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NG Interface

TP00005-V-1701 V0 - S03M01 Ed1

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Learning objectives
Upon completion of this module, you should be able to:

Describe NG-C protocol stack and signaling messages
Describe NG-U protocol stack and GTPU header

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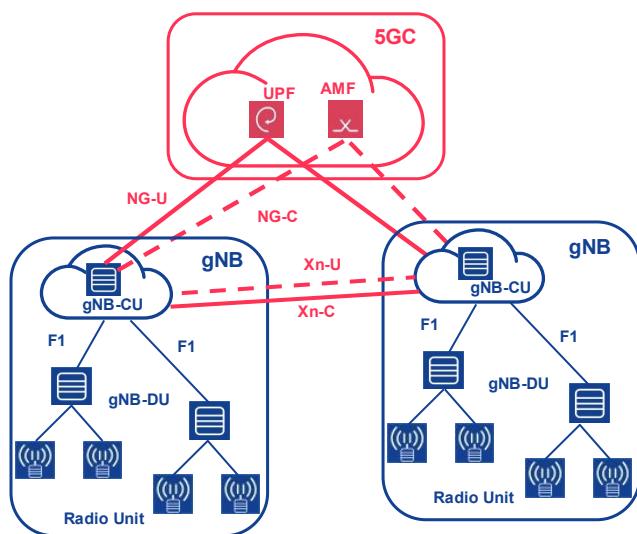
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NG-C interface

3GPP 38.413 NG Application Protocol (NGAP)

NG-C interface

NG-C Protocol Stack

NG Application Protocol : Application Layer Protocol between the 5GAN node and the AMF

Stream Control Transmission Protocol : This protocol guarantees delivery of signaling messages between AMF and 5G-AN node (N2)

SCTP is improved TCP for signaling traffic over IP

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 ;
- Location Reporting function
- NRPPa Signalling Transport ;
- NR MBS Session Management

3GPP 23.501 **8.2**   **Control Plane Protocol Stacks**

The NG interface supports a one-to-many relation between NG-RAN nodes and 5GC nodes.

The NG control plane interface (NG-C) is defined between the NG-RAN node and the Access and Mobility management Function (AMF). The control plane protocol stack of the NG-C interface is shown in the Figure here on the slide. The transport network layer is built on IP transport. For the reliable transport of signaling messages, SCTP is added on top of IP. The application layer signaling 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 signaling PDUs. SCTP/IP is the agreed transport protocol for NG-C.

- L2: Data link layer: The support of any suitable Data Link Layer protocol, e.g. PPP, Ethernet, etc.,

- IP layer:
  The 5GC and NG-RAN shall support IPv6 (IETF RFC 2460) and/or IPv4 (IETF RFC 791).
  The IP layer of NG-C only supports point-to-point transmission for delivering NG AP message.
  The 5GC and NG-RAN shall support the Diffserv Code Point marking as described in IETF RFC 2474

- SCTP: SCTP refers to the Stream Control Transmission Protocol developed by the Sigtran working group of the IETF for the purpose of transporting various signaling protocols over IP network.

NGAP interface is also used between a non-3GPP Access Node (N3IWF) connect to AMF via NGAP

- 3GPP TS38.413:
  New NG-RAN node ID is defined for non-3GPP N3IWF node, i.e. Global N3IWF ID
  New content for User Location Information is defined for non-3GPP access.

- 3GPP TS29.413:
  Defines the applicable NGAP procedures and NGAP messages
  Also defines the handing of non-applicable IEs, i.e. receiver node shall ignore the non-application Ies
  The handling for non-applicable messages is the same as normal NGAP.

NG Interface Management
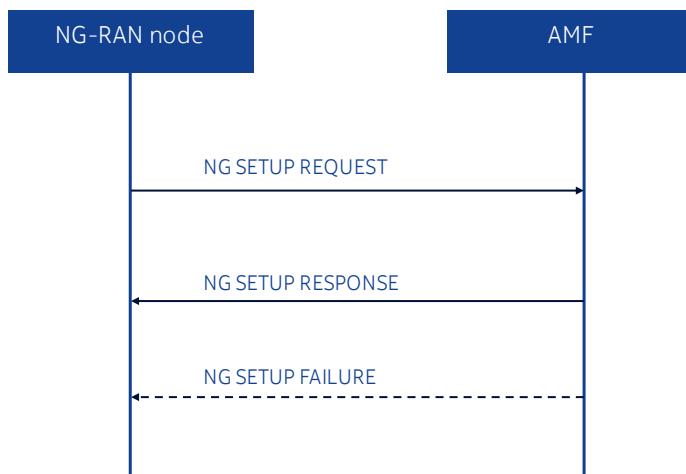
NG Interface Management

This procedure covers:

NG Setup	To exchange application level data needed for the NG-RAN node and the AMF to correctly interoperate on the NG-C interface
RAN Configuration Update	To update application level configuration data needed for the NG-RAN node and the AMF to interoperate correctly on the NG-C interface
AMF Configuration Update	To update application level configuration data needed for the NG-RAN node and AMF to interoperate correctly on the NG-C interface
NG Reset	To initialise or re-initialise the RAN, or part of RAN NGAP UE-related contexts
Error Indication	To report detected errors in one incoming message, provided they cannot be reported by an appropriate failure message
AMF Status Indication	To support AMF management functions.
Overload Start	To inform an NG-RAN node to reduce the signalling load towards the concerned AMF
Overload Stop	To signal to an NG-RAN node the AMF is connected to that the overload situation at the AMF has ended and normal operation shall resume.

NG Setup Procedure

The purpose of the NG Setup procedure is to exchange application level data needed for the NG-RAN node and the AMF to correctly interoperate on the NG-C interface.

