, beams, quality…) - QoS flow handling in DC - RACH procedure message usage for on-demand SI - Random Access Procedure triggers - DRX baseline	0.2.0
2017.05	RAN2 98	R2-1704452	-	-	-	RAN3 agreements captured (R3-171329) 5G logo and specification title updated	0.2.1
2017.05	RAN2 98	R2-1705994	-	-	-	RLC failure for RLF generalized.	0.3.0
2017.06	RAN2 98	R2-1706204	-	-	-	Agreements of RAN2#98 captured: - Duplication Control - RLC mode for SRB0 and System Info - Provision of Assistance Info for AMF Selection - QoS Handling from R2-1706011 - Beam measurements combining - MSG1 request details for on-demand SI - RNA and RLAU terminology introduced for INACTIVE - Skipping of SPS resources when nothing to transmit - Duplication detection at RLC only for AM - Provision of access category by NAS for connection control Editorial updates in addition: - QFI used consistently	0.3.1
2017.06	RAN2 98	R2-1706205	-	-	-	RAN3 agreements captured (R3-171932)	0.4.0
2017.06	RAN2 98	R2-1706206	-	-	-	Corrections: - provision of AC in INACTIVE is FFS - agreements on measurement moved from 9.2.1.1 to 9.2.4	0.4.1
2017.06	NR Adhoc 2	R2-1706540	-	-	-	Editorial corrections Agreement on RLC Segmentation captured Duplicated statement in 9.2.1.1. and 7.3 removed	0.5.0
2017.08	RAN2 99	R2-1707748	-	-	-	Agreements of RAN2 NR June Adhoc captured: - TP on Security in R2-1707466 - TP on Measurement Model in R2-1707480 - NCR Acronym addition - Duplication control details - UE capabilities and band combinations - Disabling of PDPC reordering as PDCP function - On-Demand SI and RACH details - Measurement Report Characteristics - Mapping rules update handling - UE Capabilities and Band Combination handling In addition: - ARQ overview aligned with Stage 3 agreements - L2 Data Flow aligned with Stage 3 agreements - References updated RAN3 TP incorporated (R3-172610)	0.6.0

变更历史记录

Date	会议	TDoc	CR	Rev	Cat	主题/评论	New 版本
2017.03	RAN2 97之二	R2-1702627	-	-	-	第一个版本。	0.1.0
2017.04	RAN2 97之二	R2-1703825	-	-	-	编辑更新： - 标记为 FFS 的 ARQ 操作的第 2 阶段详细信息 - 添加了 CU/DU 拆分概述的占位符 - 删除了过时的编辑注释 - 协议架构更新 - NG-RAN术语一致 - L2 概述中的标头放置为 FFS	0.1.1
2017.04	RAN2 97之二	R2-1703952	-	-	-	编辑更新： - 明确了移动性测量的描述 - 一些小区重选细节将FFS - 删除了过时的参考资料	0.1.2
2017.04	RAN2 98	R2-1704296	-	-	-	编辑更新： - NG 接口命名与 RAN3 一致 - 一致使用5GC - 从 9.3.2 中删除了关于无损传送的声明 - 详细了解CP的PDCP功能概述	0.1.3
2017.05	RAN2 98	R2-1704298	-	-	-	捕获的 RAN2#97bis 协议： - 复制操作概述 - DRB 和 SRB 的 RLC 模式 - 无损移动性的条件 - 交接时的 L2 处理 - RLF 触发器 - 测量细节（过滤、光束、质量……） - DC 中的 QoS 流处理 - 用于按需 SI 的 RACH 过程消息使用 - 随机访问过程触发器 - DRX基线	0.2.0
2017.05	RAN2 98	R2-1704452	-	-	-	更新了 RAN3 协议 (R3-171329) 5G 徽标和规范标题	0.2.1
2017.05	RAN2 98	R2-1705994	-	-	-	RLC 失败导致 RLF 普遍化。	0.3.0
2017.06	RAN2 98	R2-1706204	-	-	-	捕获的 RAN2#98 协议： - 重复控制 - SRB0 和系统信息的 RLC 模式 - 提供AMF选择的辅助信息 - R2-1706011 的 QoS 处理 - 光束测量结合 - 按需 SI 的 MSG1 请求详细信息 - 为 INACTIVE 引入了 RNA 和 RLAU 术语 - 当没有要传输的内容时跳过 SPS 资源 - RLC 的重复检测仅适用于 AM - NAS 提供访问类别以进行连接控制 另外的编辑更新： - 一致使用 QFI	0.3.1
2017.06	RAN2 98	R2-1706205	-	-	-	捕获的 RAN3 协议 (R3-171932)	0.4.0
2017.06	RAN2 98	R2-1706206	-	-	-	更正： - 在 INACTIVE 中提供 AC 是 FFS - 测量协议从 9.2.1.1 移至 9.2.4	0.4.1
2017.06	NR 临时2	R2-1706540	-	-	-	编辑更正关于 RLC 分段的协议捕获了 9.2.1.1 中的重复声明。 7.3 删除	0.5.0
2017.08	RAN2 99	R2-1707748	-	-	-	RAN2 NR June Adhoc 协议捕获： - R2-1707466 中的安全性 TP - R2-1707480 中测量模型的 TP - NCR 缩写添加 - 重复控制细节 - UE功能和频段组合 - 禁用 PDPC 重新排序作为 PDCP 功能 - 按需 SI 和 RACH 详细信息 - 测量报告特征 - 映射规则更新处理 - UE 功能和频段组合处理 此外： - ARQ 概述与第 3 阶段协议一致 - L2 数据流与第 3 阶段协议一致 - 引用更新的 RAN3 TP 合并 (R3-172610)	0.6.0

