

# 5G NR SA Signaling with 5GC Call flow

TP00005-V-1701 V0 - S04M02 Ed1

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## Learning objectives

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

- Describe 5G NR Registration Procedure
- Describe 5G NR PDU Session Establishment Procedure
- Describe 5G NR PDU Session Modification Procedure
- Describe 5G NR PDU Release Procedure
- Describe 5G NR Access Network Release
- Describe 5G NR Service Request procedures
- Describe 5G NR Deregistration Procedure

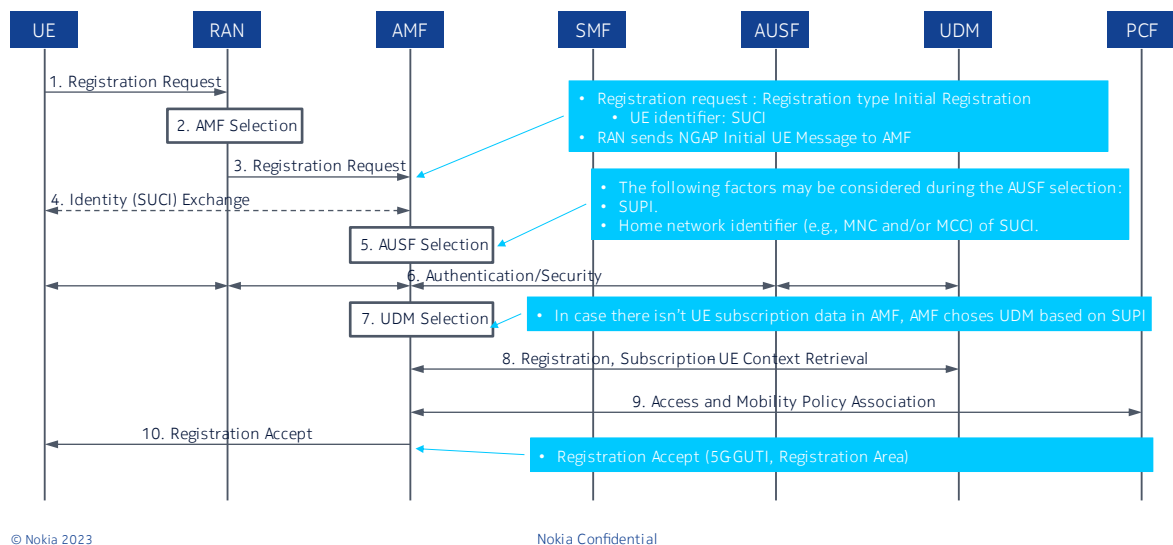
# Table of contents

Registration  
PDU Session Establishment  
PDU Session Modification  
PDU Session Release  
Access Network Release  
Service Request  
Deregistration  
Wrap-ap

# Registration

# UE Network Acquisition Process

## Registration Procedure -Simplified Signaling Flow



A UE needs to register with the network to receive services that requires registration. Once registered and if applicable the UE updates its registration with the network : periodically, in order to remain reachable (Periodic Registration Update); or upon mobility (Mobility Registration Update); or to update its capabilities or re-negotiate protocol parameters.

The registration procedure protocol flow is displayed on the slide.

The Initial Registration procedure involves execution of Network Access Control functions as discussed previously (i.e. user authentication and access authorization based on subscription profiles in UDM). As result of the Registration procedure, the identifier of the serving AMF serving the UE in the access through which the UE has registered will be registered in UDM. \*\*3\*\*The AMF associates multiple access-specific RM contexts for a UE as listed below.

As outlined earlier, the registration management procedures are applicable over both 3GPP access and Non-3GPP access. The 3GPP and Non-3GPP RM states are independent of each other.

AMF selection by the 5G-AN:

When the UE provides no 5G-S-TMSI nor the GUAMI to the 5G-AN.

When the UE provides 5G-S-TMSI or GUAMI but the routing information is not sufficient and/or not usable

AMF has instructed AN that the AMF (identified by GUAMI(s)) is unavailable and no target AMF is identified and/or AN has detected that the AMF has failed.

AMF supports the AMF selection functionality to select an AMF for relocation or because the initially selected AMF was not an appropriate AMF to serve the UE (e.g. due to change of Allowed NSSAI).

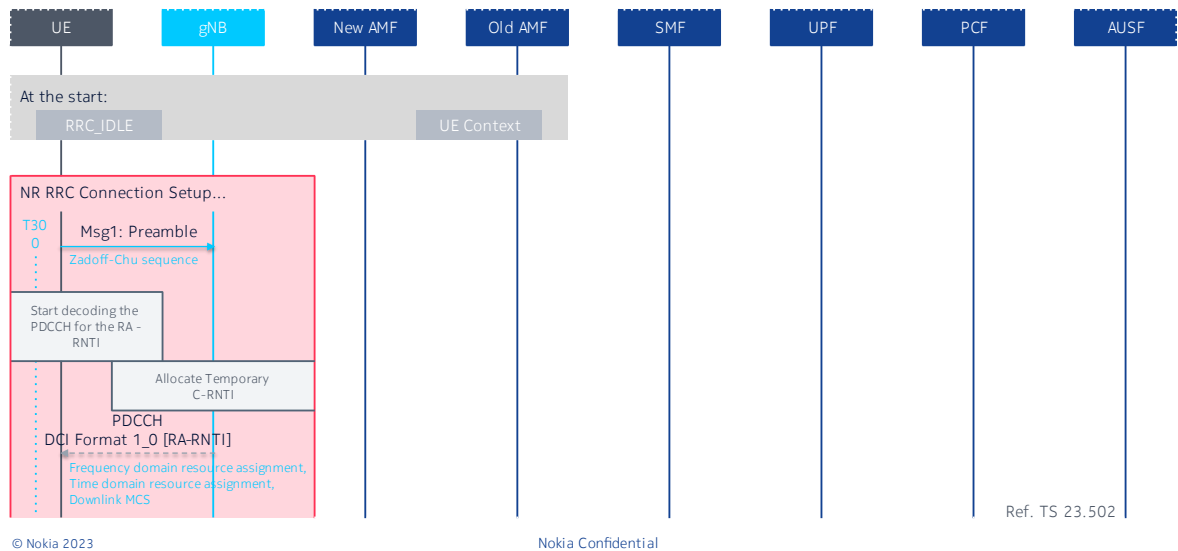
Other CP NF(s), e.g. SMF, supports the AMF selection functionality to select an AMF from the AMF set when the original AMF serving a UE is unavailable.

An AMF associates multiple access-specific RM contexts for an UE with:

- a 5G-GUTI that is common to both 3GPP and Non-3GPP accesses. This 5G-GUTI is globally unique.
- a Registration state per access type (3GPP / Non-3GPP)
- a Registration Area (RA) per access type (independent RA).
- timers for 3GPP access:
  - a Periodic Registration timer; and
  - a Mobile Reachable timer and an Implicit Deregistration timer.
- timers for non-3GPP access:
  - a UE Non-3GPP Deregistration timer; and
  - a Network Non-3GPP Implicit Deregistration timer.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



A UE needs to register with the network to

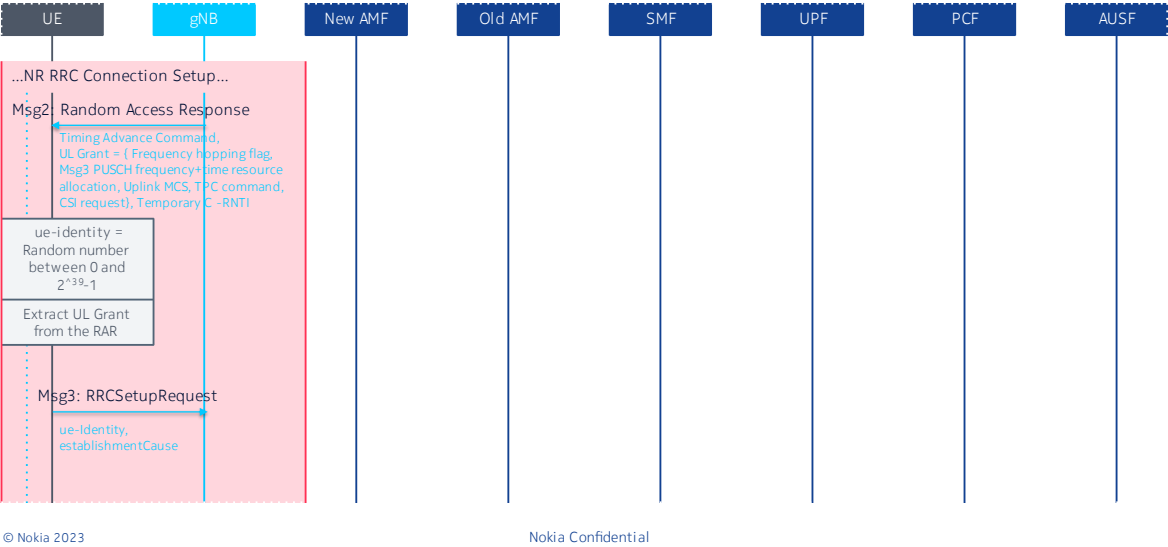
- get authorized to receive services
- enable mobility tracking
- enable reachability.

The Registration procedure is used when the UE needs to perform:

- Initial Registration to the 5GS
- Mobility Registration Update
  - upon changing to a new Tracking Area (TA) outside the UE's Registration Area in both CM-CONNECTED and CM-IDLE state, or
  - when the UE needs to update its capabilities or protocol parameters that are negotiated in Registration procedure with or without changing to a new TA.
- Periodic Registration Update (due to a predefined time period of inactivity).

# UE Network Acquisition Process

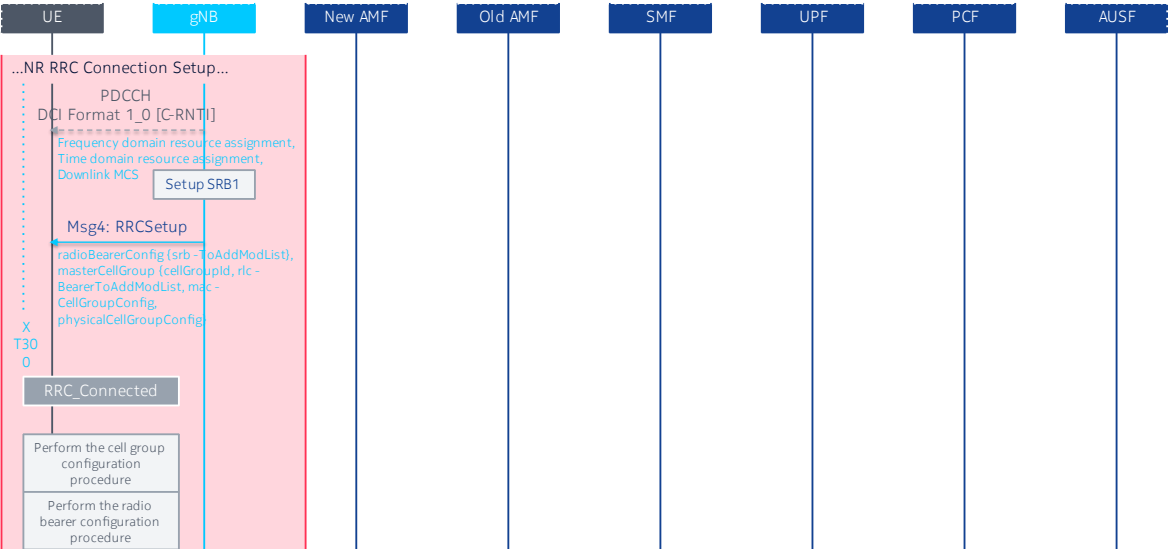
## Registration Procedure - Detailed Signaling Flow



UE uses RRCSetupRequest to setup a new connection from RRC\_IDLE (SRB0).

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow

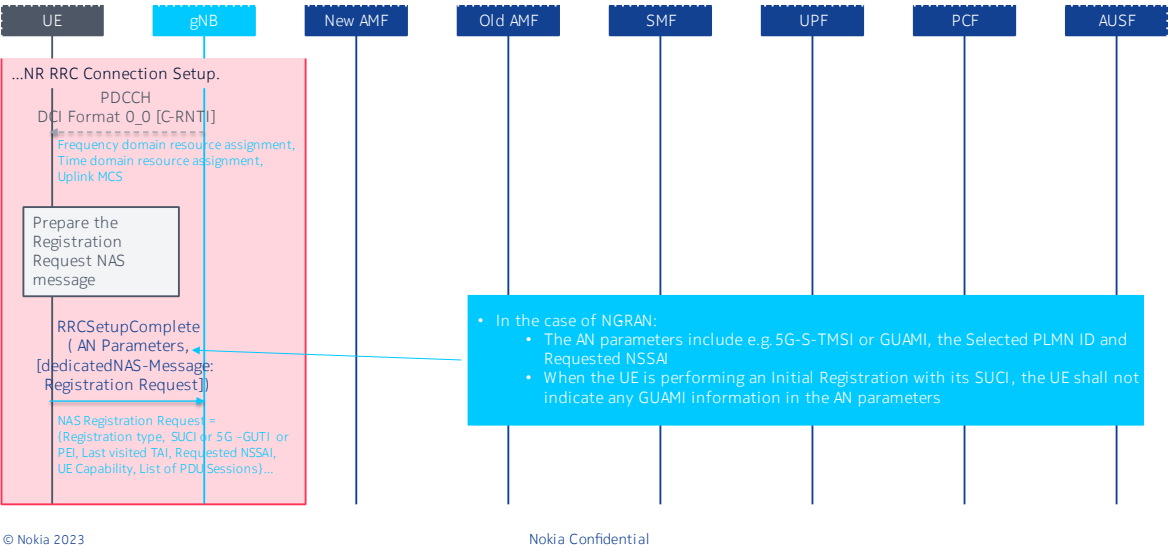


The gNB completes the RRC setup procedure (SRB0).



# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow

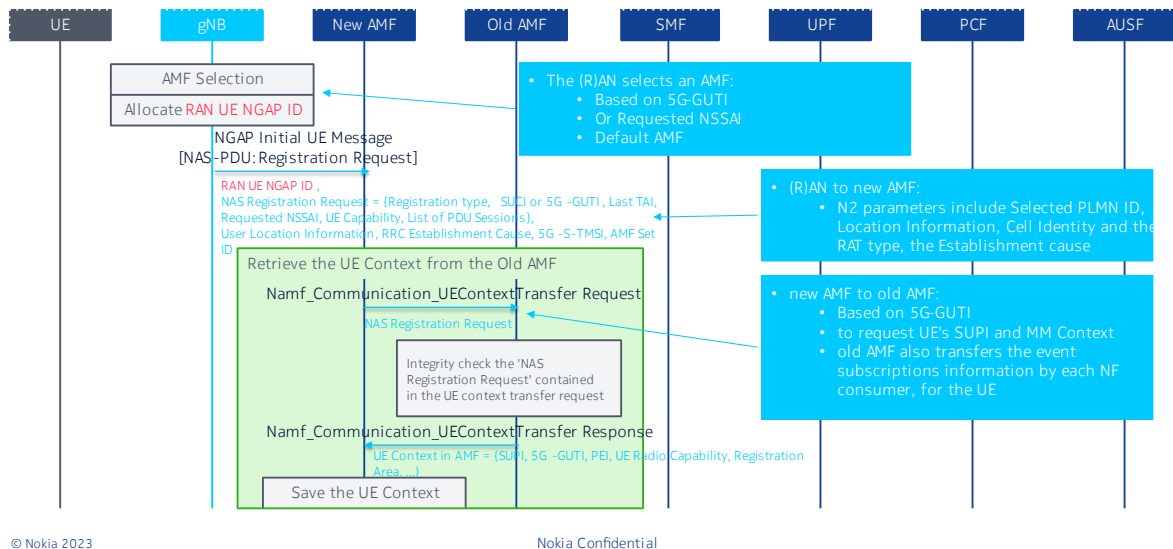


The first NAS message from the UE, piggybacked in RRCSetupComplete, is sent to AMF (from now on SRB1).

When the UE is performing an Initial Registration with a native 5G-GUTI then the UE shall indicate the related GUAMI information in the AN parameters. When the UE is performing an Initial Registration with its SUCI, the UE shall not indicate any GUAMI information in the AN parameters.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow

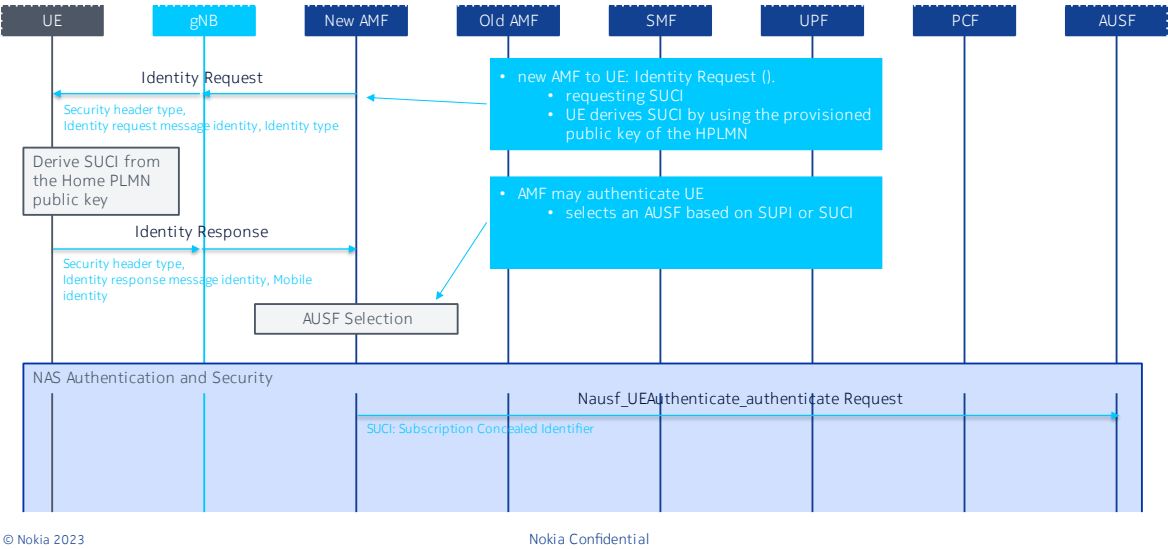


### Registration Request:

- Registration type
- SUCI or 5G-GUTI
- PEI
- last visited TAI (if available) - to help AMF produce Registration Area for the UE
- Security parameters
- Requested NSSAI
- UE MM Core Network Capability
- Follow on request
- MICO mode preference
- Requested DRX parameters
- PDU Session status, List Of PDU Sessions To Be Activated
- The Registration type indicates: an Initial Registration (i.e. the UE is in RM-DEREGISTERED state), a Mobility Registration Update (i.e. the UE is in RM-REGISTERED state and initiates a Registration procedure due to mobility or due to the UE needs to update its capabilities or protocol parameters), a Periodic Registration Update or an Emergency Registration (i.e. the UE is in limited service state).
- The PDU Session status indicates the previously established PDU Sessions in the UE. When the UE is connected to the two AMFs belonging to different PLMN via 3GPP access and non-3GPP access then the PDU Session status indicates the established PDU Session of the current PLMN in the UE.
- The PDU Session(s) to be re-activated is included to indicate the PDU Session(s) for which the UE intends to activate UP connections.
- The Follow on request is included when the UE has pending uplink signaling and the UE doesn't include PDU Session(s) to be re-activated, or the Registration type indicates the UE wants to perform an Emergency Registration.
- In Initial Registration and Mobility Registration Update, UE provides the UE Requested DRX parameters
- The UE MM Core Network Capability is provided and handled by AMF as defined in TS 23.501 clause 5.4.4a.
- The UE access selection and PDU session selection identifies the list of UE access selection and PDU session selection policy information stored in the UE, defined in clause 6.6 of TS 23.503. They are used by the PCF to determine if the UE has to be updated with new PSIs or if some of the stored ones are no longer applicable and have to be removed.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



[Conditional] new AMF to Old AMF: `Namf_Communication_UEContextTransfer`

- Based on 5G-GUTI
- to request UE's SUPI and MM Context
- Old AMF also transfers the event subscriptions information for the UE.

[Conditional] new AMF to UE: Identity Request ().

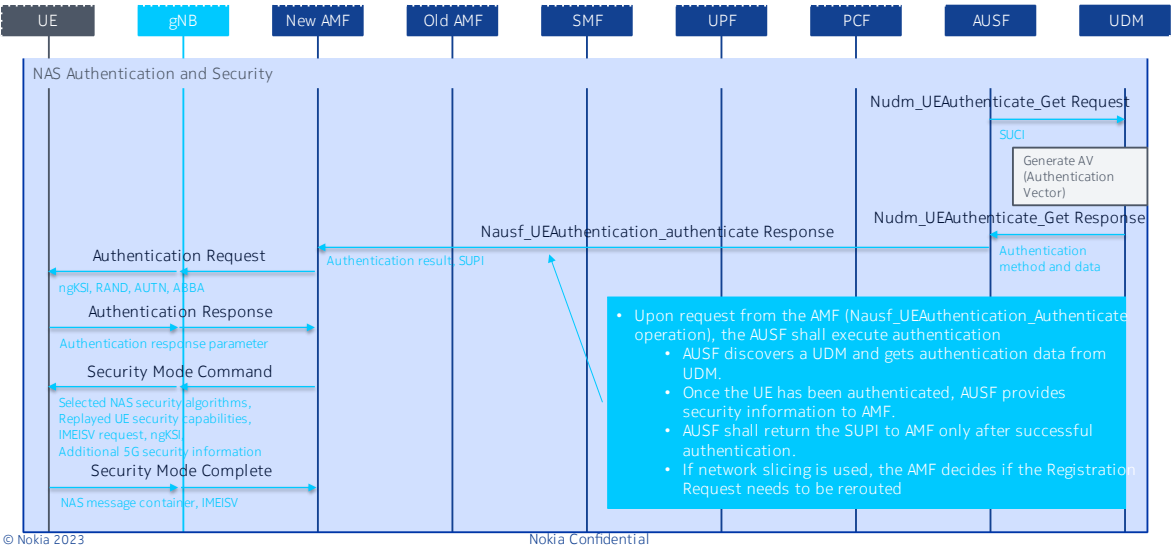
- requesting SUCI
- UE derives SUCI by using the provisioned public key of the HPLMN.

AMF may authenticate UE

- selects an AUSF based on SUPI or SUCI.

# UE Network Acquisition Process

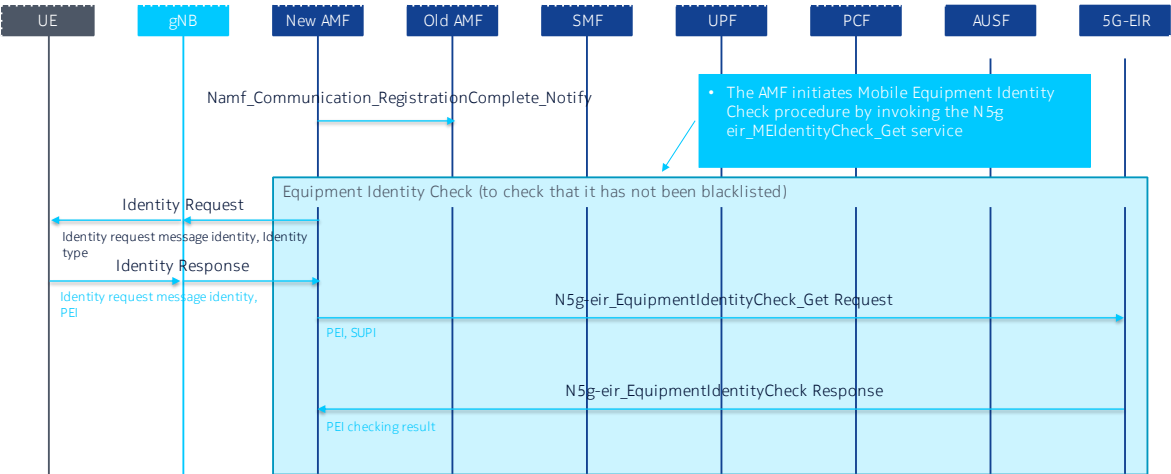
## Registration Procedure - Detailed Signaling Flow



- Upon request from the AMF (Nausf\_UEAuthentication\_authenticate operation), the AUSF shall execute authentication
  - AUSF discovers a UDM and gets authentication data from UDM.
  - Once the UE has been authenticated, AUSF provides security information to AMF.
  - AUSF shall return the SUPI to AMF only after successful authentication.
  - If network slicing is used, the AMF decides if the Registration Request needs to be rerouted.
- NAS security initiation is performed
- Then AMF initiates NGAP procedure to provide 5G-AN with security context.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



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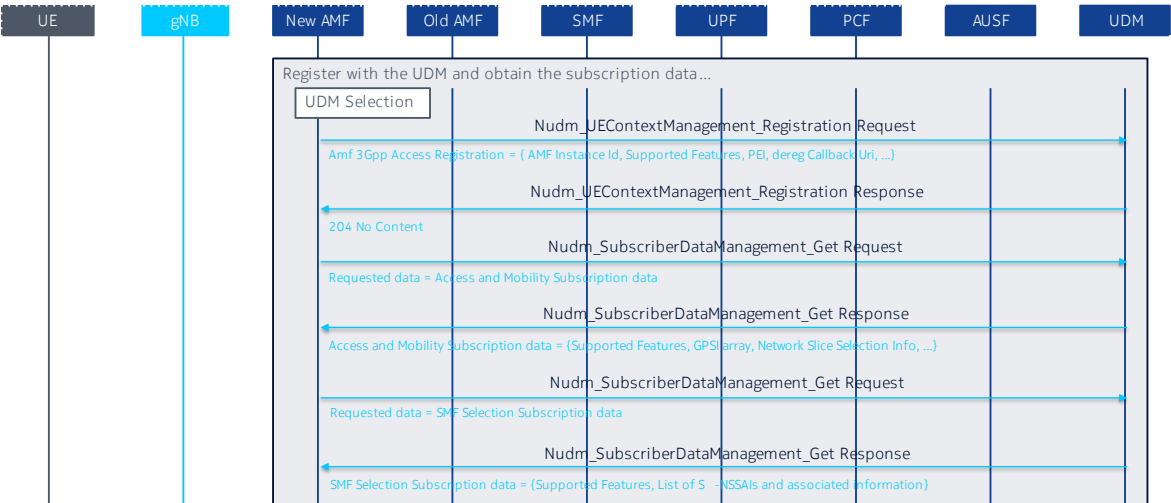
- new AMF to old AMF: Namf\_Communication\_RegistrationCompleteNotify (). registration in the new AMF is completed successfully or rejected
- The AMF initiates Mobile Equipment Identity Check procedure by invoking the N5g-eir\_MEIdentityCheck\_Get service
- new AMF to UE: Identity Request/Response (PEI).

If the PEI was not provided by the UE nor retrieved from the old AMF the Identity Request procedure is initiated by AMF sending an Identity Request message to the UE to retrieve the PEI. The PEI shall be transferred encrypted unless the UE performs Emergency Registration and cannot be authenticated. For an Emergency Registration, the UE may have included the PEI in the Registration Request. If so, the PEI retrieval is skipped.

- Optionally new AMF initiates ME identity check .