NG-RAN node	AMF

NG SETUP REQUEST →

← NG SETUP RESPONSE

← NG SETUP FAILURE
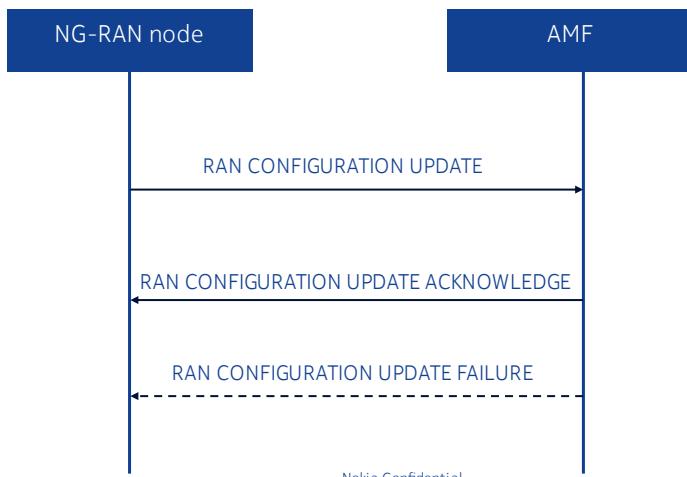
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RAN Configuration Update

The purpose of the RAN Configuration Update procedure is to update application level configuration data needed for the NG-RAN node and the AMF to interoperate correctly on the NG-C interface.
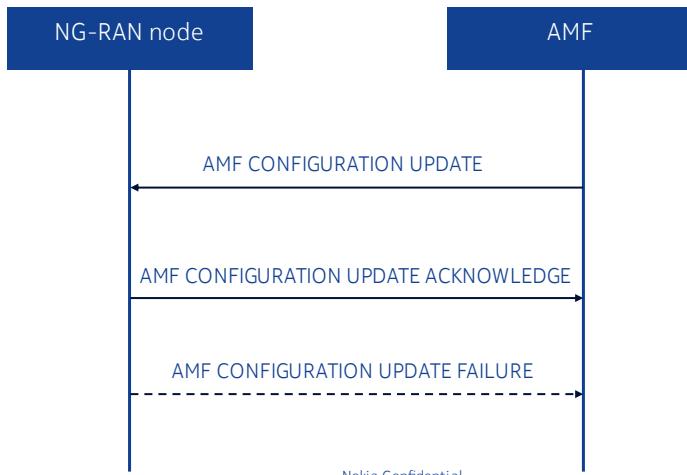
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AMF Configuration Update

The purpose of the AMF Configuration Update procedure is to update application level configuration data needed for the NG-RAN node and the AMF to interoperate correctly on the NG-C interface.

NG-RAN node	AMF

AMF CONFIGURATION UPDATE

AMF CONFIGURATION UPDATE ACKNOWLEDGE

AMF CONFIGURATION UPDATE FAILURE
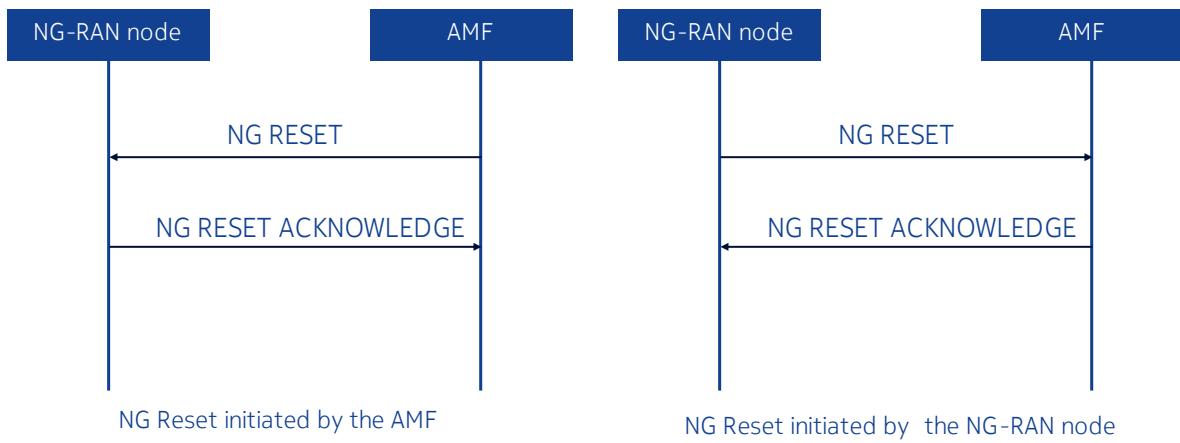
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NG Reset

The purpose of the NG Reset procedure is to initialise or re-initialise the RAN, or part of RAN NGAP UE-related contexts, in the event of a failure in the 5GC or vice versa.

| NG-RAN node | AMF | NG-RAN node | AMF |

NG RESET

NG RESET ACKNOWLEDGE

NG RESET

NG RESET ACKNOWLEDGE

NG Reset initiated by the AMF

NG Reset initiated by the NG-RAN node
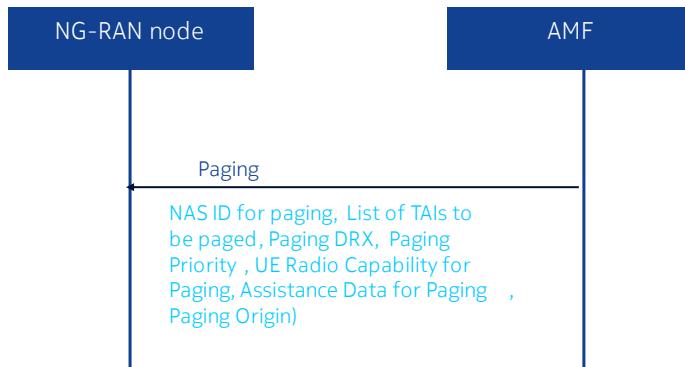
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Paging

