5GS Interworking with EPC

TP00005-V-1701 V0 - S04M07 Ed1

Learning Objectives

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

- Describe the Architecture for the interworking between 5GS and EPC.
- Explain Single registration and Dual registration.
- Describe EPS to 5GS Idle mode mobility.
- Describe 5GS to EPS Idle mode mobility.
- Describe EPS to 5GS handover using N26 interface.
- Describe 5GS to EPS handover using N26 interface.

Table of Contents

NOKIA

Architecture for Interworking between 5GS and EPC

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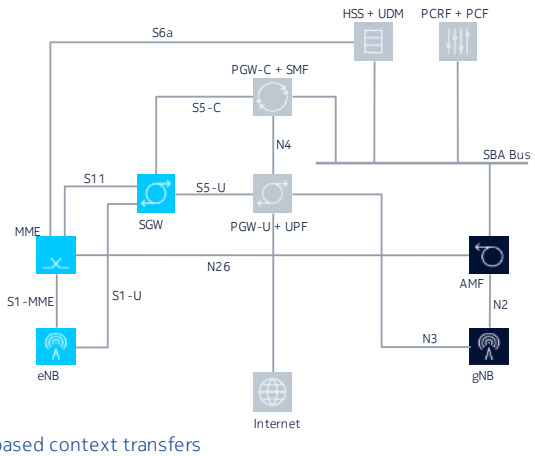
4G and 5G Core Interworking

Interworking based on deploying some combined 4G+5G functions. SGW, MME and AMF are deployed independently

4G CUPS (Control and User Plane Separation) is a pre requisite for this model, with the SGW separated from the PGW. Use of CUPS for the SGW is optional

4G functions use Diameter, 5G functions use the SBA. The PCRF+PCF only uses the SBA.

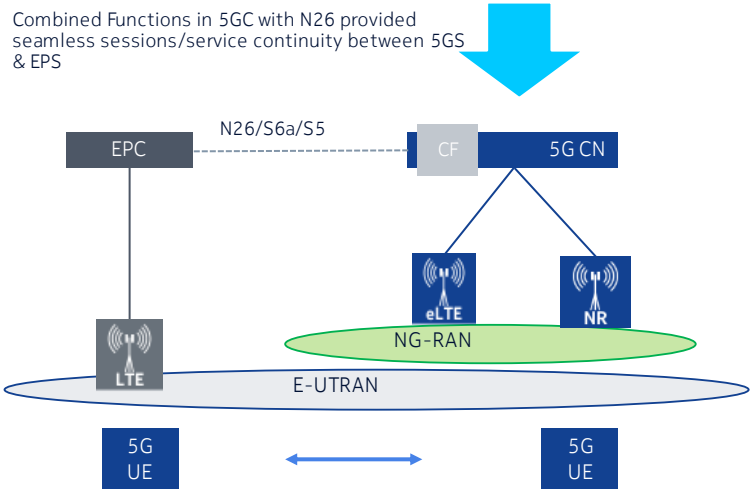


N26 based context transfers

Architecture for Interworking between 5GS and EPC

Architecture and Combine functions for Interworking between5GS and EPC

- 5G Capable UE sessions always anchored in 5G CN
- Common Subscription Data Access(HSS/UDM)
- N26 required for seamless handover (VoLTE)
- Combined functions to minimize EPC impact