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



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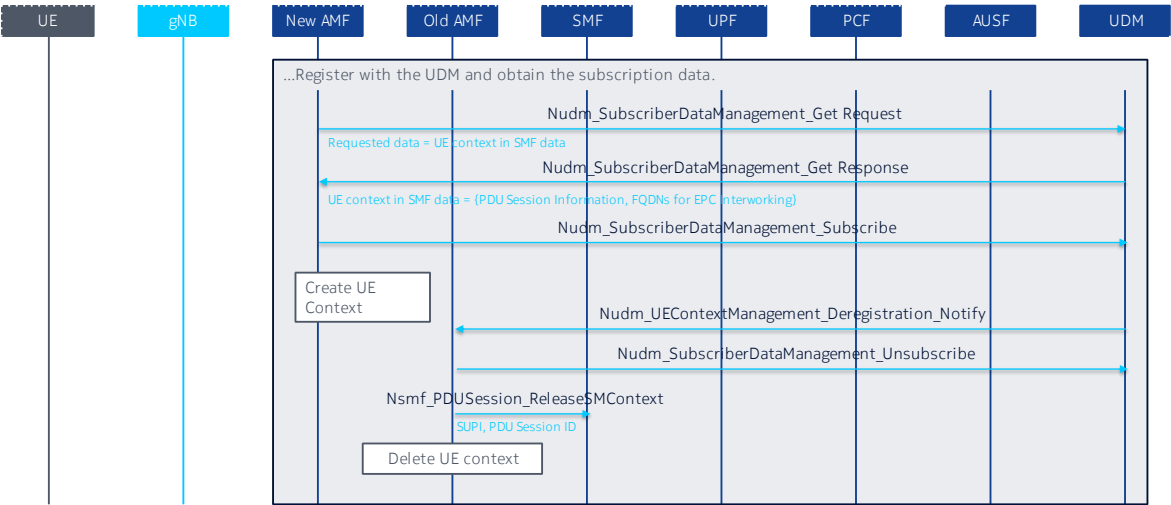
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If the AMF has changed since the last Registration procedure, or if the UE provides a SUPI which doesn't refer to a valid context in the AMF, the new AMF registers with the UDM using Nudm\_UECM\_Registration for the access to be registered and subscribes to be notified when the UDM deregisters this AMF.

- new AMF, based on the SUPI, selects a UDM.
- new AMF registers with UDM
  - using Nudm\_UECM\_Registration to register and subscribes to be notified when UDM deregisters.
  - UDM stores AMF identity associated to the Access Type
  - If the AMF does not have subscription data for the UE, the AMF retrieves the Access and Mobility Subscription data, SMF Selection Subscription data and UE context in SMF data using Nudm\_SDM\_Get
  - AMF subscribes to be notified using Nudm\_SDM\_Subscribe when the data requested is modified.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



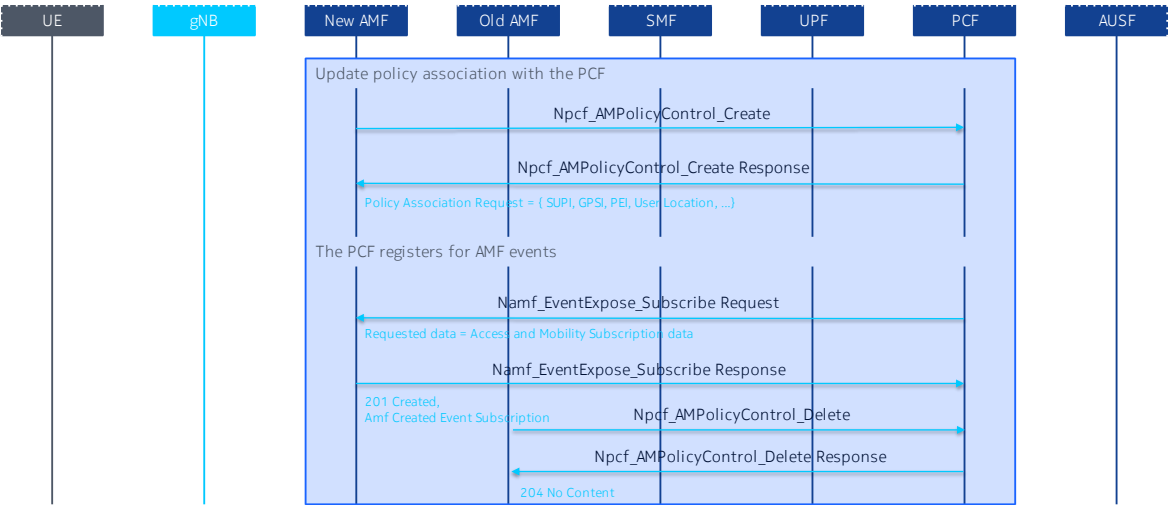
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- new AMF creates an MM context for the UE
- It will cause UDM to initiate a **Nudm\_UECM\_DeregistrationNotification** to old AMF corresponding to the same (e.g. 3GPP) access
- Old AMF unsubscribes with the UDM using **Nudm\_SDM\_unsubscribe**.

# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



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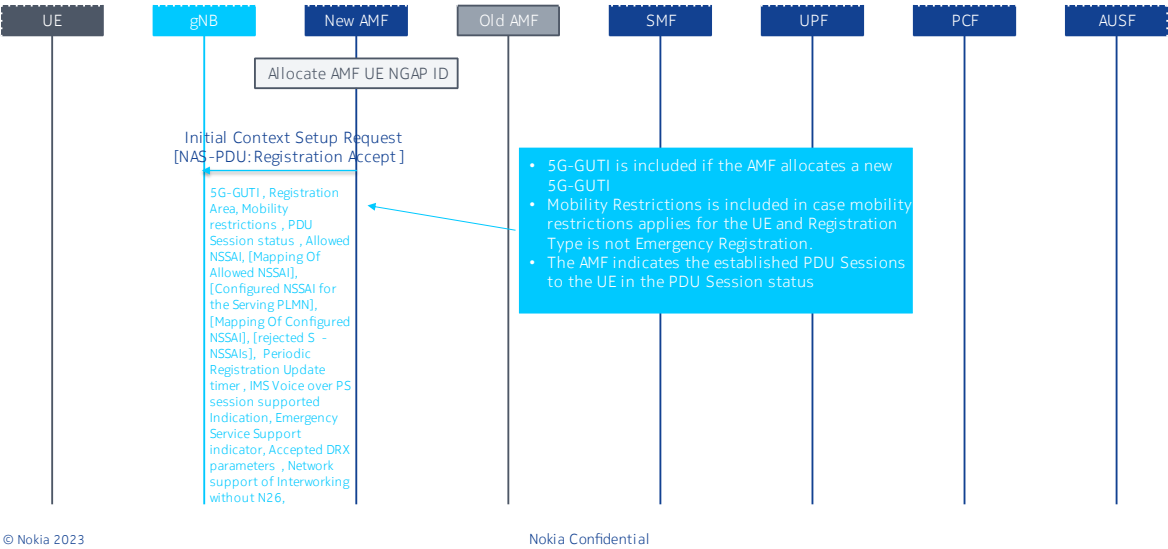
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- AMF may initiate PCF communication
- [Optional] new AMF performs a Policy Association Establishment
  - e.g. Mobility Restrictions.
- PCF may invoke Namf\_EventExposure\_Subscribe service operation for UE event subscription.



# UE Network Acquisition Process

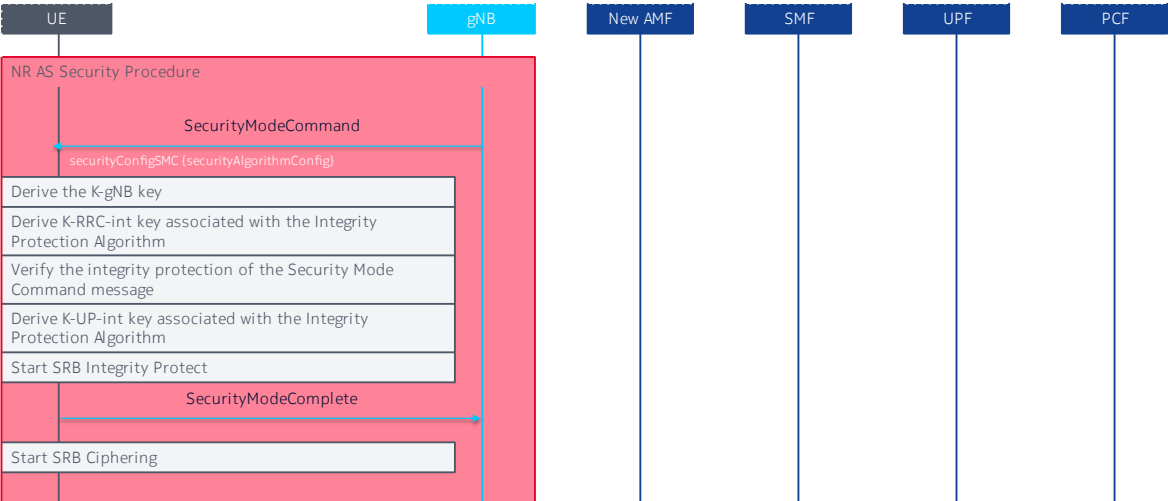
## Registration Procedure - Detailed Signaling Flow



- New AMF to UE: Registration Accept :
  - 5G-GUTI, Registration Area, Mobility restrictions
  - PDU Session status
  - Allowed NSSAI , [Configured NSSAI for the Serving PLMN
  - Periodic Registration Update timer
  - LADN Information
  - accepted MICO mode
  - IMS Voice over PS session supported Indication, Emergency Service Support indicator
  - Accepted DRX parameters
  - Network support of Interworking without N26
  - The Handover Restriction List and UE-AMBR are provided to NG-RAN.

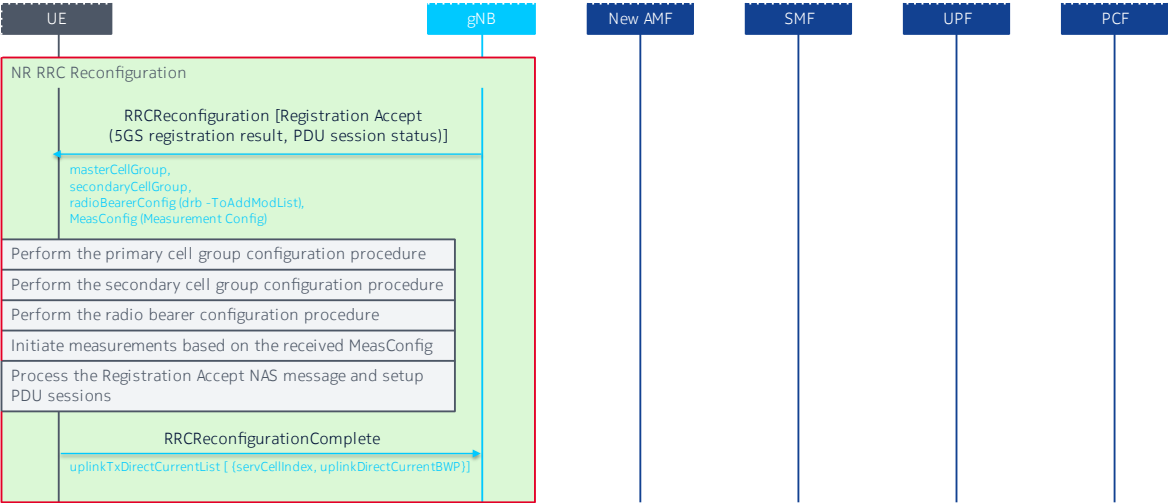
# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



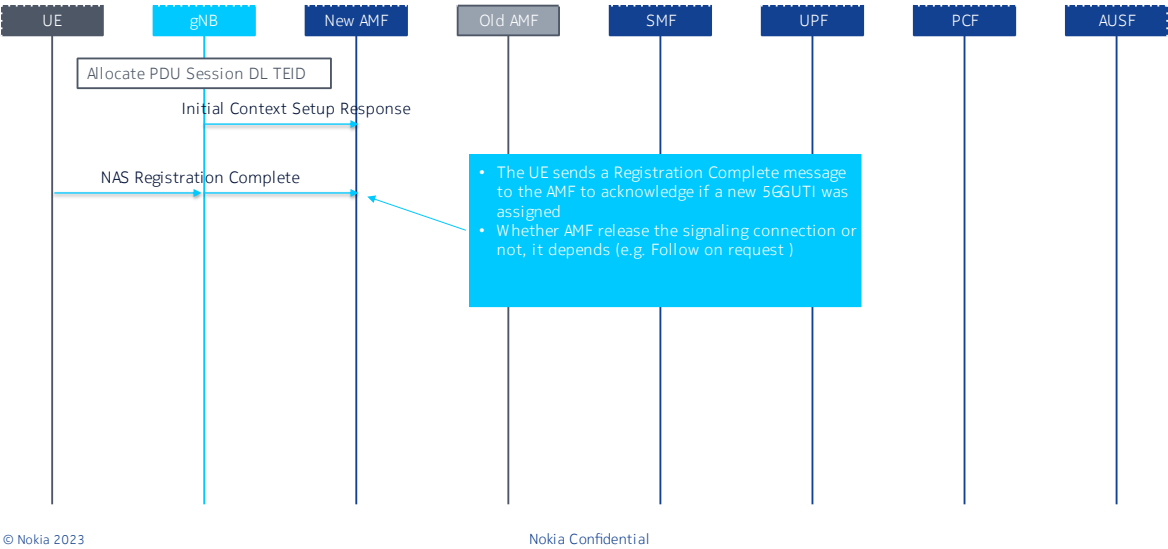
# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



# UE Network Acquisition Process

## Registration Procedure - Detailed Signaling Flow



UE to new AMF: Registration Complete (). to acknowledge if a new 5G-GUTI was assigned.

When the List Of PDU Sessions To Be Activated is not included in the Registration Request and the Registration procedure was not initiated in CM-CONNECTED state, the AMF releases the signaling connection with UE.

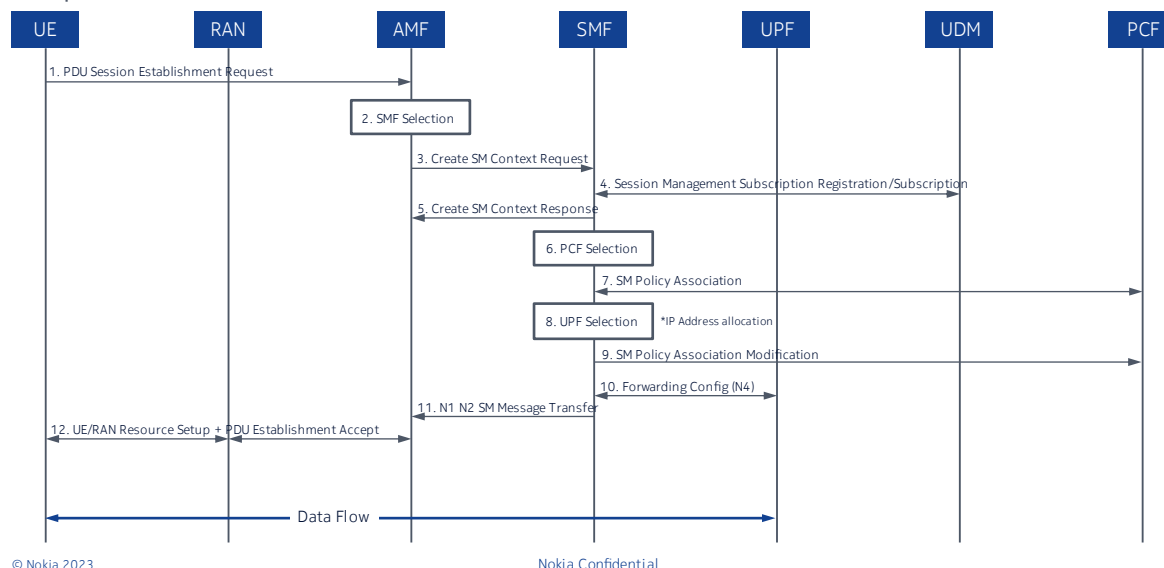
When the Follow-on request is included in the Registration Request, the AMF should not release the signaling connection after the completion of the Registration procedure.