Paging Procedure

The purpose of the Paging procedure is to enable the AMF to page a UE in the specific NG-RAN node.

```
   ┌─────────────────────┐              ┌─────────────────────┐
   │    NG-RAN node      │              │        AMF          │
   └─────────────────────┘              └─────────────────────┘
             │                                     │
             │            Paging                   │
             │◄────────────────────────────────────│
             │  NAS ID for paging,  List of TAIs to│
             │  be paged, Paging DRX,  Paging      │
             │  Priority , UE Radio Capability for │
             │  Paging, Assistance Data for Paging ,│
             │  Paging Origin)                     │
             │                                     │
```

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Transport of NAS Messages

Transport of NAS Messages Procedures
Overview

The NAS Signaling Transport function provides means to transport or reroute a NAS message (e.g. for NAS mobility management),or report the non-delivery of a NAS message for a specific UE over the NG interface.

The procedures providing this functionality are:
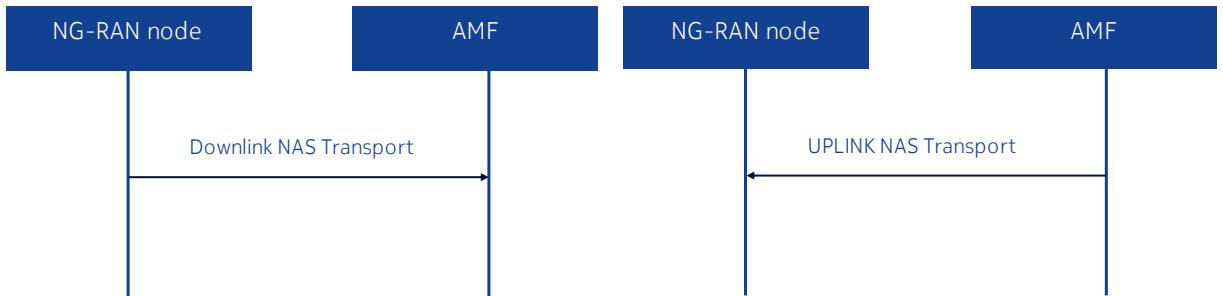
- Initial UE Message (NG-RAN node initiated);
- Uplink NAS transport (NG-RAN node initiated);
- Downlink NAS transport (AMF initiated);
- NAS non delivery indication (NG-RAN node initiated);
- Reroute NAS Request (AMF initiated).

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Initial UE Message

The Initial UE Message procedure is used when the NG-RAN node has received from the radio interface the first uplink NAS message to be forwarded to an AMF.

NG-RAN node	AMF

Initial UE Message →

Downlink NAS Transport / Uplink NAS Transport

NG-RAN node	AMF	NG-RAN node	AMF

Downlink NAS Transport →

UPLINK NAS Transport ←

The Downlink NAS Transport procedure is used when the AMF only needs to send a NAS message transparently via the NG-RAN node to the UE, and a UE-associated logical NG-connection exists for the UE or the AMF has received the *RAN UE NGAP ID* IE in an INITIAL UE MESSAGE message or if the NG-RAN node has already initiated a UE-associated logical NG-connection by sending an INITIAL UE MESSAGE message via another NG interface instance.

The Uplink NAS Transport procedure is used when the NG-RAN node has received from the radio interface a NAS message to be forwarded to the AMF to which a UE-associated logical NG-connection for the UE exists.

UE Context Management

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UE Context Management Procedures
Overview
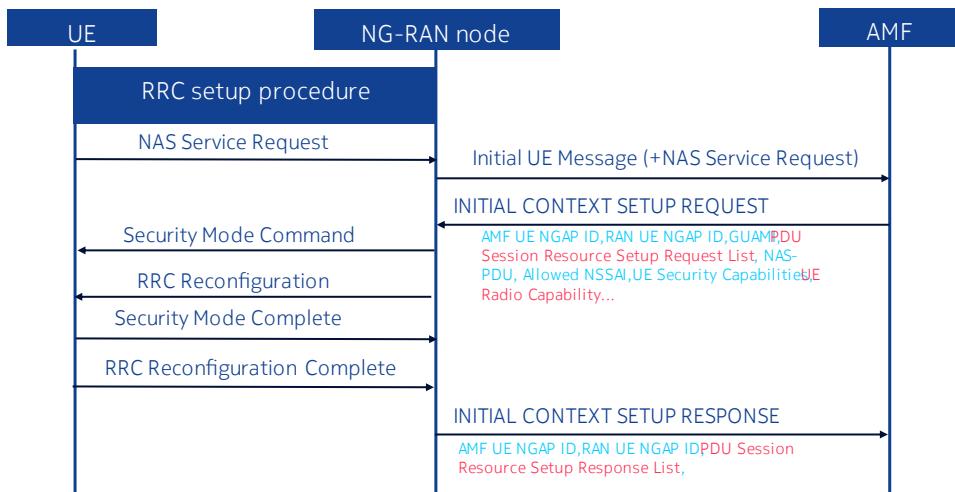
The UE Context management function allows the AMF to establish, modify or release a UE Context in the AMF and the NG-RAN node e.g. to support user individual signalling on NG.

The function also enables the AMF to manage RRC state notifications of a CM-CONNECTED UE.

The following UE Context management procedures are used to establish, release or modify the UE context.

- Initial Context Setup;
- UE Context Release Request;
- UE Context Release;
- UE Context Modification;
- RRC Inactive Transition Report.