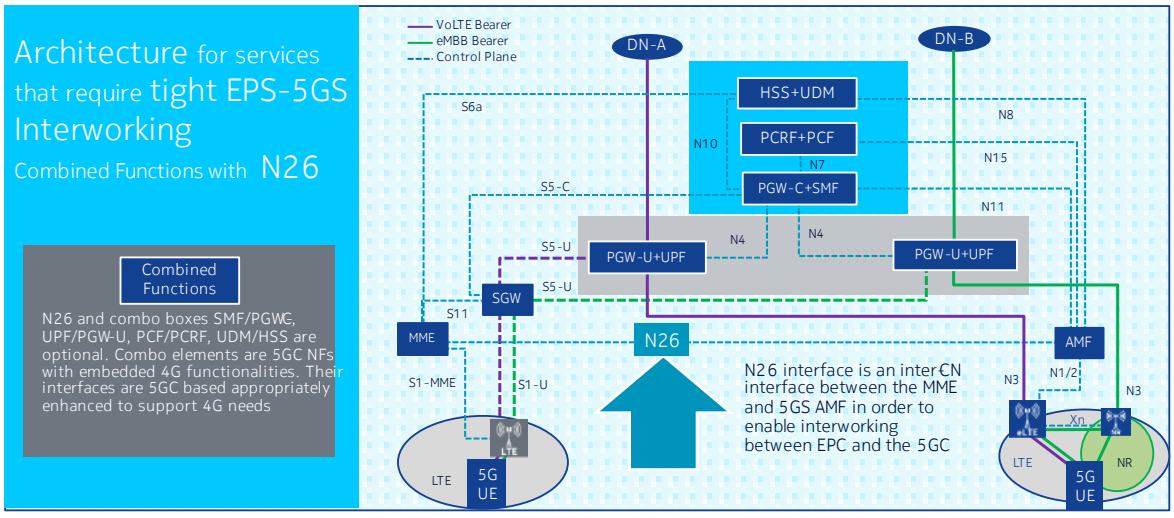


5GC has Combined Functions to support tight interworking between EPC and 5GC. Combined Functions with N26 provide seamless sessions and service continuity between 5GS and EPS.

Keep in mind, Combined Functions are only required for services requiring tight interworking with EPS.

Architecture for Interworking between 5GS and EPC

Architecture and Combine functions for Interworking between5GS and EPC



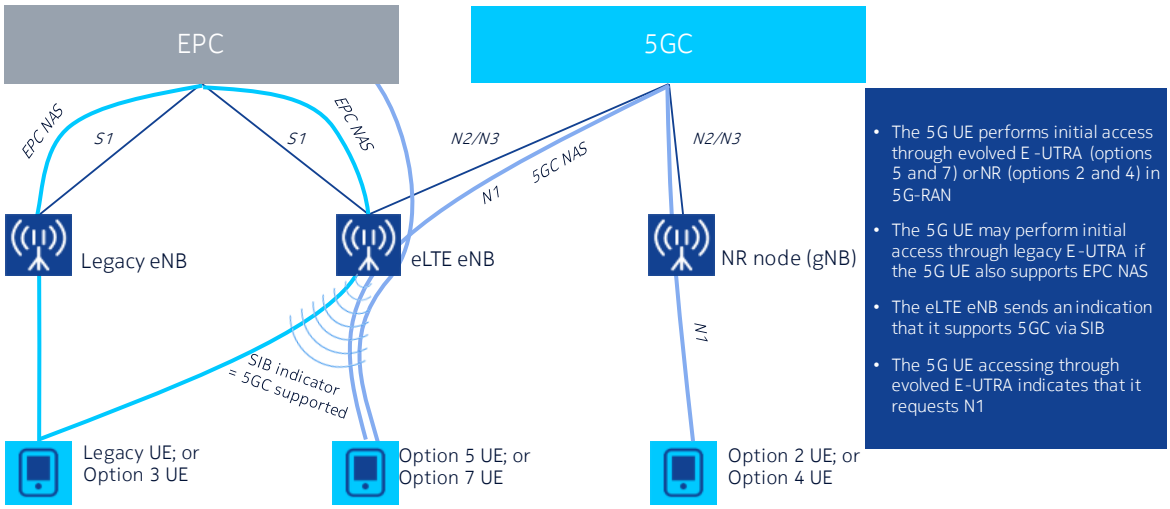
N26 interface is an inter-CN interface between the MME and 5GS AMF in order to enable interworking between EPC and the NG core. Support of N26 interface in the network is optional for interworking. N26 supports subset of the functionalities (essential for interworking) that are supported over S10.