For Registration over 3GPP Access, if the AMF does not release the signaling connection, the AMF sends the RRC Inactive Assistance Information to the NG-RAN.

# PDU Session Establishment

## Typical UE Call Processes

### Simplified PDU Session Establishment Call Flow



This Call flow shows end to end procedures during a PDU session establishment procedure.

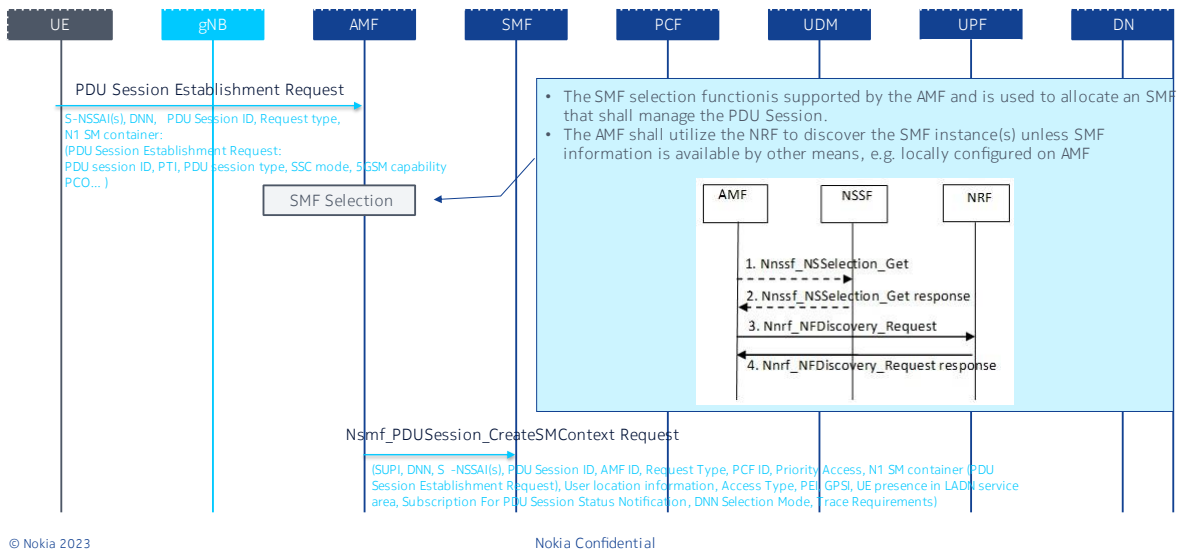
PDU Sessions are established (upon UE request), modified (upon UE and 5GC request) and released (upon UE and 5GC request) using NAS SM signaling exchanged over N1 between the UE and the SMF. Upon request from an Application Server, the 5GC is able to trigger a specific application in the UE. When receiving that trigger message, the UE shall pass it to the identified application in the UE. The identified application in the UE may establish a PDU Session to a specific DNN.

#### PDU Session Establishment:

- a UE initiated PDU Session Establishment procedure.
- a UE initiated PDU Session handover between 3GPP and non-3GPP.
- a UE initiated PDU Session handover from EPS to 5GS.
- a Network triggered PDU Session Establishment procedure:
  - network sends device trigger message to UE
  - The payload in Device Trigger Request message contains information on which application to trigger the PDU Session establishment request.

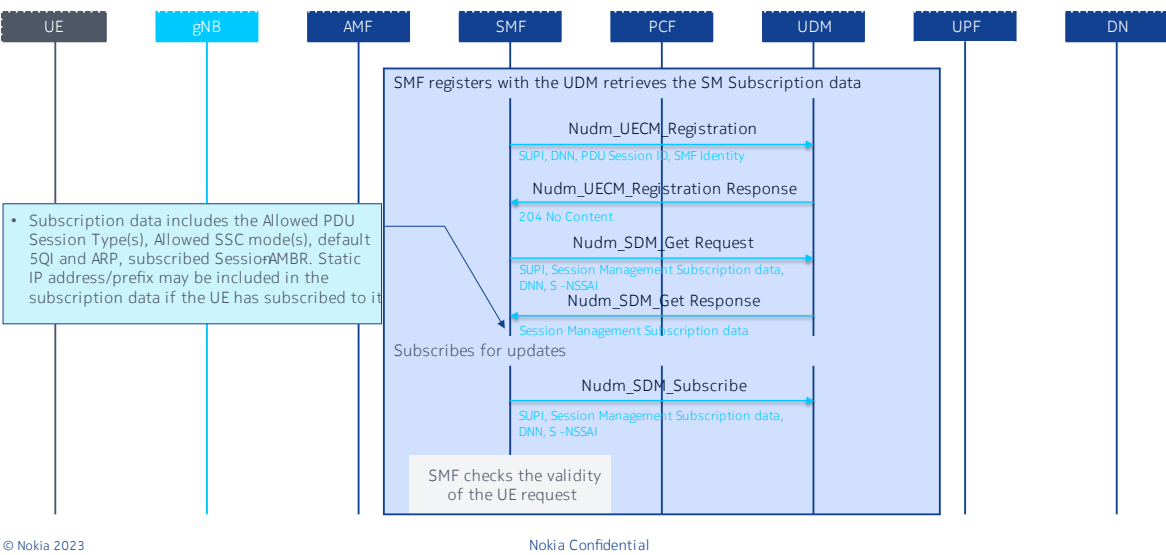
Detailed flow is given in coming slides.

## PDU Session Establishment



- The UE initiates the UE Requested PDU Session Establishment procedure by the transmission of a NAS message containing a PDU Session Establishment Request within the N1 SM container. The PDU Session Establishment Request includes a PDU session ID, Requested PDU Session Type, a Requested SSC mode, 5GSM Capability PCO, SM PDU DN Request Container, Number Of Packet Filters, and optionally Always-on PDU Session Requested.
- The AMF selects an SMF. If the Request Type indicates "Initial request", the AMF stores an association of the S-NSSAI(s), the DNN, the PDU Session ID, the SMF ID as well as the Access Type of the PDU Session.
  - The following factors may be considered during the SMF selection:
    - Selected Data Network Name (DNN).
    - S-NSSAI.
    - NSI-ID.
    - Subscription information from UDM, e.g.
      - per DNN: whether LBO roaming is allowed.
      - per S-NSSAI: the subscribed DNN(s).
      - per (S-NSSAI, subscribed DNN): whether LBO roaming is allowed.
    - per (S-NSSAI, subscribed DNN): whether EPC interworking is supported.
    - Local operator policies.
    - Load conditions of the candidate SMFs.
    - Access technology being used by the UE.
- If the AMF does not have an association with an SMF for the PDU Session ID provided by the UE (e.g. when Request Type indicates "initial request"), the AMF invokes the Nsmf\_PDUSession\_CreateSMContext Request, but if the AMF already has an association with an SMF for the PDU Session ID provided by the UE (e.g. when Request Type indicates "existing PDU Session"), the AMF invokes the Nsmf\_PDUSession\_UpdateSMContext Request. The AMF ID is the UE's GUAMI which uniquely identifies the AMF serving the UE. The AMF forwards the PDU Session ID together with the N1 SM container containing the PDU Session Establishment Request received from the UE. The GPSI shall be included if available at AMF.

# PDU Session Establishment



- If Session Management Subscription data for corresponding SUPI, DNN and S-NSSAI is not available, then SMF retrieves the Session Management Subscription data using Nudm\_SDM\_Get (SUPI, Session Management Subscription data, DNN, S-NSSAI) and subscribes to be notified when this subscription data is modified using Nudm\_SDM\_Subscribe (SUPI, Session Management Subscription data, DNN, S-NSSAI). Subscription data includes the Allowed PDU Session Type(s), Allowed SSC mode(s), default 5QI and ARP, subscribed Session-AMBR. Static IP address/prefix may be included in the subscription data if the UE has subscribed to it.

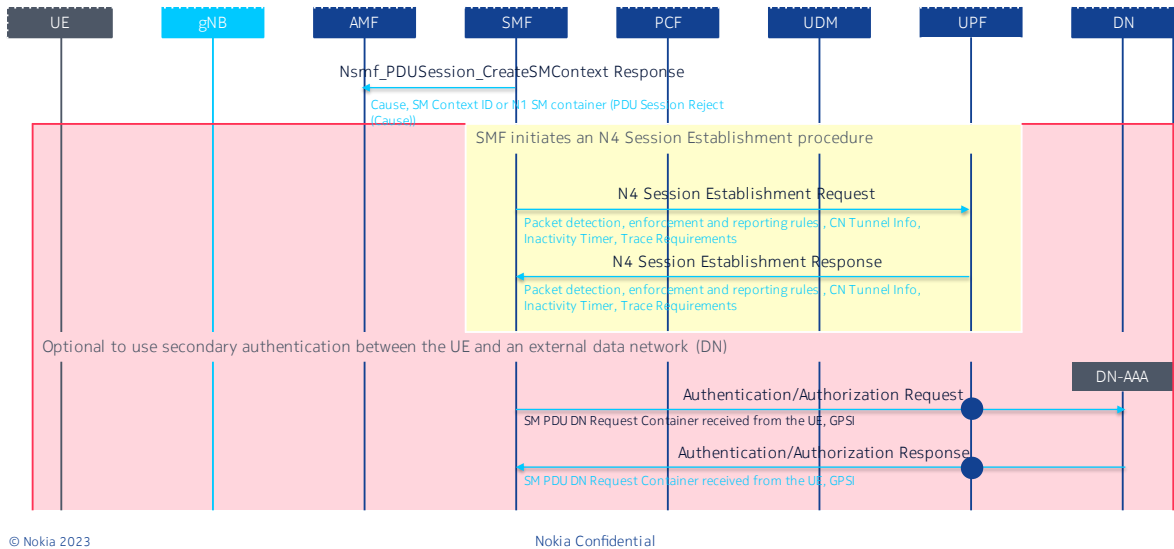
The SMF checks the validity of the UE request: it checks

- Whether the UE request is compliant with the user subscription and with local policies;
- If the DNN corresponds to an LADN, whether the UE is located within the LADN service area based on the "UE presence in LADN service area" indication from the AMF. If the AMF does not provide the "UE presence in LADN service area" indication and the SMF determines that the DNN corresponds to a LADN, then the SMF considers that the UE is OUT of the LADN service area.

If the UE request is considered as not valid, the SMF decides to not accept to establish the PDU Session.



## PDU Session Establishment



- From SMF to AMF: Either Nsmf\_PDUSession\_CreateSMContext Response (Cause, SM Context ID or N1 SM container (PDU Session Reject (Cause))) or an Nsmf\_PDUSession\_UpdateSMContext Response depending on the request received in step 3.

When the SMF decides to not accept to establish a PDU Session, the SMF rejects the UE request via NAS SM signaling including a relevant SM rejection cause by responding to the AMF with Nsmf\_PDUSession\_CreateSMContext Response. The SMF also indicates to the AMF that the PDU Session ID is to be considered as released, the SMF proceeds to step 20 and the PDU Session Establishment procedure is stopped.

The SMF determines that it needs to contact the DN-AAA server. The SMF identifies the DN-AAA server based on local configuration, possibly using the SM PDU DN Request Container provided by the UE in its NAS request

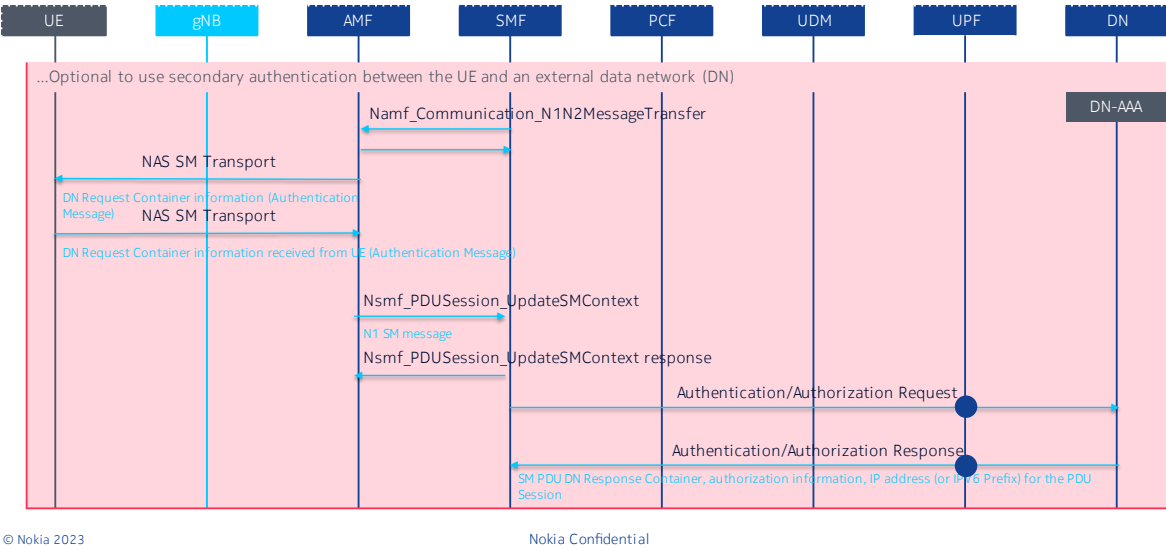
- SMF initiates an N4 Session Establishment procedure: If there is no existing N4 session that can be used to carry DN-related messages between the SMF and the DN, the SMF selects a UPF and triggers N4 session establishment.