Initial Context Setup

```
    UE                    NG-RAN node                                    AMF

        ┌─────────────────────────┐
        │   RRC setup procedure   │
        └─────────────────────────┘
        NAS Service Request ──────────────►  Initial UE Message (+NAS Service Request)

                                          INITIAL CONTEXT SETUP REQUEST
        ◄────── Security Mode Command         AMF UE NGAP ID, RAN UE NGAP ID, GUAMI, PDU
                                              Session Resource Setup Request List, NAS-
        ◄────── RRC Reconfiguration           PDU, Allowed NSSAI, UE Security Capabilities, UE
        Security Mode Complete ──────►        Radio Capability...

        RRC Reconfiguration Complete ──►
                                          INITIAL CONTEXT SETUP RESPONSE
                                              AMF UE NGAP ID, RAN UE NGAP ID, PDU Session
                                              Resource Setup Response List,
```

The purpose of the Initial Context Setup procedure is to establish the necessary overall initial UE context at the NG-RAN node, when required, including PDU session context, the Security Key, Mobility Restriction List, UE Radio Capability and UE Security Capabilities, etc.

UE Context Modification

```
┌──────────────┐                    ┌──────────────┐
│  NG-RAN node │                    │     AMF      │
└──────┬───────┘                    └──────┬───────┘
       │                                   │
       │    UE CONTEXT MODIFICATION REQUEST│
       │◄──────────────────────────────────│
       │                                   │
       │    UE CONTEXT MODIFICATION REPONSE│
       │──────────────────────────────────►│
       │                                   │
       │    UE CONTEXT MODIFICATION FAILURE│
       │◄─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─│
       │                                   │
```
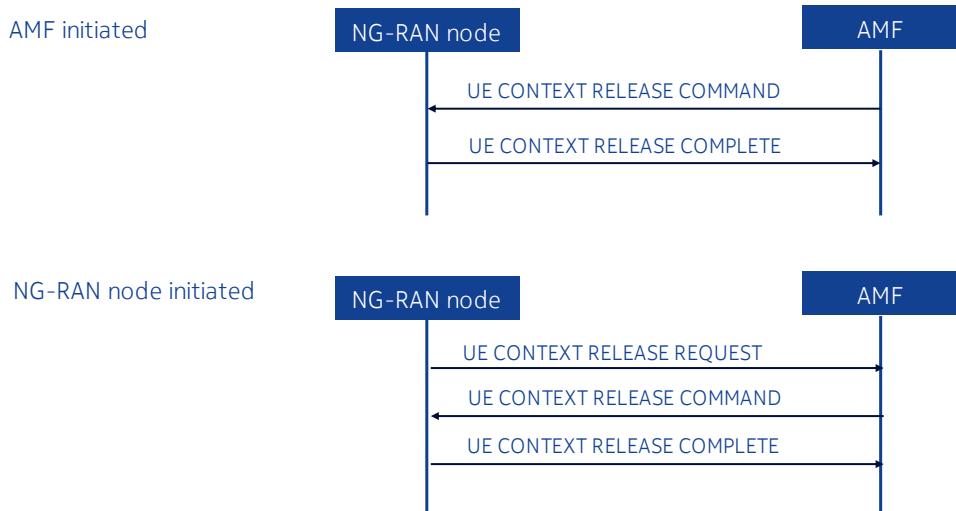
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The purpose of the UE Context Modification procedure is to partly modify the established UE context.

UE Context Release

AMF initiated

NG-RAN node		AMF
	← UE CONTEXT RELEASE COMMAND	
	UE CONTEXT RELEASE COMPLETE →	

NG-RAN node initiated

NG-RAN node		AMF
	UE CONTEXT RELEASE REQUEST →	
	← UE CONTEXT RELEASE COMMAND	
	UE CONTEXT RELEASE COMPLETE →	

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UE Context Release (AMF initiated): The purpose of the UE Context Release procedure is to enable the AMF to order the release of the UE-associated logical NG-connection due to various reasons.

UE Context Release Request (NG-RAN node initiated): The purpose of the UE Context Release Request procedure is to enable the NG-RAN node to request the AMF to release the UE-associated logical NG-connection due to NG-RAN node generated reasons.

PDU Session Management
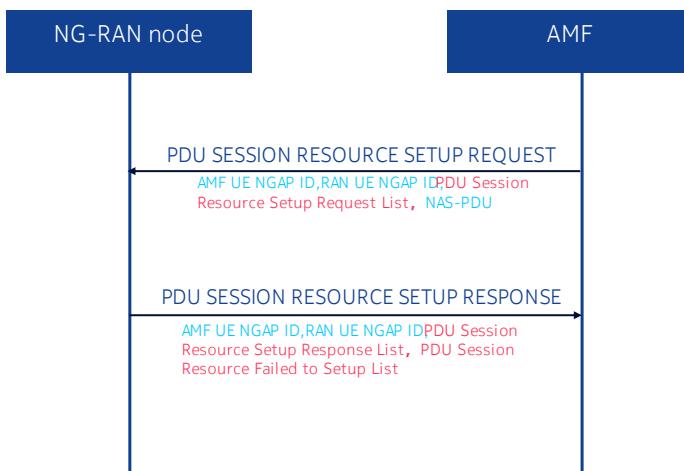
PDU Session Management Procedures
Overview

The PDU Session function is responsible for establishing, modifying and releasing the involved PDU sessions NG-RAN resources for user data transport once a UE context is available in the NG-RAN node.

The following PDU Session management procedures are used to establish, release or modify PDU sessions.
- PDU Session Resource Setup;
- PDU Session Resource Release;
- PDU Session Resource Modify;
- PDU Session Resource Notify;
- PDU Session Resource Modify Indication.