5G Networks that support interworking with EPC, may support interworking procedures that use the N26 interface or interworking procedures that do not use the N26 interface.

The support for N26 interface between AMF in 5GC and MME in EPC is required to enable seamless session continuity (e.g. for voice services) for inter-system change.

UE's supporting EPC and 5G NAS indicate such capabilities to the EPC or 5GC that it attempts to Attach/Register with to enable priority assignment of a Combined Functions anchor (PGW-C/SMF). UEs that are not subject to 5GS and EPC interworking may be served by entities not dedicated for interworking, i.e. by either by PGW or SMF/UPF. 5G Capable UE sessions always anchored in 5GC.

Architecture for Interworking between 5GS and EPC
Core Network Selection



When camping on an E-UTRA cell connected to both EPC and 5GC (the eLTE eNodeB in the middle, here on this slide), a UE supporting both EPC NAS and 5GC NAS shall select a core network type (EPC or 5GC) and initiate the corresponding NAS procedure.

A UE that supports only EPC based Dual Connectivity with secondary RAT NR: always performs initial access through E-UTRA but never through NR and performs EPC NAS procedures over E-UTRA.

A UE that supports camping on 5G Systems with 5GC NAS:

- performs initial access either through E-UTRAN that connects to 5GC or NR towards 5GC;
- performs initial access through E-UTRAN towards EPC, if supported and needed;
- performs EPC NAS or 5GC NAS procedures over E-UTRAN or NR respectively depending on whether the UE requests 5GC access or EPC access, if the UE also supports EPC NAS.

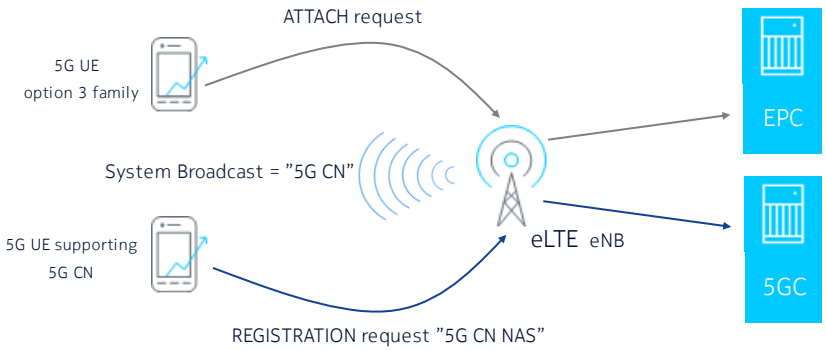
It is worth noting that based on the Core Network type restriction (e.g. due to lack of roaming agreements) the 5GC network may steer the UE towards EPC.

Also, in Release 15 there is no support in 5G System for some functionalities supported in EPS such as Proximity-based services, MBMS, Cellular IoT optimizations, V2X etc. The UE that wants to use one or more of these functionalities not supported by 5G System, when in CM-IDLE may disable all the related radio capabilities that allow the UE to access 5G System. The triggers to disable and re-enable the 5GS capabilities to access 5G System in this case are left up to UE implementation. This features are described on the 3GPP Release 16 version, issued on July 2020.