Selection of an UPF for a particular PDU Session;

The following parameter(s) and information may be considered by the SMF for UPF selection and re-selection:

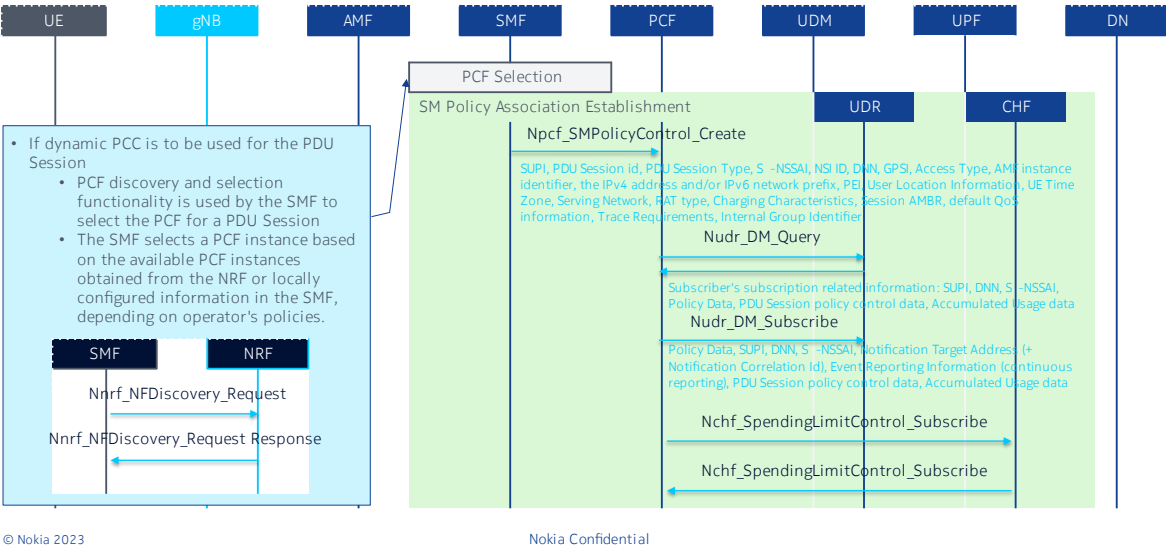
- UPF's dynamic load.
- UPF's relative static capacity among UPFs supporting the same DNN.
- UPF location available at the SMF.
- UE location information.
- Capability of the UPF and the functionality required for the particular UE session: An appropriate UPF can be selected by matching the functionality and features required for an UE.
- Data Network Name (DNN).
- PDU Session Type (i.e. IPv4, IPv6, IPv4v6, Ethernet Type or Unstructured Type) and if applicable, the static IP address/prefix.
- SSC mode selected for the PDU Session.
- UE subscription profile in UDM.
- DNAI as included in the PCC Rules
- Local operator policies.
- S-NSSAI.
- Access technology being used by the UE.
- Information related to user plane topology and user plane terminations, that may be deduced from:
  - AN-provided identities (e.g. CellID, TAI), available UPF(s) and DNAI(s);
- Information regarding the user plane interfaces of UPF(s). This information may be acquired by the SMF using N4;
- Information regarding the N3 User Plane termination(s) of the AN serving the UE. This may be deduced from AN-provided identities (e.g. CellID, TAI);
- Information regarding the N9 User Plane termination(s) of UPF(s) if needed;
- Information regarding the User plane termination(s) corresponding to DNAI(s).
- Optional Secondary authorization/authentication (by a DN-AAA server).

# PDU Session Establishment



Optional Secondary authorization/authentication (by a DN-AAA server).

# PDU Session Establishment



SMF retrieves SMF level subscription data from UDM, and subscribe to receive update notifications per DNN and S-NSSAI:

- allowed PDU Session Types and default value.
- allowed SSC modes and default value.
- QoS Information : subscribed Session-AMBR, Default 5QI and Default ARP.
- static IP address/prefix.
- subscribed User Plane Security Policy.
- Charging Characteristics

The SMF may utilize the NRF to discover the candidate PCF instance(s) for a PDU Session. In addition, PCF information may also be locally configured in the SMF. The SMF selects a PCF instance based on the available PCF instances obtained from the NRF or locally configured information in the SMF, depending on operator's policies.

The following factors may be considered during the PCF selection by the SMF:

- Local operator policies.
- Selected Data Network Name (DNN).
- S-NSSAI of the PDU Session.
- SUPI range.

To enable the enforcement in the 5GC of the policy decisions made by the PCF for the policy and charging control of a service data flow, the 5GC shall provide 5G Policy and Charging Control information from the PCF to the SMF.

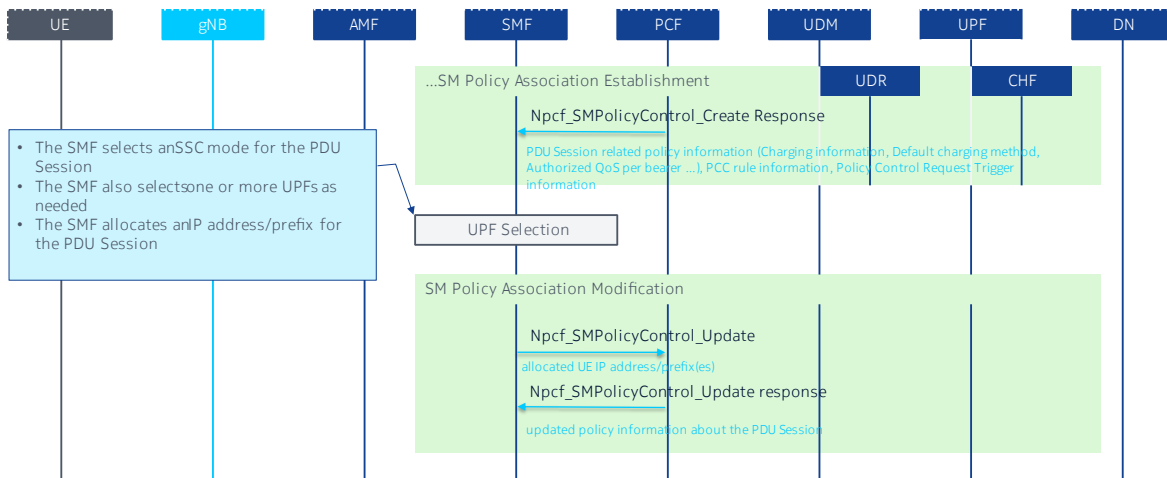
Two different types of PCC rules exist: Dynamic rules and predefined rules. The dynamic PCC rules are provisioned by the PCF to the SMF, while the predefined PCC rules are configured into the SMF, and only referenced by the PCF.

## PDU Session ID

Assigned by UE:

- to uniquely identify an UE's PDU Sessions
- A UE's multiple PDU Sessions may be served by different SMF.
- SMF registered and deregistered per PDU Session in UDM
- DNN+S-NSSAI.

## PDU Session Establishment



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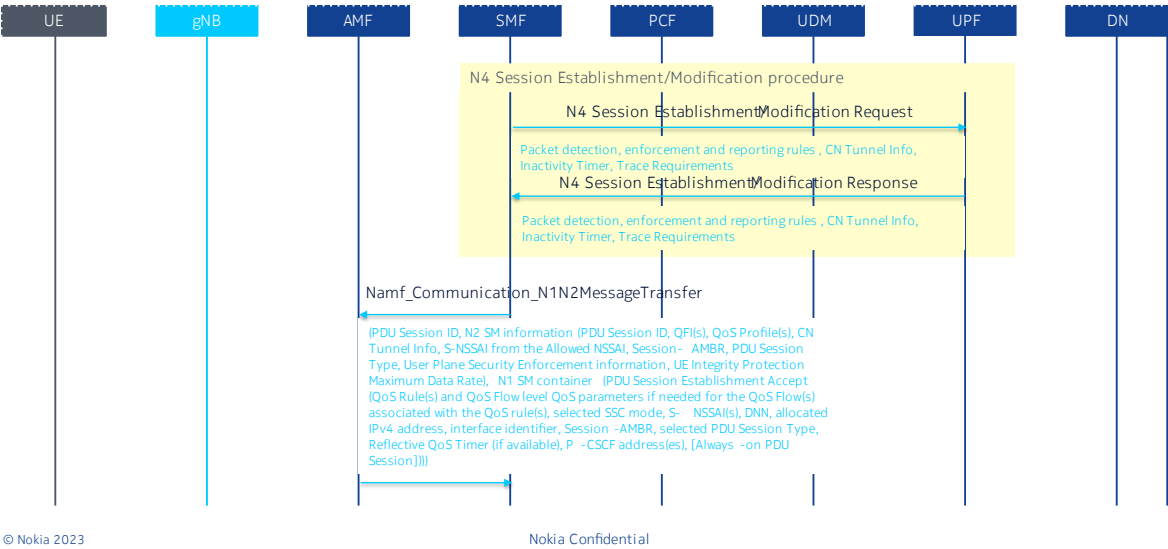
SSC mode selection is done by the SMF based on the allowed SSC modes (including the default SSC mode) in the user subscription as well as the PDU Session type and if present, the SSC mode requested by the UE.

The selection and reselection of the UPF are performed by the SMF by considering UPF deployment scenarios such as centrally located UPF and distributed UPF located close to or at the Access Network site. The selection of the UPF shall also enable deployment of UPF with different capabilities, e.g. UPFs supporting no or a subset of optional functionalities.

The following parameter(s) and information may be considered by the SMF for UPF selection and re-selection:

- UPF's dynamic load.
- UPF's relative static capacity among UPFs supporting the same DNN.
- UPF location available at the SMF.
- UE location information.
- Capability of the UPF and the functionality required for the particular UE session: An appropriate UPF can be selected by matching the functionality and features required for an UE.
- Data Network Name (DNN).
- PDU Session Type (i.e. IPv4, IPv6, IPv4v6, Ethernet Type or Unstructured Type) and if applicable, the static IP address/prefix.
- SSC mode selected for the PDU Session.
- UE subscription profile in UDM.
- DNAI as included in the PCC Rules
- Local operator policies.
- S-NSSAI.
- Access technology being used by the UE.
- Information related to user plane topology and user plane terminations, that may be deduced from:
  - AN-provided identities (e.g. CellID, TAI), available UPF(s) and DNAI(s);
- Information regarding the user plane interfaces of UPF(s). This information may be acquired by the SMF using N4;
- Information regarding the N3 User Plane termination(s) of the AN serving the UE. This may be deduced from AN-provided identities (e.g. CellID, TAI);
- Information regarding the N9 User Plane termination(s) of UPF(s) if needed;
- Information regarding the User plane termination(s) corresponding to DNAI(s).

# PDU Session Establishment



The SMF initiates an N4 Session Establishment procedure with the selected UPF.

If Request Type indicates "initial request", the SMF initiates an N4 Session Establishment procedure with the selected UPF, otherwise it initiates an N4 Session Modification procedure with the selected UPF  
if multiple UPFs are selected for the PDU Session, the SMF initiate N4 Session Establishment/Modification procedure with each UPF of the PDU Session.

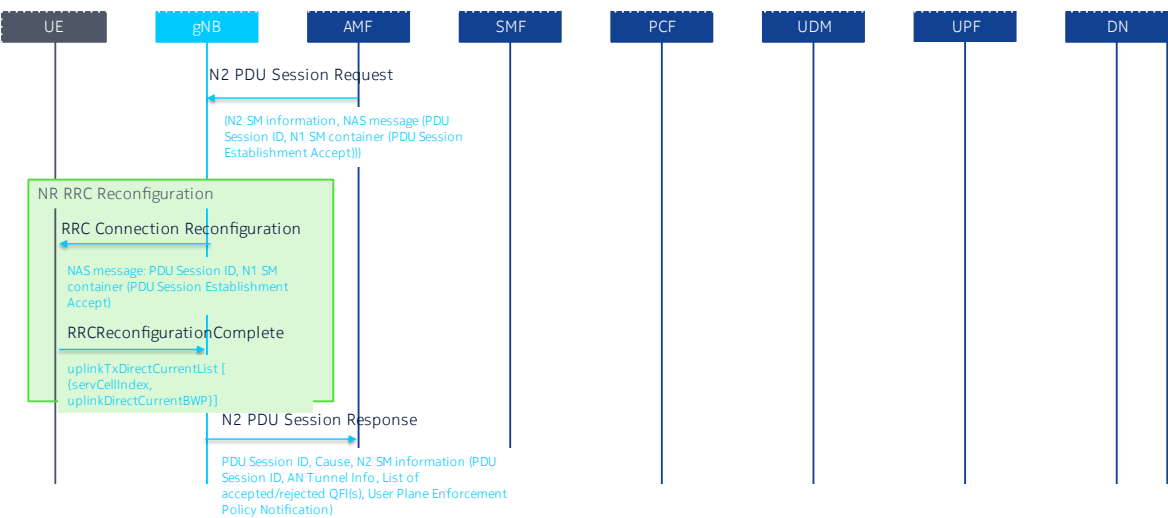
In case of PDU Type IPv6 or IPv4v6, the SMF also allocates an interface identifier to the UE for the UE to build its link-local address.  
For Unstructured PDU Type the SMF may allocate an IPv6 prefix for the PDU Session and N6 point-to-point tunneling (based on UDP/IPv6). For Ethernet PDU type PDU Session, neither a MAC nor an IP address is allocated by the SMF to the UE for this PDU Session.  
If the Request Type was "Existing PDU Session", the SMF maintains the same IP address/prefix that has already been allocated to the UE in the source network.

- The N2 SM information carries information that the AMF shall forward to the (R)AN which includes:
- The CN Tunnel Info corresponds to the Core Network address of the N3 tunnel corresponding to the PDU Session.
  - One or multiple QoS profiles and the corresponding QFIs can be provided to the (R)AN.
  - The PDU Session ID may be used by AN signaling with the UE to indicate to the UE the association between (R)AN resources and a PDU Session for the UE.
  - A PDU Session is associated to an S-NSSAI and a DNN. The S-NSSAI provided to the (R)AN, is the S-NSSAI with the value for the serving PLMN.
  - User Plane Policy Enforcement information is determined by the SMF.

The N1 SM container contains the PDU Session Establishment Accept that the AMF shall provide to the UE. If the UE requested P-CSCF discovery then the message shall also include the P-CSCF IP address(es) as determined by the SMF. The PDU Session Establishment Accept includes S-NSSAI from the Allowed NSSAI.