PDU Session Resource Setup

```
┌─────────────────┐                    ┌─────────────────┐
│   NG-RAN node   │                    │       AMF       │
└─────────────────┘                    └─────────────────┘
         │                                      │
         │   PDU SESSION RESOURCE SETUP REQUEST │
         │ ◄────────────────────────────────────│
         │   AMF UE NGAP ID,RAN UE NGAP ID,PDU Session
         │   Resource Setup Request List, NAS-PDU
         │                                      │
         │   PDU SESSION RESOURCE SETUP RESPONSE│
         │ ────────────────────────────────────►│
         │   AMF UE NGAP ID,RAN UE NGAP ID,PDU Session
         │   Resource Setup Response List, PDU Session
         │   Resource Failed to Setup List
         │                                      │
```
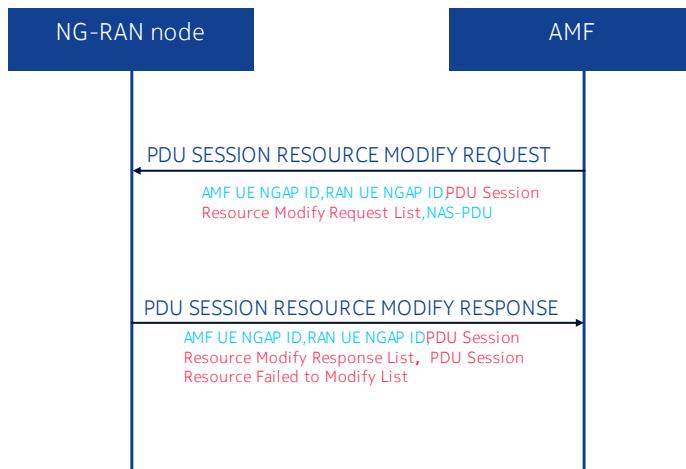
The purpose of the PDU Session Resource Setup procedure is to assign resources on Uu and NG-U for one or several PDU sessions and the corresponding QoS flows, and to setup corresponding DRBs for a given UE.

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PDU Session Resource Modify

NG-RAN node		AMF

PDU SESSION RESOURCE MODIFY REQUEST
AMF UE NGAP ID, RAN UE NGAP ID, PDU Session Resource Modify Request List, NAS-PDU

PDU SESSION RESOURCE MODIFY RESPONSE
AMF UE NGAP ID, RAN UE NGAP ID, PDU Session Resource Modify Response List, PDU Session Resource Failed to Modify List
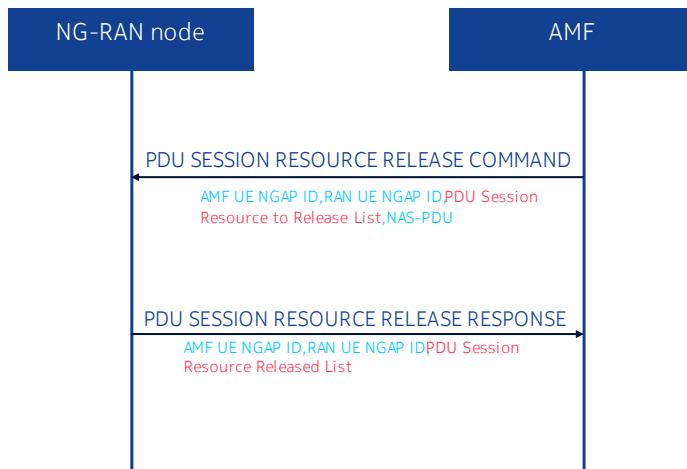
The purpose of the PDU Session Resource Modify procedure is to enable configuration modifications of already established PDU session(s) for a given UE. It is also to enable the setup, modification and release of the QoS flow for already established PDU session(s).

PDU Session Resource Release


```
        NG-RAN node                              AMF

             │                                    │
             │   PDU SESSION RESOURCE RELEASE COMMAND
             │◄───────────────────────────────────┤
             │   AMF UE NGAP ID,RAN UE NGAP ID,PDU Session
             │   Resource to Release List,NAS-PDU
             │                                    │
             │                                    │
             │   PDU SESSION RESOURCE RELEASE RESPONSE
             ├───────────────────────────────────►│
             │   AMF UE NGAP ID,RAN UE NGAP ID,PDU Session
             │   Resource Released List
             │                                    │
             │                                    │
```

The purpose of the PDU Session Resource Release procedure is to enable the release of already established PDU session resources for a given UE.

UE Mobility Management
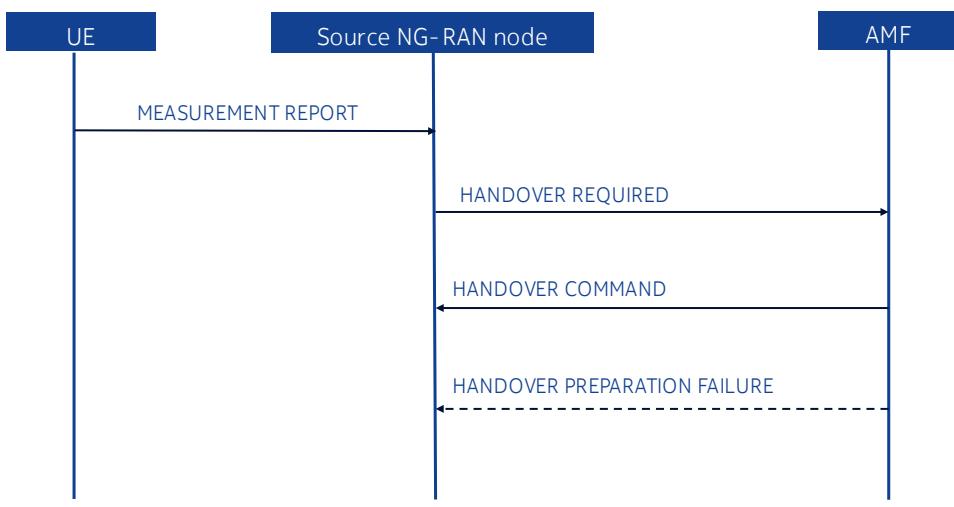
UE Mobility Management Procedures
Overview

Handover Preparation — To request the preparation of resources at the target side via the 5GC

Handover Resource Allocation — To reserve resources at the target NG-RAN node for the handover of a UE

Handover Notification — To indicate to the AMF that the UE has arrived to the target cell and the NG-based handover has been successfully completed.