2017.08	RAN2 99	R2-1709937	-	-	-	Agreements of RAN2 99 captured: - QoS update in R2-1709830 - Description of the RRC states in R2-1707690 - Correction on RRC_INACTIVE state in R2-1709833 - LCP description in R2-1709829 - Baseline HO procedure update in R2-1709850 with corrections - UE identities in R2-1709868 - Radio Link Failure handling in R2-1709870 - RAN3 agreements on roaming restrictions in R3-172655 - Integrity protection configurable on a per DRB basis - Various Acronyms added - Slicing details - PWS basic principles - UE capability restrictions	0.7.0
2017.09	RAN 77	RP-171730	-	-	-	Provided for information to RAN	1.0.0
2017.10	RAN2 99bis	R2-1710693	-	-	-	Editorial Updates and Corrections: - inter RAT mobility in 9.3.2 restructured - SON promoted to top subclause level (as it is not a vertical) - Obsolete subclauses 14 and 15 removed. - Description of paging in idle aligned with 23.501 - I-RNTI suggested for INACTIVE - Missing agreement from RAN2 99 on INACTIVE captured	1.0.1
2017.10	RAN2 99bis	R2-1711936	-	-	-	Clean version	1.1.0
2017.10	RAN2 99bis	R2-1711972	-	-	-	Corrections: - Container for mobility in 9.2.3.2.1 - "HO" changed to "handover" for consistency Agreements from RAN2 99bis captured: - URLLC text in R2-1710253 - Clarification on RRC States in R2-1710074 - Resume ID terminology in R2-1711778 - Slicing clarifications in R2-1712034 - Usage of SRB0 and SRB1 in INACTIVE - Prioritisation of RACH resources for handover - SPS configuration per SCell in CA - Enabling / Disabling IP on DRB via handover only - First agreements on Supplementary Uplink - Maximum supported data rate calculation RAN3 agreements: - R3-173639 on Rapporteur updates to RAN3-related sections - R3-174162 on AMF discovery by NG-RAN - R3-174187 on RAN paging failure handling in RRC_INACTIVE - R3-174188 on Unreachability in RAN Inactive State - R3-174225 on Inter System Handover - R3-174230 on RRC Inactive Assistant Information RAN agreement: - RP-172113 on UE categories.	1.1.1
2017.11	RAN2 100	R2-1712266	-	-	-	Clean version	1.2.0
2017.11	RAN2 100	R2-1712355	-	-	-	Editorial Clean Up: - Editor's Notes & relevant FFS moved to R2-17112357 - Protocol stack figures for NG interface updated - Dual Connectivity changed to Multi-RAT connectivity - Details about SI handling added to tackle RMSI - Access Control updated and reference to 22.261 added - DC specific details removed (37.340 is used instead) - Notes numbered wherever required	1.2.1
2017.12	RAN2 100	R2-174079	-	-	-	Agreements from RAN2 100 captured: - QoS update in R2-1714230 - Updates to stage 2 QoS flow in R2-1712687 - BWP Description in R2-172360 - Transition from INACTIVE to CONNECTED in R2-173937 - SUL overview - Removal of DC related definitions - BWP agreements - SPS terminology changed to CS to cover both types RAN3 agreements in R3-175011 RAN1 agreements in R1-1721728	1.2.2
2017.12	RAN2 100	R2-1714252	-	-	-	Clean version	1.3.0
2017.12	RP-78	RP-172496	-	-	-	Provided for approval to RAN	2.0.0
2017/12	RP-78					Upgraded to Rel-15 (MCC)	15.0.0
2018/03	RP-79	RP-180440	0009	1	F	Miscellaneous Corrections & Additions	15.1.0
2018/06	RP-80	RP-181214	0010	1	F	Clarification on NR Carrier Aggregation	15.2.0
	RP-80	RP-181214	0011	2	F	Miscellaneous Corrections	15.2.0
	RP-80	RP-181214	0012	1	F	Paging Mechanisms	15.2.0