Multiple QoS Rules and QoS Profiles may be included in the PDU Session Establishment Accept within the N1 SM and in the N2 SM information.  
The Namf\_Communication\_N1N2MessageTransfer further contains the PDU Session ID and information allowing the AMF to know which access towards the UE to use.

# PDU Session Establishment



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AMF to gNB: N2 PDU Session Request: The AMF sends the NAS message containing PDU Session ID and PDU Session Establishment Accept targeted to the UE and the N2 SM information received from the SMF within the N2 PDU Session Request to the (R)AN.

RRC Connection Reconfiguration may take place with the UE establishing the necessary NG-RAN resources related to the QoS Rules for the PDU Session request received.

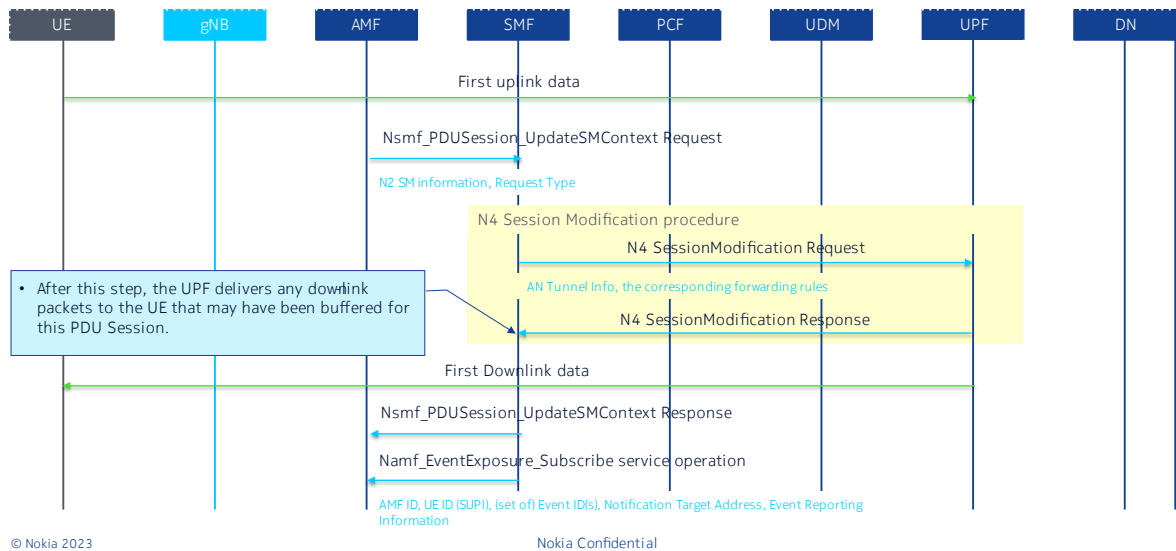
(R)AN shall only provide the NAS message to the UE if the necessary (R)AN resources are established and the allocation of (R)AN Tunnel Info are successful.

The NG-RAN rejects the establishment of UP resources for the PDU Session when it cannot fulfill User Plane Security Enforcement information with a value of Required. In this case the SMF releases the PDU session. The NG-RAN notifies the SMF when it cannot fulfill a User Plane Security Enforcement with a value of Preferred.

gNB to AMF: N2 PDU Session Response (PDU Session ID, Cause, N2 SM information (PDU Session ID, AN Tunnel Info, List of accepted/rejected QFI(s), User Plane Enforcement Policy Notification)).

The AN Tunnel Info corresponds to the Access Network address of the N3 tunnel corresponding to the PDU Session.

## PDU Session Establishment



AMF to SMF: Nsmf\_PDUSession\_UpdateSMContext Request (N2 SM information, Request Type).

The SMF initiates an N4 Session Modification procedure with the UPF. The SMF provides AN Tunnel Info to the UPF as well as the corresponding forwarding rules.

After this step, the UPF delivers any down-link packets to the UE.

The SMF may subscribe to the UE mobility event notification from the AMF (e.g. location reporting, UE moving into or out of Area Of Interest).

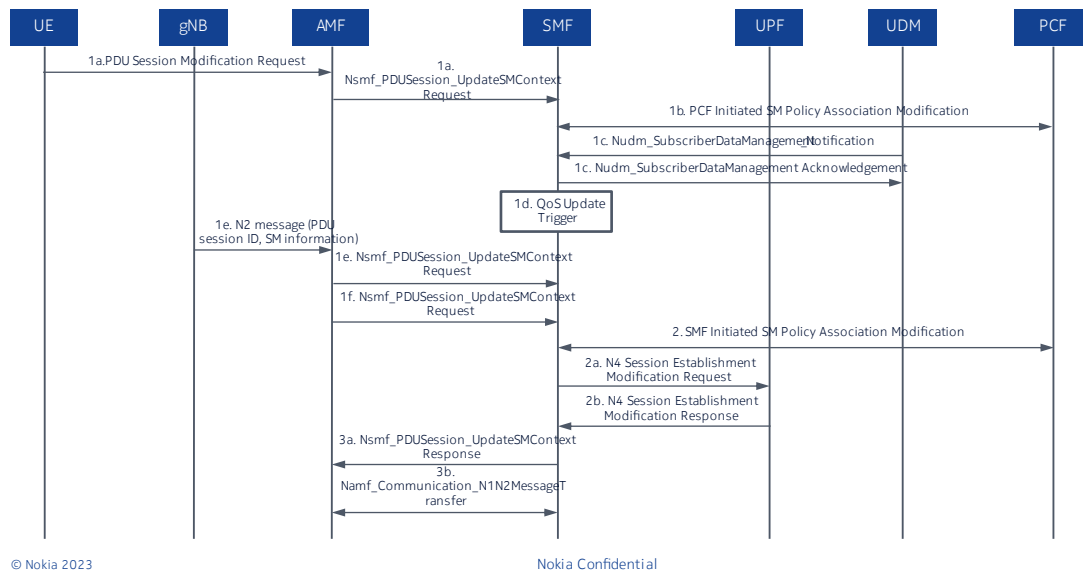
Following UE access and mobility information event are considered :

- Location changes (TAI, Cell ID, N3IWF node, UE local IP address and optionally UDP source port number, Area Of Interest);
- UE moving in or out of a subscribed "Area Of Interest"
- Time zone changes (UE Time zone);
- Access Type changes (3GPP access or non-3GPP access);
- Registration state changes (Registered or Deregistered);
- Connectivity state changes (IDLE or CONNECTED);
- UE loss of communication;
- UE reachability status;
- UE indication of switching off SMS over NAS service;
- Subscription Correlation ID change (implicit subscription); and
- Subscription Correlation ID addition (implicit subscription).

# PDU Session Modification



# PDU Session Modification



The procedure may be started by different events and instances:

1a. The UE initiates the PDU Session Modification procedure by the transmission of an NAS message towards the AMF and depending on the Access Type, if the UE was in CM-IDLE state, this SM-NAS message is preceded by the Service Request procedure. The NAS message is forwarded by the gNB to the AMF with an indication of User location Information and the AMF invokes Nsmf\_PDUSession\_UpdateSMContext.

1b. The PCF performs a PCF initiated SM Policy Association Modification procedure to notify SMF about the modification of policies. This may have been triggered by a policy decision or upon any other Network Function requests. If the QoS Monitoring for URLLC is requested by the NF, the PCF generates the QoS Monitoring policy for the corresponding service data flow and provides the policy in the Policy and Changing Control rules to the SMF.

1c. The UDM updates the subscription data of SMF by Nudm\_SDM\_Notification (SUPI, Session Management Subscription Data).

1c. The SMF updates the Session Management Subscription Data and acknowledges the UDM by returning an Ack with SUPI.

1d. The SMF may decide to modify PDU Session. This procedure also may be triggered based on locally configured policy or triggered from the gNB. It may also be triggered if the UP connection is activated and the SMF has marked that the status of one or more QoS Flows are deleted in the 5GC but not synchronized with the UE yet. If the SMF receives one of the triggers in step 1b..1d, the SMF starts SMF requested PDU Session Modification procedure.

1e. The gNB indicates the SMF when the Access Network resources onto which a QoS Flow is mapped are released regardless of whether notification control is configured. gNB sends the NAS Uplink message to the AMF. The N2 SM information includes the QFI, User location Information and an indication that the QoS Flow has been released. The AMF invokes Nsmf\_PDUSession\_UpdateSMContext.

If notification control is configured for a GBR QoS Flow, the gNB sends a N2 message to the SMF, when the gNB decides the QoS targets of the QoS Flow cannot be fulfilled or can be fulfilled again, respectively. The N2 SM information includes the QFI and an indication that the QoS targets for that QoS Flow cannot be fulfilled or can be fulfilled again, respectively. When QoS targets cannot be fulfilled, the N2 SM information indicates a reference to the Alternative QoS Profile matching the values of the QoS parameters that the NG-RAN is currently fulfilling. The AMF invokes Nsmf\_PDUSession\_UpdateSMContext. If the PCF has subscribed to the event, SMF reports this event to the PCF for each PCC Rule.

1f. If the UE supports CE mode B and use of CE mode changes from restricted to unrestricted or vice versa in the Enhanced Coverage Restriction information in the UE context in the AMF and the UE has already established PDU sessions, then the AMF shall trigger a PDU session modification to the SMFs serving the UE's PDU sessions when the AMF determines that NAS-SM timer shall be updated due to the change of Enhanced Coverage Restriction and include the extended NAS-SM indication only if use of CE mode B is now unrestricted in the Enhanced Coverage Restriction information in the UE context in the AMF.

2. The SMF may need to report some subscribed event to the PCF by performing an SMF initiated SM Policy Association Modification procedure. This does not apply if the PDU Session Modification procedure is triggered by step 1b or 1d. If dynamic PCC is not deployed, the SMF may apply local policy to decide whether to change the QoS profile. Steps 2a to 7 may not be required when the PDU Session Modification requires only action at a UPF, according to TS 24.501 (4.16.5.1).

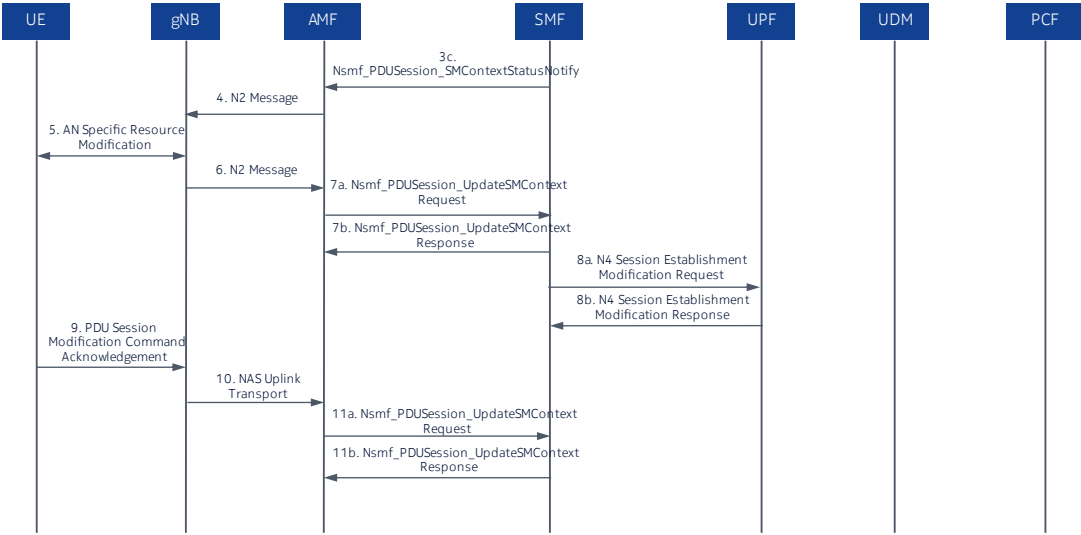
2a. The SMF may update the UPF with N4 Rules related to new or modified QoS Flow(s).

2b. The UPF respond to the SMF. If redundant transmission has not been activated to the PDU session and the SMF indicated the UPF to perform packet duplication and elimination for the QoS Flow in the previous step, the UPF then allocates an additional CN Tunnel Info.

3a. For UE or AN initiated modification, the SMF responds to the AMF through Nsmf\_PDUSession\_UpdateSMContext Response. If the PDU Session Modification was requested by the UE to modify a PDU Session to an always-on PDU Session, the SMF shall include an Always-on PDU Session Granted indication in the PDU Session Modification Command to indicate whether the PDU Session is to be changed to an always-on PDU Session in the PDU Session Modification Command.

3b. For SMF requested modification, the SMF invokes Namf\_Communication\_N1N2MessageTransfer. The SMF may indicate for each QoS Flow whether redundant transmission shall be performed by a corresponding redundant transmission indicator. If the SMF decides to activate redundant transmission in step 2a, the SMF includes the allocated additional CN Tunnel Info in the N2 SM information. If the SMF decides to perform redundant transmission for new QoS Flow with two I-UPFs in step 2a, the SMF includes the allocated CN Tunnel Info of the two I-UPFs in the N2 SM information.