Path Switch Request — To establish a UE associated signalling connection to the 5GC and, if applicable, to request the switch of the downlink termination point of the NG-U transport bearer towards a new termination point.

Handover Cancellation — To enable a source NG-RAN node to cancel an ongoing handover preparation or an already prepared handover.

Uplink RAN Status Transfer — To enable lossless NG-based handover

Downlink RAN Status Transfer — To enable lossless NG-based handover.

Procedures used during a DAPS Handover:

Handover Success To inform the source NG-RAN node that the UE has successfully accessed the target NG-RAN node.

Uplink RAN Early Status Transfer — To transfer the COUNT of the first downlink SDU, from the source NG-RAN node to the target NG-RAN node via the AMF

Downlink RAN Early Status Transfer — To transfer the COUNT of the first downlink, from the source NG-RAN node to the target NG-RAN node via the AMF

Handover Preparation procedure

```
   ┌──────────┐      ┌────────────────────┐                    ┌──────────┐
   │    UE    │      │  Source NG-RAN node │                    │   AMF    │
   └──────────┘      └────────────────────┘                    └──────────┘
        │                     │                                     │
        │  MEASUREMENT REPORT │                                     │
        │────────────────────>│                                     │
        │                     │                                     │
        │                     │        HANDOVER REQUIRED            │
        │                     │────────────────────────────────────>│
        │                     │                                     │
        │                     │        HANDOVER COMMAND             │
        │                     │<────────────────────────────────────│
        │                     │                                     │
        │                     │   HANDOVER PREPARATION FAILURE      │
        │                     │<- - - - - - - - - - - - - - - - - - │
        │                     │                                     │
```
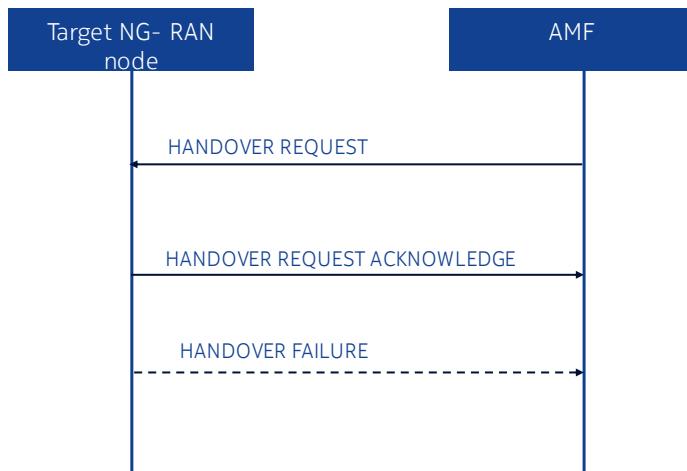
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The purpose of the Handover Preparation procedure is to request the preparation of resources at the target side via the 5GC.

There is only one Handover Preparation procedure ongoing at the same time for a certain UE.

# Handover Resource Allocation procedure

```
┌──────────────────┐                    ┌──────────────────┐
│  Target NG- RAN  │                    │       AMF        │
│       node       │                    │                  │
└──────────────────┘                    └──────────────────┘
        │                                        │
        │         HANDOVER REQUEST               │
        │◄───────────────────────────────────────│
        │                                        │
        │     HANDOVER REQUEST ACKNOWLEDGE       │
        │───────────────────────────────────────►│
        │                                        │
        │         HANDOVER FAILURE               │
        │- - - - - - - - - - - - - - - - - - - - ►│
        │                                        │
```
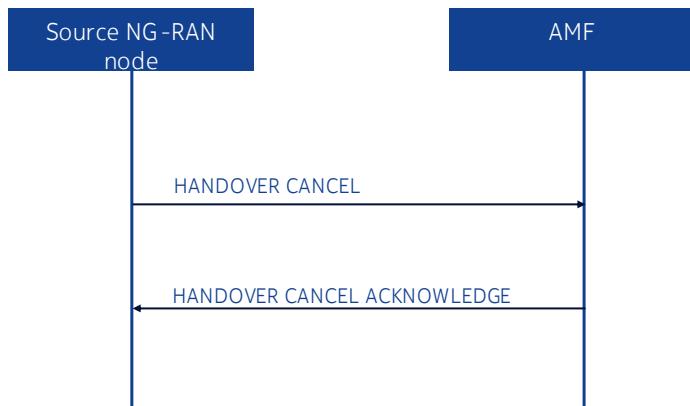
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The purpose of the Handover Resource Allocation procedure is to reserve resources at the target NG-RAN node for the handover of a UE.