2017.08	RAN2 99	R2-1709937	-	-	-	捕获的 RAN2 99 协议： - R2-1709830 中的 QoS 更新 - R2-1707690 中 RRC 状态的描述 - 更正了 R2-1709833 中的 RRC_INACTIVE 状态 - R2-1709829 中的 LCP 描述 - R2-1709850 中的基线 HO 程序更新并进行了更正 - R2-1709868 中的 UE 身份 - R2-1709870 中的无线电链路故障处理 - R3-172655 中有关漫游限制的 RAN3 协议 - 可基于每个 DRB 配置完整性保护 - 添加了各种缩写词 - 切片细节 - PWS基本原理 - UE能力限制	0.7.0
2017.09	兰77	RP-171730	-	-	-	提供给 RAN 的信息	1.0.0
2017.10	RAN2 99之二	R2-1710693	-	-	-	编辑更新和更正： - 9.3.2 中的 RAT 间移动性已重组 - SON 提升到最高子条款级别（因为它不是垂直的） - 删除了过时的第 14 和 15 款。 - 空闲寻呼的描述与 23.501 一致 - I-RNTI 建议为 INACTIVE - RAN2 99 缺少关于 INACTIVE 捕获的协议	1.0.1
2017.10	RAN2 99之二	R2-1711936	-	-	-	纯净版	1.1.0
2017.10	RAN2 99之二	R2-1711972	-	-	-	更正： - 9.2.3.2.1 中的移动容器 - 为了保持一致性，“HO”更改为“移交” 捕获的 RAN2 99bis 协议： - R2-1710253 中的 URLLC 文本 - R2-1710074 中对 RRC 状态的澄清 - R2-1711778 中的简历 ID 术语 - R2-1712034 中的切片说明 - SRB0 和 SRB1 在 INACTIVE 中的使用 - 用于切换的RACH资源的优先级 - CA 中每个 SCell 的 SPS 配置 - 仅通过切换启用/禁用 DRB 上的 IP - 第一份补充上行链路协议 - RAN3协议支持的最大数据速率计算： - R3-173639 关于报告员对 RAN3 相关部分的更新 - R3-174162 关于 NG-RAN 发现 AMF - R3-174187 关于 RRC_INACTIVE 中 RAN 寻呼失败处理 - R3-174188 关于 RAN 非活动状态下的不可达性 - R3-174225 关于系统间切换 - R3-174230 关于 RRC 非活动辅助信息 RAN 协议： - RP-172113 关于 UE 类别。	1.1.1
2017.11	RAN2 100	R2-1712266	-	-	-	纯净版	1.2.0
2017.11	RAN2 100	R2-1712355	-	-	-	编辑清理： - 编者注和相关 FFS 移至 R2-17112357 - 更新了 NG 接口的协议栈图 - 双连接更改为多 RAT 连接 - 添加了有关 SI 处理的详细信息以解决 RMSI - 更新了访问控制并添加了对 22.261 的引用 - 删除了 DC 特定细节（改为使用 37.340） - 注释在需要的地方编号	1.2.1
2017.12	RAN2 100	R2-174079	-	-	-	从 RAN2 100 捕获的协议： - R2-1714230 中的 QoS 更新 - R2-1712687 中第 2 阶段 QoS 流的更新 - R2-172360 中的 BWP 描述 - 在 R2-173937 中从“不活动”转换为“已连接” - SUL 概述 - 删除DC相关定义 - BWP协议 - SPS 术语更改为 CS，以涵盖 R3-175011 中的两种类型 RAN3 协议和 R1-1721728 中的 RAN1 协议	1.2.2
2017.12	RAN2 100	R2-1714252	-	-	-	纯净版	1.3.0
2017.12	RP-78	RP-172496	-	-	-	供 RAN 批准	2.0.0
2017/12	RP-78					升级至 Rel-15 (MCC)	15.0.0
2018/03	RP-79	RP-180440	0009	1	F	杂项更正和补充	15.1.0
2018/06	RP-80	RP-181214	0010	1	F	关于 NR 载波聚合的澄清	15.2.0
	RP-80	RP-181214	0011	2	F	杂项更正	15.2.0
	RP-80	RP-181214	0012	1	F	寻呼机制	15.2.0