Architecture for Interworking between 5GS and EPC
Core Network Selection

Option 3 only UE does not nee to understand new broadcast information

5G UE option 3 family does not provide this "5G CN NAS" at Access Stratum when it performs initial access and therefore eNB uses the "default" CN selection mechanism to direct this UE to an MME



In order to support in the same network both UEs that are capable of only EPC NAS (possibly including EPC based Dual Connectivity with secondary NR) and UEs that support 5GC NAS procedures:

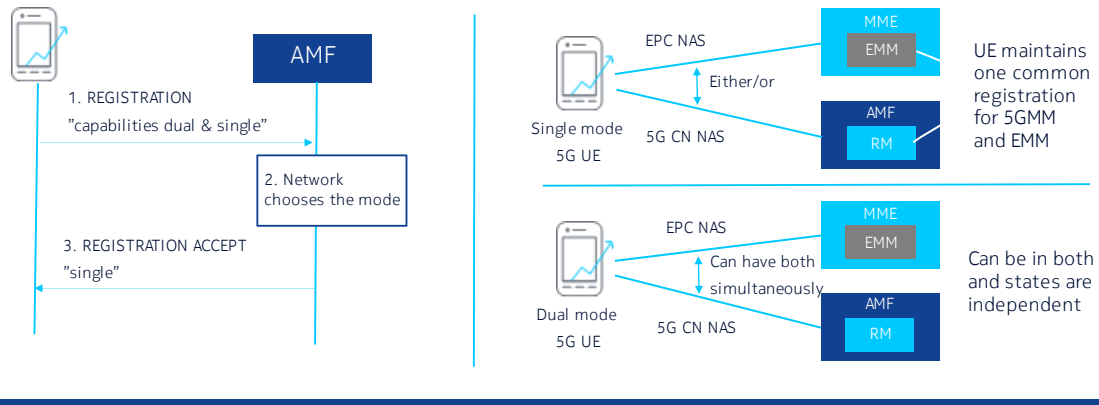
- eNB that supports access to 5GC shall broadcast that it can connect to 5GC.
- The UE AS layer is made aware by the UE NAS layer whether a NAS signaling connection is to be initiated to the 5GC. Based on that, UE AS layer indicates to the RAN whether it is requesting 5GC access (i.e. "5GC requested" indication). The RAN uses this indication to determine whether a UE is requesting 5GC access or an EPC access. RAN routes NAS signaling to the applicable AMF or MME accordingly.

During the EPS attach procedure or initial registration procedure, the mode for inter-system interworking is selected if the UE supports both S1 mode and N1 mode, and the network supports inter-system interworking.

When the UE requests to establish a PDN connection to an APN, the MME may use the UE's support for 5GC NAS indication included in the UE Network Capability and/or UE's subscription from HSS that includes UE's mobility restriction parameters related to 5GS and/or indication of support for interworking with 5GS for this APN to determine if PGW-C+SMF or a standalone PGW-C should be selected.

The UE that supports EPC based Dual Connectivity with secondary RAT only does not provide this "5GC requested" indication at Access Stratum when it performs initial access and therefore eNB uses the "default" CN selection mechanism to direct this UE to an MME.

Architecture for Interworking between 5GS and EPC
Single Registration and Dual-registration



On initial 3GPP NR specification, 5G UE supporting 5G CN are mandated to support single registration mode

In order to interwork with E-UTRAN connected to EPC, the UE supporting both S1 mode and N1 mode can operate in single-registration mode or dual-registration mode . Support of single-registration mode is mandatory for UEs supporting both S1 mode and N1 mode.

a UE operating in single-registration mode, shall maintain one common registration for 5GMM and EMM. Whereas, a UE operating in dual-registration mode handles independent registrations for 5GC and EPC using separate RRC connections.

In single-registration mode, UE has only one active Mobility Management state (either RM state in 5GC or EMM state in EPC) and it is either in 5GC NAS mode or in EPC NAS mode (when connected to 5GC or EPC, respectively). UE maintains a single coordinated registration for 5GC and EPC.

Accordingly, the UE maps the EPS-GUTI to 5G GUTI during mobility between EPC and 5GC and vice versa. To enable re-use of a previously established 5G security context when returning to 5GC, the UE also keeps the native 5G-GUTI and the native 5G security context when moving from 5GC to EPC.