Handover cancellation procedure

```
┌─────────────────┐              ┌─────────────────┐
│  Source NG-RAN  │              │       AMF       │
│      node       │              │                 │
└─────────────────┘              └─────────────────┘
         │                                │
         │        HANDOVER CANCEL         │
         │───────────────────────────────►│
         │                                │
         │   HANDOVER CANCEL ACKNOWLEDGE  │
         │◄───────────────────────────────│
         │                                │
```
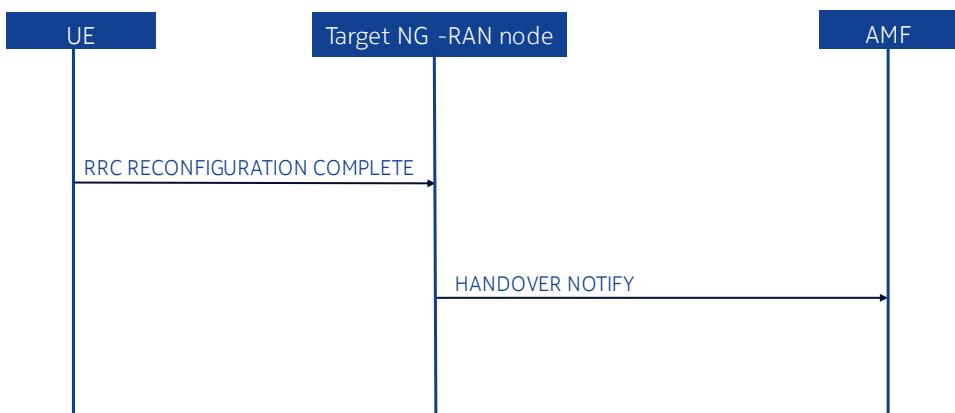
The purpose of the Handover Cancellation procedure is to enable a source NG-RAN node to cancel an ongoing handover preparation or an already prepared handover. The procedure uses UE-associated signalling.

Handover completion procedure   (NG-based handover)

```
┌──────────┐          ┌──────────────────────┐          ┌──────────┐
│    UE    │          │  Target NG -RAN node │          │   AMF    │
└──────────┘          └──────────────────────┘          └──────────┘
     │                           │                            │
     │  RRC RECONFIGURATION COMPLETE                          │
     │──────────────────────────►│                            │
     │                           │                            │
     │                           │      HANDOVER NOTIFY        │
     │                           │───────────────────────────►│
     │                           │                            │
```
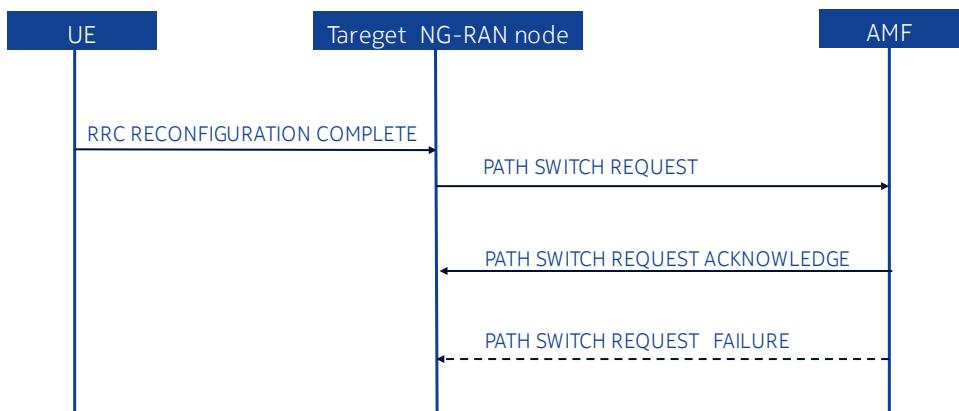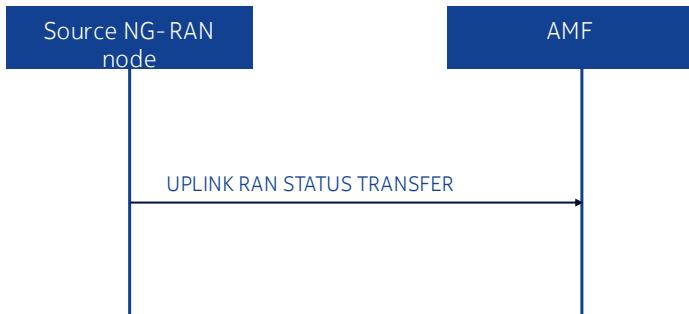
The purpose of the Handover Notification procedure is to indicate to the AMF that the UE has arrived to the target cell and the NG-based handover has been successfully completed.

Path Switch procedure (Xn-based HO)

```
        UE                 Tareget  NG-RAN node                        AMF

        RRC RECONFIGURATION COMPLETE
        ───────────────────────────────►
                                    PATH SWITCH REQUEST
                                    ──────────────────────────────────►

                                    PATH SWITCH REQUEST ACKNOWLEDGE
                                    ◄──────────────────────────────────

                                    PATH SWITCH REQUEST   FAILURE
                                    ◄- - - - - - - - - - - - - - - - - -
```

The purpose of the Path Switch Request procedure is to request the switch of the downlink termination point of the NG-U transport bearer towards a new termination point.

Uplink RAN Status Transfer

```
┌─────────────────┐                    ┌─────────────────┐
│ Source NG-RAN   │                    │      AMF        │
│      node       │                    │                 │
└─────────────────┘                    └─────────────────┘
         │                                      │
         │     UPLINK RAN STATUS TRANSFER       │
         │─────────────────────────────────────▶│
         │                                      │
```
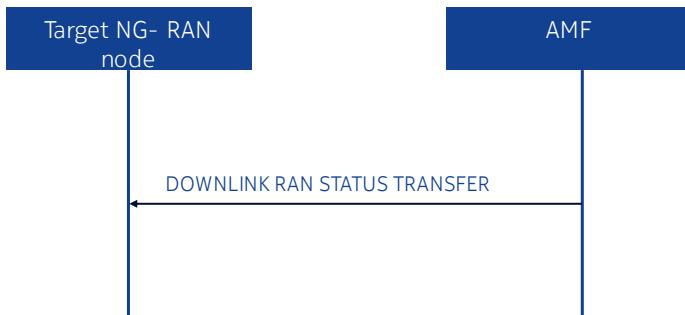
The purpose of the Uplink RAN Status Transfer procedure is to enable lossless NG-based handover. The procedure uses UE-associated signalling.