	RP-80	RP-181214	0013	2	F	Security Update	15.2.0
	RP-80	RP-181214	0014	1	F	UE Identities	15.2.0
	RP-80	RP-181214	0015	1	F	Corrections on deactivation of PUCCH SCell	15.2.0
	RP-80	RP-181214	0022	2	F	Clarification on count wrap around	15.2.0
	RP-80	RP-181214	0024	1	F	Slicing assistance information	15.2.0
	RP-80	RP-181214	0025	-	F	Physical Layer Update	15.2.0
	RP-80	RP-181214	0026	1	F	Default DRB & QoS Remapping	15.2.0
	RP-80	RP-181214	0027	1	F	SSB Clarifications	15.2.0
	RP-80	RP-181217	0029	2	B	CR on U-plane handling for handover	15.2.0
	RP-80	RP-181217	0030	2	B	CR on message content in inter-RAT handover	15.2.0
	RP-80	RP-181215	0032	1	F	Clarifications on (de)activation of Duplication and (de)activation of SCells	15.2.0
	RP-80	RP-181216	0033	2	B	Introduce ANR in NR	15.2.0
	RP-80	RP-181215	0036	1	F	Corrections to Unified Access Control	15.2.0
	RP-80	RP-181215	0040	-	F	Correction to TS 38.300 on Open Issues for Handover	15.2.0
	RP-80	RP-181216	0041	-	B	Baseline CR for June version of RAN2 TS 38.300 (RAN3 part) covering agreements of RAN3#100	15.2.0
	RP-80	RP-181216	0042	-	B	Delay budget report and MAC CE adaptation for NR for TS 38.300	15.2.0
2018/09	RP-81	RP-181941	0035	3	B	ECN support in NR	15.3.0
	RP-81	RP-181938	0043	2	D	Miscellaneous Clean Up and Corrections	15.3.0
	RP-81	RP-181938	0045	1	F	Mobility Call Flows	15.3.0
	RP-81	RP-181938	0046	2	F	QoS Handling Corrections	15.3.0
	RP-81	RP-181938	0047	4	F	MDBV Enforcement	15.3.0
	RP-81	RP-181939	0050	1	F	Completion of description of power saving	15.3.0
	RP-81	RP-181940	0051	1	F	Correction to description of bandwidth adaptation	15.3.0
	RP-81	RP-181939	0053	1	F	Clarification of PDCP functionality	15.3.0
	RP-81	RP-181939	0062	2	F	Clarification on number of CC for NR CA	15.3.0
	RP-81	RP-181938	0070	1	F	Beam management, failure detection and recovery	15.3.0
	RP-81	RP-181941	0071	-	F	System Information Handling in TS38.300	15.3.0
	RP-81	RP-181941	0072	1	F	Correction on RRC Resume procedure	15.3.0
	RP-81	RP-181940	0077	-	F	CR on RACH configuration during HO	15.3.0
	RP-81	RP-181941	0078	1	F	Missing Call Flows	15.3.0
	RP-81	RP-181942	0079	1	F	CN type indication for Redirection from NR to E-UTRA	15.3.0
	RP-81	RP-181942	0080	1	F	QoS Flow to DRB Remapping during Handover	15.3.0
	RP-81	RP-181941	0081	1	F	NR Corrections (38.300 Baseline CR covering RAN3-101 agreements)	15.3.0
2018/10	-	-	-	-	-	Changes of CR0035 rev 3 were undone since this CR was actually not approved by RAN #81 as it was not submitted to RAN #81	15.3.1