In dual-registration mode, as mentioned above, the UE handles independent registrations for 5GC and EPC using separate RRC connections. In this mode, UE maintains 5G-GUTI and EPS-GUTI independently. UE provides native 5G-GUTI, if previously allocated by 5GC, for registrations towards 5GC and it provides native EPS-GUTI, if previously allocated by EPC, for Attach/TAU towards EPC. In this mode, the UE may be registered to 5GC only, EPC only, or to both 5GC and EPC.

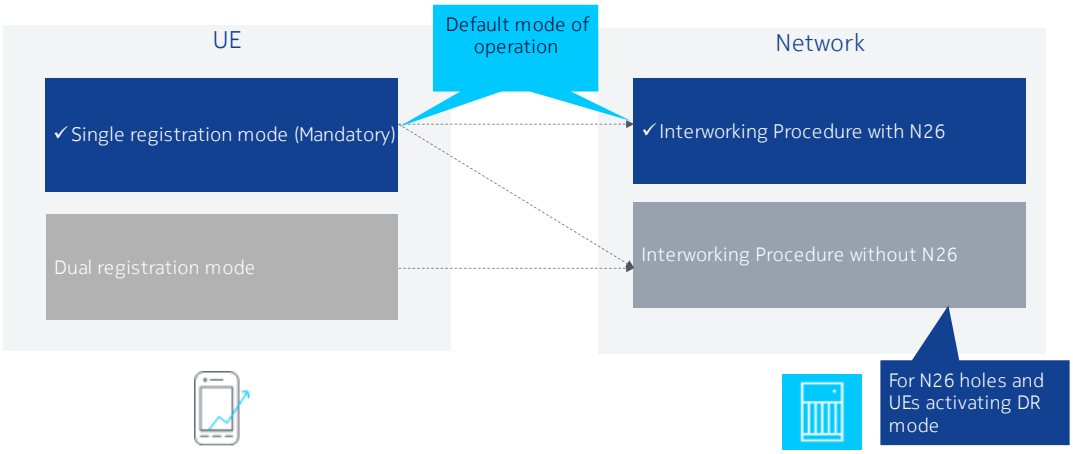
Dual-registration mode is intended for interworking between EPS/E-UTRAN and 5GS/NR. A dual-registered UE should not send its E-UTRA capability to NR access when connected to 5GS/NR to avoid being handed over to 5GC-connected E-UTRA.

During E-UTRAN Initial Attach, UE supporting both 5GC and EPC NAS shall indicate its support of 5G NAS in UE Network Capability.

During registration to 5GC, UE supporting both 5GC and EPC NAS shall indicate its support of EPC NAS.

This indication may be used to give the priority towards selection of PGW-C + SMF for UEs that support both EPC and 5GC NAS.

Architecture for Interworking between 5GS and EPC
UE and Network Support for Interworking



3GPP specifies full solution for Single Radio, Single Registration Solution.

3GPP specifies Dual registration solution, however it makes no assumption on Single radio or Dual radio support in the UE. Thus there is no assumption that the UE supports paging in two radios simultaneously; this is left up to implementation.

Support for voice with seamless service continuity between EPS and 5GS requires Single registration based interworking solution with N26. N26 interface is an inter-Core Network interface between the MME and 5GS AMF in order to enable interworking between EPC and the 5G Core. Support of N26 interface in the network is optional for interworking: As already outlined in a previous slide, 5G Networks that support interworking with EPC, may support interworking procedures that use the N26 interface or interworking procedures that do not use the N26 interface.

Interworking procedures with N26 support provides IP address continuity on inter-system mobility to UEs that support 5GC NAS and EPC NAS and that operate in single registration mode. Networks that support interworking procedures without N26 shall support procedures to provide IP address continuity on inter-system mobility to UEs operating in both single-registration mode and dual-registration mode. In such networks, AMF shall provide the indication that interworking without N26 is supported to UEs during initial Registration in 5GC or MME may optionally provide the indication that interworking without N26 is supported in the Attach procedure in EPC.