Downlink RAN Status Transfer

```
┌─────────────────────┐        ┌─────────────────────┐
│  Target NG- RAN     │        │        AMF          │
│      node           │        │                     │
└─────────────────────┘        └─────────────────────┘
         │                              │
         │   DOWNLINK RAN STATUS TRANSFER │
         │◄─────────────────────────────┤
         │                              │
```

The purpose of the Downlink RAN Status Transfer procedure is to is to enable lossless NG-based handover. The procedure uses UE-associated signalling.
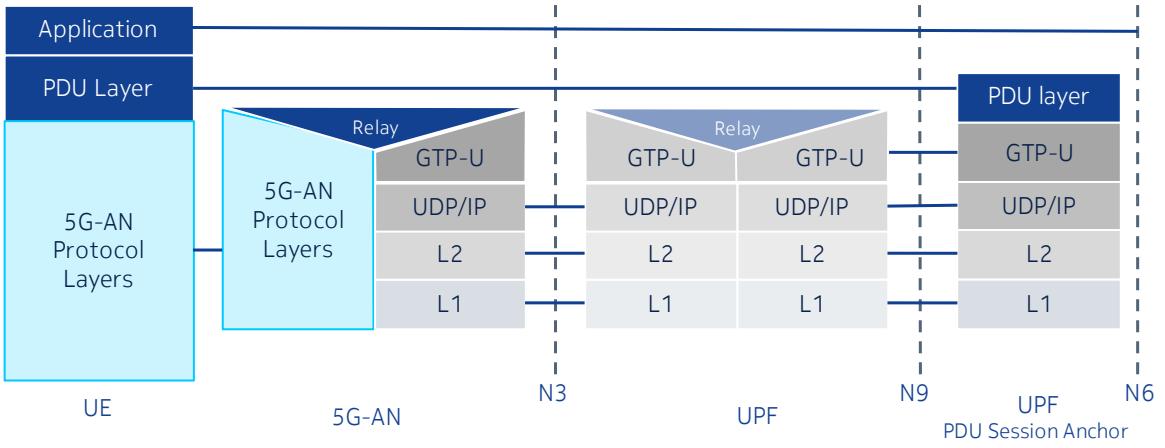
NG-U interface

NG User Plane Protocol Stack

NG-U Protocol Stack

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For NGU interface: 3GPP 23.501 8.3 User Plane Protocol Stacks.

The NG user plane interface (NG-U) is defined between the NG-RAN node and the UPF. 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 User Plane Function (UPF).

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

The PDU layer corresponds to the PDU carried between the UE and the Data Network (DN) over the PDU Session. When the PDU Session Type is IPv4 or IPv6 or IPv4v6, it corresponds to IPv4 packets or IPv6 packets or both of them; When the PDU Session Type is Ethernet, it corresponds to Ethernet frames; etc.

The GPRS Tunneling Protocol for the user plane (GTP U) supports multiplexing traffic of different PDU Sessions (possibly corresponding to different PDU Session Types) by tunneling user data over N3 (that is to say, between the 5G-AN node and the UPF) in the backbone network. GTP shall encapsulate all end user PDUs. It provides encapsulation on a per PDU Session level.

The 5G Encapsulation layer supports multiplexing traffic of different PDU Sessions (possibly corresponding to different PDU Session Types) over N9 (i.e. between different UPF of the 5GC). It provides encapsulation on a per PDU Session level.

UDP/IP: These are the backbone network protocols

GTP-U Header

Octets	Bits							
	8	7	6	5	4	3	2	1
1	Version			PT	(*)	E	SN	PN
2	Message Type							
3	Message Length (1st Octet)							
4	Message Length (2nd Octet)							
5	Tunnel Endpoint Identifier (1st Octet)							
6	Tunnel Endpoint Identifier (2nd Octet)							
7	Tunnel Endpoint Identifier (3rd Octet)							
8	Tunnel Endpoint Identifier (4th Octet)							
9	Sequence Number (1st Octet) [1] [4]							
10	Sequence Number (2nd Octet) [1] [4]							
11	N-PDU Number [2] [4]							
12	Next Extension Header Type [3] [4]							

NOTE 0: (*) This bit is a spare bit. It shall be sent as '0'. The receiver shall not evaluate this bit.
NOTE 1: 1) This field shall only be evaluated when indicated by the S flag set to 1.
NOTE 2: 2) This field shall only be evaluated when indicated by the PN flag set to 1.
NOTE 3: 3) This field shall only be evaluated when indicated by the E flag set to 1.
NOTE 4: 4) This field shall be present if and only if any one or more of the S, PN and E flags are set.

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GTP-U Extension Header

- Extension Header Length: the length of the particular Extension header in 4 octets units.

- Next Extension Header Type: the type of any Extension Header that may follow a particular Extension Header. If no such Header follows, then the value of the Next Extension Header Type shall be 0.

PDU Session Container:

This extension header shall be transmitted in the G -PDUs over the N3 and N9 user plane interfaces, between NG-RAN and UPF, or between two UPFs

NOTE: The value of this field is '0' if no other Extension header follows.

DL PDU SESSION INFORMATION (PDU Type 0) Format

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UL PDU SESSION INFORMATION (PDU Type 1) Format

Wrap-up
In this module we have covered the following items

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Describe NG-C protocol stack and signaling messages
Describe NG-U protocol stack and GTPU header

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