	RP-80	RP-181214	0013	2	F	安全更新	15.2.0
	RP-80	RP-181214	0014	1	F	UE身份	15.2.0
	RP-80	RP-181214	0015	1	F	PUCCH SCell 停用的更正	15.2.0
	RP-80	RP-181214	0022	2	F	关于计数环绕的澄清	15.2.0
	RP-80	RP-181214	0024	1	F	切片辅助信息	15.2.0
	RP-80	RP-181214	0025	-	F	物理层更新	15.2.0
	RP-80	RP-181214	0026	1	F	默认 DRB 和 QoS 重新映射	15.2.0
	RP-80	RP-181214	0027	1	F	SSB 澄清	15.2.0
	RP-80	RP-181217	0029	2	B	U 平面上的 CR 处理以进行移交	15.2.0
	RP-80	RP-181217	0030	2	B	跨RAT切换中消息内容的CR	15.2.0
	RP-80	RP-181215	0032	1	F	关于复制（去）激活和 SCell （去）激活的澄清	15.2.0
	RP-80	RP-181216	0033	2	B	在NR中引入ANR	15.2.0
	RP-80	RP-181215	0036	1	F	对统一访问控制的更正	15.2.0
	RP-80	RP-181215	0040	-	F	对 TS 38.300 有关移交的未解决问题的更正	15.2.0
	RP-80	RP-181216	0041	-	B	6 月版 RAN2 TS 38.300（RAN3 部分）的基线 CR，涵盖 RAN3#100 协议	15.2.0
	RP-80	RP-181216	0042	-	B	TS 38.300 NR 的延迟预算报告和 MAC CE 适配	15.2.0
2018/09	RP-81	RP-181941	0035	3	B	NR 中的 ECN 支持	15.3.0
	RP-81	RP-181938	0043	2	D	杂项清理和更正	15.3.0
	RP-81	RP-181938	0045	1	F	移动呼叫流程	15.3.0
	RP-81	RP-181938	0046	2	F	QoS 处理更正	15.3.0
	RP-81	RP-181938	0047	4	F	MDBV 执法	15.3.0
	RP-81	RP-181939	0050	1	F	完成省电描述	15.3.0
	RP-81	RP-181940	0051	1	F	修正带宽适配描述	15.3.0
	RP-81	RP-181939	0053	1	F	PDCP功能的澄清	15.3.0
	RP-81	RP-181939	0062	2	F	关于 NR CA 的 CC 数量的澄清	15.3.0
	RP-81	RP-181938	0070	1	F	光束管理、故障检测和恢复	15.3.0
	RP-81	RP-181941	0071	-	F	TS38.300 中的系统信息处理	15.3.0
	RP-81	RP-181941	0072	1	F	对 RRC 恢复过程的更正	15.3.0
	RP-81	RP-181940	0077	-	F	HO期间RACH配置上的CR	15.3.0
	RP-81	RP-181941	0078	1	F	未接来电流程	15.3.0
	RP-81	RP-181942	0079	1	F	从 NR 重定向到 E-UTRA 的 CN 类型指示	15.3.0
	RP-81	RP-181942	0080	1	F	切换期间 QoS 流到 DRB 重新映射	15.3.0
	RP-81	RP-181941	0081	1	F	NR 修正（涵盖 RAN3-101 协议的 38.300 基线 CR）	15.3.0
2018/10	-	-	-	-	-	CR0035 修订版 3 的更改已撤消，因为该 CR 实际上未得到 RAN #81 批准，因为它未提交给 RAN #81	15.3.1

History

Document history		
V15.2.0	September 2018	Publication
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历史

文档历史记录		
V15.2.0	2018年9月	出版物
V15.3.1	2018年10月	出版物