# PDU Session Modification

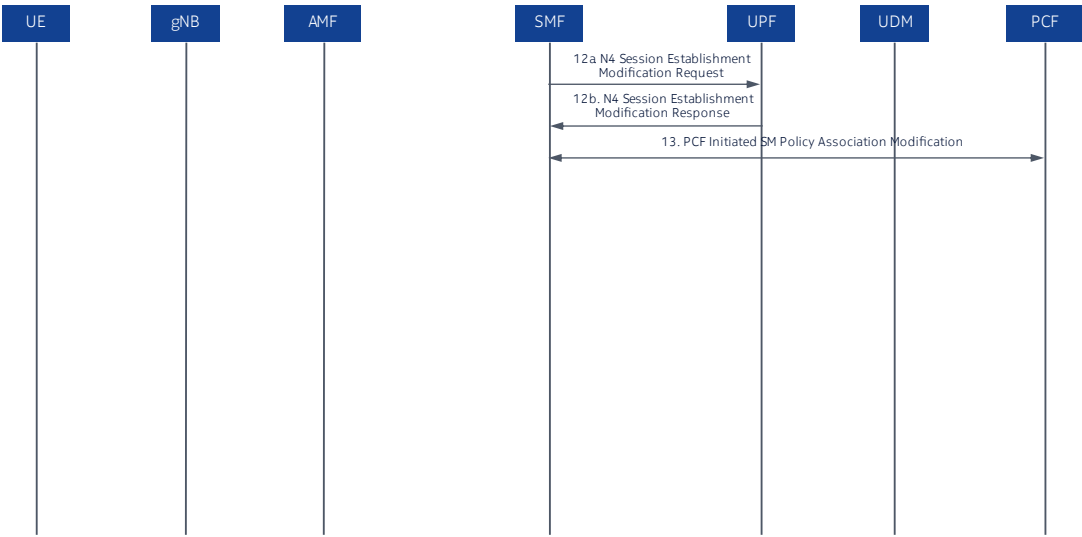


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- 3c. For SMF requested modification due to updated SMF-Associated parameters from the UDM, the SMF may provide the SMF derived CN assisted RAN parameters tuning to the AMF. The SMF invokes Nsmf\_PDUSession\_SMContextStatusNotify towards the AMF. The AMF stores the SMF derived CN assisted RAN parameters tuning in the associated PDU Session context for this UE.
4. The AMF may send N2 NAS message to the gNB.
5. The gNB may issue AN specific signaling exchange with the UE that is related with the information received from SMF. For example, in the case of a NG-RAN, an RRC Connection Reconfiguration may take place with the UE modifying the necessary (R)AN resources related to the PDU Session or if only N1 SM container is received in step 4 from AMF, RAN transports only the N1 SM container to the UE.
6. The gNB may acknowledge N2 PDU Session Request by sending a N2 PDU Session Ack message to the AMF. In the case of DC, if one or more QFIs are added to the PDU Session, the Master RAN node may assign one or more of these QFIs to a NG-RAN node which was not involved in the PDU Session earlier. In this case the AN Tunnel Info includes a new N3 tunnel endpoint for QFIs assigned to the new NG-RAN node.
- 7a. The AMF forwards the N2 SM information and the User location Information received from the gNB to the SMF via Nsmf\_PDUSession\_UpdateSMContext service operation.
- 7b. The SMF replies with a Nsmf\_PDUSession\_UpdateSMContext Response.
8. The SMF may update N4 session of the involved UPF by the PDU Session Modification by sending N4 Session Modification Request message to the UPF.
9. The UE acknowledges the PDU Session Modification Command by sending a NAS message.
10. The gNB forwards the NAS message to the AMF.
- 11a. The AMF forwards the PDU Session Modification Command Ack and User Location Information received from the gNB to the SMF using the Nsmf\_PDUSession\_UpdateSMContext message.
- 11b. The SMF replies with a Nsmf\_PDUSession\_UpdateSMContext Response.

# PDU Session Modification



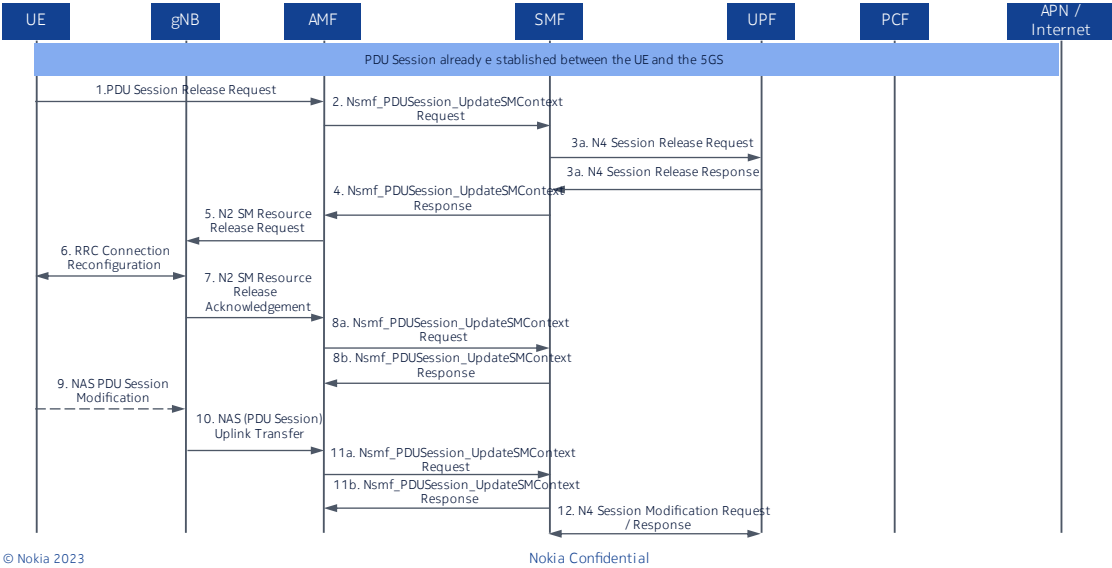
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- 12a. The SMF may update N4 session of the involved UPF by the PDU Session Modification, this is done by sending a N4 Session Modification Request message to the UPF.
- 12b. The UPF provides an acknowledgment response using a N4 Session Establishment Modification.
13. According to TS 23.502 and based on the initial scenario (step 1), if the SMF interacted with the PCF, the SMF notifies the PCF whether the PCC decision could be enforced or not by performing an SMF initiated SM Policy Association Modification procedure.

# PDU Session Release

# PDU Session Release

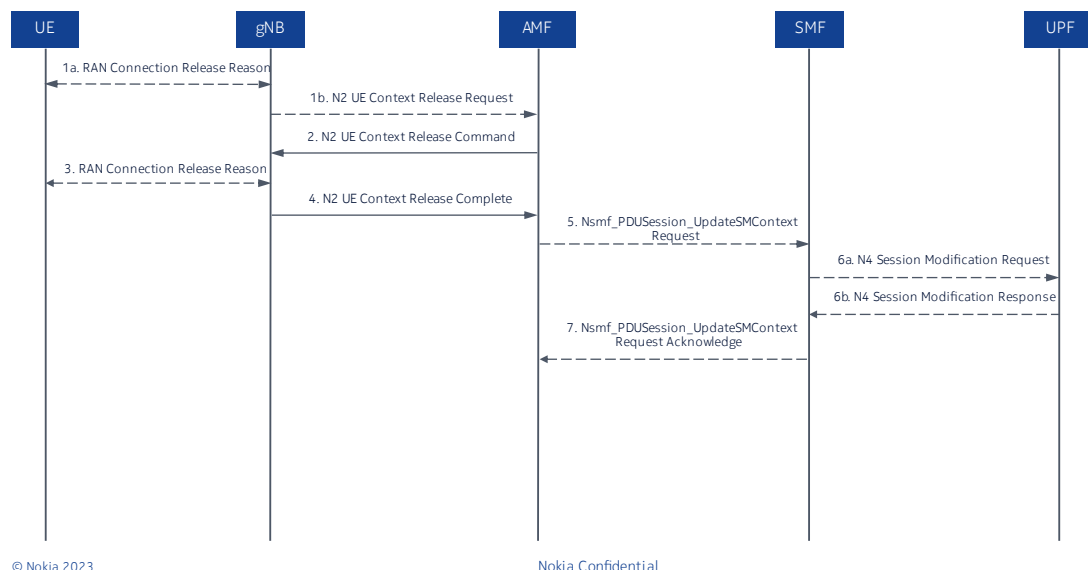


This signaling flow shows UE Requested PDU Session Release procedure. The procedure also allows the AMF, the SMF or the PCF to initiate the release of a PDU Session: For network requested PDU Session Release procedure, please refer to TS.23502.

1. The UE initiates the UE Requested PDU Session Release procedure by the transmission of an NAS message (N1 SM container (PDU Session Release Request (PDU session ID)), PDU Session ID) message.
2. The AMF invokes the Nsmf\_PDUSession\_UpdateSMContext service operation and provides the N1 SM container to the SMF together with User Location Information (ULI) received from the (R)AN
3. The SMF releases the IP address / Prefix(es) that were allocated to the PDU Session and releases the corresponding User Plane resources
4. The SMF responds to the AMF with the Nsmf\_PDUSession\_UpdateSMContext response (N2 SM Resource Release request, N1 SM container (PDU Session Release Command))
5. If the UE is in CM-CONNECTED state, then the AMF transfers the SM information received from the SMF in step 4 (N2 SM Resource Release request, N1 SM container) to the (R)AN.
6. RRC Connection Reconfiguration may take place with the UE releasing the NG-RAN resources related to the PDU Session. During this procedure, the gNB sends any NAS message (N1 SM container (PDU Session Release Command)) received from the AMF
7. gNB acknowledges the N2 SM Resource Release Request by sending an N2 SM Resource Release Ack (User Location Information, Secondary RAT usage data) Message to the AMF.
8. (a) The AMF invokes the Nsmf\_PDUSession\_UpdateSMContext (N2 SM Resource Release Ack (Secondary RAT usage data), User Location Information) to the SMF. (b) The SMF responds to the AMF with an Nsmf\_PDUSession\_UpdateSMContext response.
9. The UE acknowledges the PDU Session Release Command by sending a NAS message (PDU Session ID, N1 SM container (PDU Session Release Ack)) message over the (R)AN.
10. The gNB forwards the NAS message from the UE by sending a N2 NAS uplink transport (NAS message (PDU Session ID, N1 SM container (PDU Session Release Ack)), User Location Information) to the AMF.
11. (a) The AMF invokes the Nsmf\_PDUSession\_UpdateSMContext (N1 SM container (PDU Session Release Ack, User Location Information) to the SMF. (b)The SMF responds to the AMF with an Nsmf\_PDUSession\_UpdateSMContext response
12. The SMF may update N4 session of the UPF(s) involved in the PDU Session Modification by sending N4 Session Modification Request and Response.

# Access Network Release

## 5G NR SA signaling with 5GC Call flow Access Network Release



Based on TS 23.502, the initiation of AN release may be due to:

- RAN-initiated with cause, unspecified failure, RAN Link Failure, user inactivity, Inter-System redirection, request for establishment of QoS Flow for IMS voice, release due to UE generated signaling connection release, mobility restriction, etc.
- AMF-initiated with cause.

1a. As per the conditions mentioned in the previous paragraph, gNB may decide to initiate the UE context release. In this case, the RAN sends an N2 UE Context Release Request message to the AMF. Cause indicates the reason for the release and the List of PDU Session ID indicates the PDU Sessions served by the gNB.

1b. If N2 Context Release Request cause indicates the release is requested due to user inactivity, then the AMF continues with the AN Release procedure unless the AMF is aware of pending MT traffic or signaling.

2. If the AMF receives the N2 UE Context Release Request message or due to an internal AMF event, including the reception of Service Request or Registration Request to establish another NAS signaling connection still via RAN, the AMF sends an N2 UE Context Release Command to the RAN.

3. If the RAN-UE connection has not been yet released:

the RAN requests the UE to release the RAN connection, if that has not been done yet. Upon receiving RAN connection release confirmation from the UE, the RAN deletes the UE's context, or

if the Cause in the N2 UE Context Release Command indicates that the UE has already locally released the RRC connection, the (R)AN locally releases the RRC connection.

4. The RAN confirms the N2 Release by returning an N2 UE Context Release Complete message to the AMF. The List of PDU Session IDs indicates the PDU Sessions served by the gNB serving the UE. The AMF stores always the latest UE Radio Capability information or NB-IoT specific UE Radio Access Capability Information received from the NG-RAN node. The N2 signaling connection between the AMF and the RAN for that UE is released. If the UE is served by an NG-eNB that supports WUS, then the NG-eNB should include the Information On Recommended Cells And RAN nodes For Paging; otherwise, the RAN may provide the list of recommended cells identifiers for paging to the AMF.

5. For each of the PDU Sessions in the N2 UE Context Release Complete, the AMF invokes Nsmf\_PDUSession\_UpdateSMContext Request. The Cause in this step shall be the same as in step 2. If List of PDU Session ID(s) with active N3 user plane is included in step 1b, the step 5 to 7 are performed before step 2. The Operation Type is set to "UP deactivate" to indicate deactivation of user plane resources for the PDU Session.

6a. If multiple UPFs are used in the PDU Session and the SMF determines to release the UPF terminating N3, SMF forwards the N4 Session Modification Request to terminate the N3/N9 tunnel. The SMF then releases the N4 session towards the N3 UPF.

If the cause of AN Release is because of User Inactivity or UE Redirection, the SMF shall preserve the GBR QoS Flows. Otherwise, the SMF shall trigger the PDU Session Modification procedure for the GBR QoS Flows of the UE after the AN Release procedure is completed.

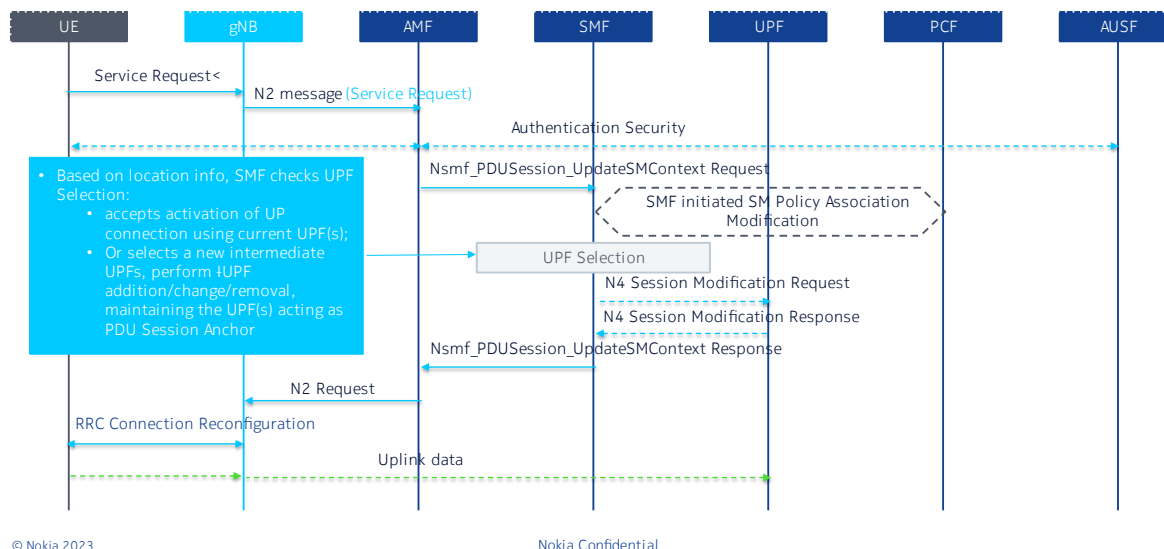
6b. N4 Session Modification Response acknowledging the SMF request.

7. Nsmf\_PDUSession\_UpdateSMContext Response from SMF to AMF. Upon completion of the procedure, the AMF considers the N2 and N3 as released and enters CM-IDLE state.

# Service Request



## UE Triggered Service Request (1/2)



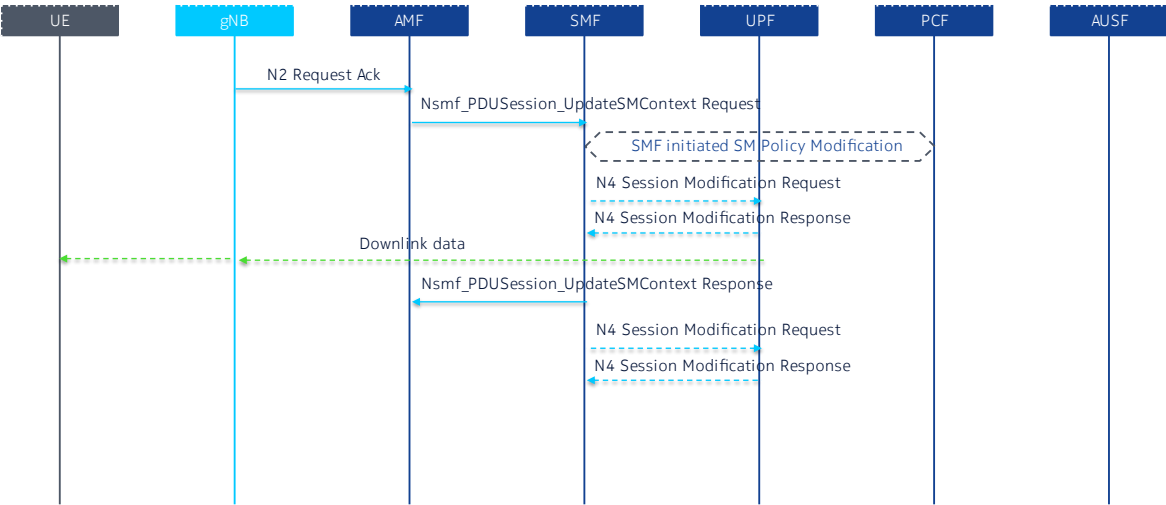
The Service Request procedure is used by a UE in CM IDLE state or the 5GC to request the establishment of a secure connection to an AMF

- in order to send uplink signaling messages, user data, or as a response to a network paging.

The Service Request procedure is also used both when the UE is in CM-IDLE and in CM-CONNECTED to activate a User Plane connection for an established PDU Session

- to request activate User Plane connection for PDU Sessions and to respond to a NAS Notification message from the AMF.
- **Service Request** (List Of PDU Sessions To Be Activated, List Of Allowed PDU Sessions, security parameters, PDU Session status)).
  - If for signaling only, UE doesn't identify any PDU Sessions To Be Activated.
  - If for paging response, but UE doesn't have user data to be transferred, UE doesn't identify any PDU Sessions To Be Activated.
  - PDU Session status indicates PDU Sessions available in the UE,
- AMF to (R)AN: **N2 Request**
  - N2 SM information from SMF, security context, AMF signaling Connection ID, Handover Restriction List, Subscribed UE-AMBR, MM NAS Service Accept, list of recommended cells / TAs / NG-RAN node identifiers
  - For UE in CM-CONNECTED state, only N2 SM information and MM NAS Service Accept are included in N2 Request.
  - MM NAS Service Accept includes PDU Session status in AMF
  - May additionally include the rejected activation of UP of a PDU Session IDs and cause
  - If NG-RAN provided list of recommended cells / TAs / NG-RAN node identifiers during AN Release procedure
  - AMF may include the UE's "RRC Inactive Assistance Information",
- (R)AN to UE: NG-RAN performs **RRC Connection Reconfiguration** and forward NAS msg to UE.

# UE Triggered Service Request (2/2)

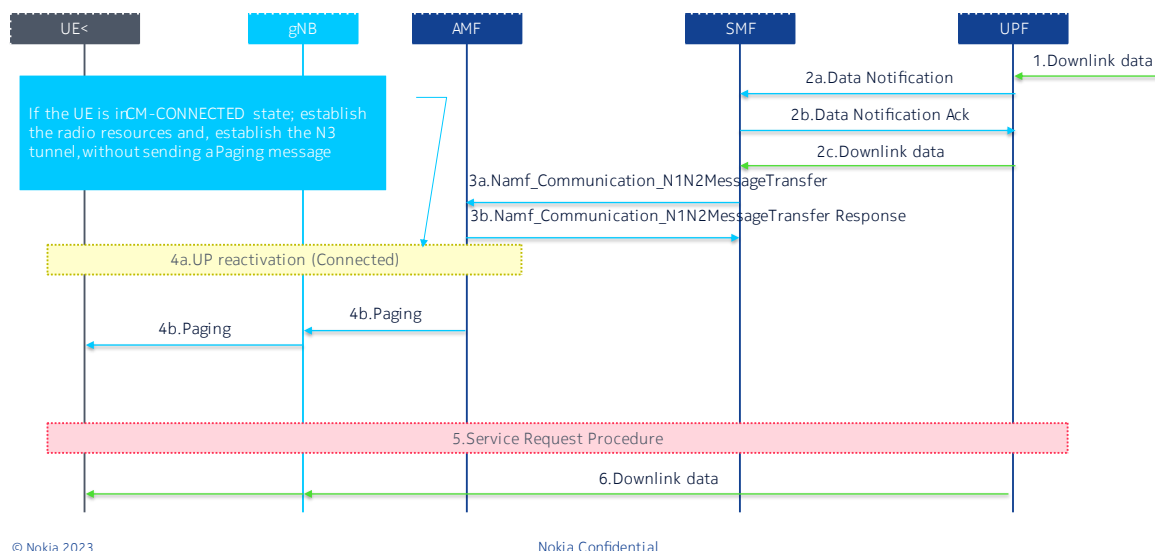


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gNB to AMF: N2 Request Ack:  
N2 SM information (AN Tunnel Info, List of accepted QoS Flows for PDU Sessions whose UP connections are activated, List of rejected QoS Flows for PDU Sessions whose UP connections are activated), PDU Session ID).

## Network Triggered Service Request



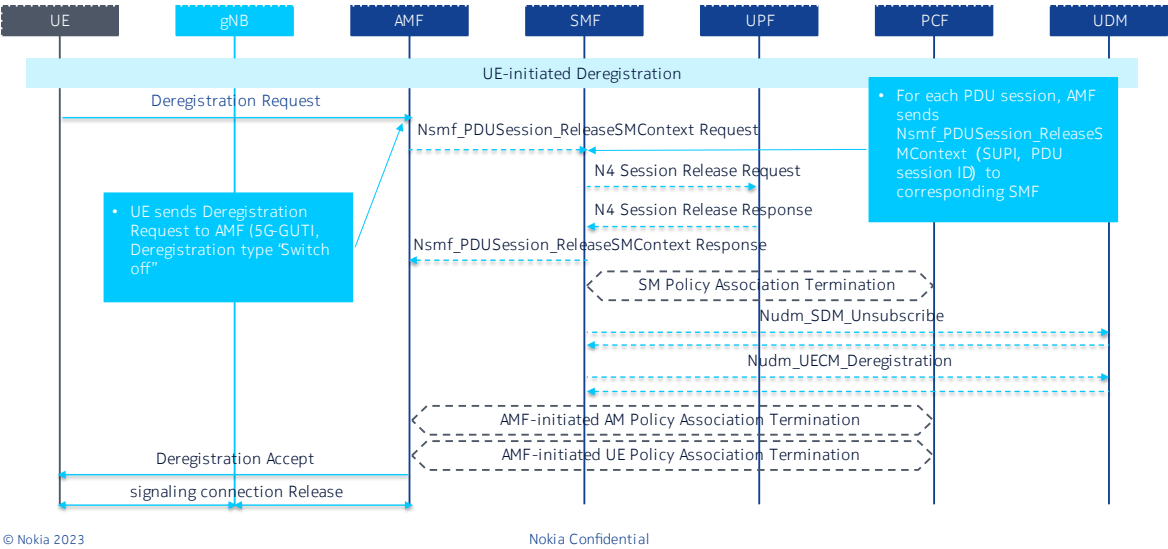
This procedure is used when the network needs to signal with a UE, e.g. N1 signaling to UE (NAS), Mobile-terminated SMS, UP connection activation for PDU Session(s) to deliver mobile terminating (MT) user data.

If the UE is in CM IDLE state or CM-CONNECTED state in 3GPP access, the network initiates a Network Triggered Service Request procedure. If the UE is in CM-IDLE state, and asynchronous type communication is not activated, the network sends a Paging Request to (R)AN/UE. The Paging Request triggers the UE Triggered Service Request procedure in the UE.

1. When a UPF receives downlink data for a PDU Session and there is no AN Tunnel Info stored in UPF for the PDU Session, the UPF may buffer the downlink data (steps 2a and 3b), or forward the downlink data to the SMF (step 2c).
2. (a) Data Notification (N4 Session ID, Information to identify the QoS Flow for the DL data packet, DSCP). (b) Data Notification Ack. (c) The UPF forwards the downlink data packets towards the SMF if the SMF instructed the UPF to do so (i.e. the SMF will buffer the data packets).
3. (a) The SMF determines the AMF and invokes the `Namf_Communication_N1N2MessageTransfer` to the AMF including the PDU Session ID of the PDU Session. (b) If the UE is in CM-IDLE state at the AMF, and the AMF is able to page the UE the AMF sends a `Namf_Communication_N1N2MessageTransfer` response to the SMF immediately with a cause "Attempting to reach UE". If the UE is in CM-CONNECTED state at the AMF then the AMF sends a `Namf_Communication_N1N2MessageTransfer` response to the SMF immediately with a cause "N1/N2 transfer success".
4. (a) If the UE is in CM-CONNECTED state, User plane is reactivated (i.e. establish the radio resources and establish the N3 tunnel) without sending a Paging message to the gNB and the UE. (b) If the UE is in RM-REGISTERED state and CM-IDLE and reachable in 3GPP access, the AMF sends a Paging message (NAS ID for paging, Registration Area list, Paging DRX length, Paging Priority, access associated to the PDU Session) to gNBs belonging to the Registration Area(s) in which the UE is registered, then the NG-RAN node pages the UE.
5. If the UE is in CM-IDLE state in 3GPP access, upon reception of paging request for a PDU Session associated to 3GPP access, the UE shall initiate the UE Triggered Service Request procedure
6. The UPF transmits the buffered downlink data toward UE.

# Deregistration

# Deregistration Procedure



The Deregistration procedure allows:

- The UE to inform the network that it does not want to access the 5GS any longer (UE initiated deregistration)
- The network to inform the UE that it does not have access to the 5GS any longer (Network-initiated deregistration).

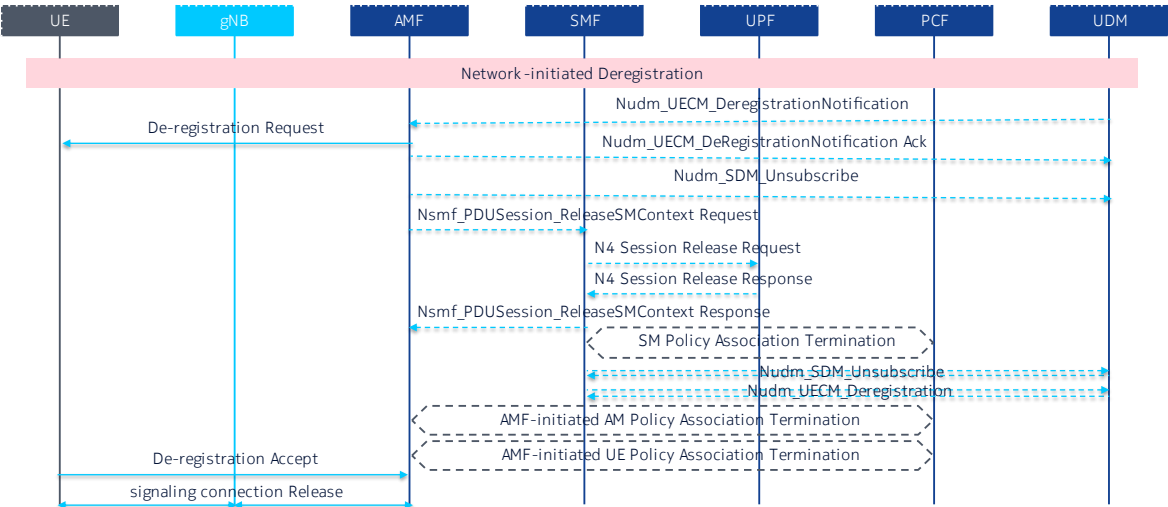
Deregistration request either by UE or by the network

include whether Deregistration applies to 3GPP access, to non-3GPP access, or to both.

UE initiated deregistration:

- UE sends NAS message Deregistration Request (5G-GUTI, Deregistration type (e.g. Switch off), Access Type)
  - [Conditional] AMF to SMF: Nsmf\_PDUSession\_ReleaseSMContext (SUPI, PDU Session ID).
- All PDU Sessions over the target access(es).
- [Conditional] SMF unsubscribes from Session Management Subscription data changes notification with the UDM by Nudm\_SDM\_Unsubscribe
  - Nudm\_UECM\_Deregistration let UDM remove stored SMF identity, SMF address and DNN and PDU Session Id
  - AMF unsubscribes by Nudm\_SDM\_Unsubscribe
    - Access and Mobility Subscription data and SMF Selection Subscription data changes notification with UDM.

# Deregistration Procedure



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Network-initiated deregistration:

## Wrap-up

In this module we have covered the following items

- Describe 5G NR Registration Procedure
- Describe 5G NR PDU Session Establishment Procedure
- Describe 5G NR PDU Session Modification Procedure
- Describe 5G NR PDU Release Procedure
- Describe 5G NR Access Network Release
- Describe 5G NR Service Request procedures
- Describe 5G NR Deregistration Procedure



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