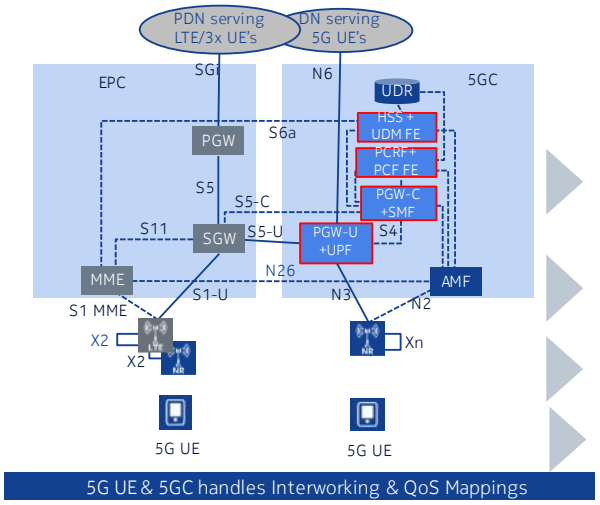
Architecture for Interworking between 5GS and EPC

Quiz 1

1. Which inter -CN interface enables interworking between EPC and the 5G Core?
   a. S10
   b. N6
   c. N26
   d. NG
2. Which of the following apply to single -registration mode?
   a. UE handles independent registrations for 5GC and EPC using separate RRC connections
   b. UE maintains 5G-GUTI and EPS -GUTI independently
   c. UE maps the EPS-GUTI to 5G GUTI during mobility between EPC and 5GC and vice versa
   d. UE has only one active MM state and it is either in 5GC NAS mode or in EPC NAS mode

Interworking Procedures with N26 Interface

Interworking Procedures with N26 Interface
QoS Mapping



5G UE served by 5GC

Mappings of QoS Parameter & Bearer ID take place during PDU Session/GBR Flow establishment & modifications.

PDU Sessions anchored in PGW-C+SMF.

PGW-C+SMF(or PCRF+PCF)

Maps 5GS QoS parameters to EPS QoS parameters: e.g. 5QI=QCI-1, 5QI-5=QCI-5

Mappings stored in UE/PGW-C+SMF

AMF: Manages EPS Bearers ID (EBI) allocation and UE/MM Context Mappings

NG-RAN: Manages mapping and creation of QoS Flows

5G UE: Stores received mapped EPS QoS parameters for use in EPS

When the UE is served by the 5GC, during PDU Session establishment and GBR QoS Flow establishment, PGW-C+SMF performs EPS QoS mappings, from the 5G QoS parameters obtained from the PCF, and allocates TFT with the PCC rules obtained from the PCF if PCC is deployed. Otherwise, EPS QoS mappings and TFT allocation are mapped by the PGW-C+SMF locally.

The PGW+SMF ignores 5G QoS parameters that are not applicable to EPC (e.g. QoS Notification control).

EPS Bearer IDs are allocated by the serving AMF requested by the SMF if the SMF determines that EPS Bearer IDs need to be assigned to the QoS Flows. For each PDU Session, EPS bearer IDs are allocated to the default EPS bearer and dedicated bearers. The SMF shall be able to determine the QoS flows that require EPS Bearer IDs, based on the QoS profile and operator policies.

The UE and the PGW-C+SMF store the association between the QoS Flow and the corresponding EBI and the EPS QoS parameters. When the QoS Flow is deleted e.g. due to PDU Session status synchronization or PDU Session Modification, the UE and the PGW-C+SMF delete any possibly existing EPS QoS parameters associated with the deleted QoS Flow.

Interworking Procedures with N26 Interface
QoS Mapping

5G UE served by EPC

When UE served by EPC mappings of QoS Parameter & PDU Sessions take place during PDN Connection/Bearer establishment & modifications. PDN Sessions anchored in PGW-C+SMF.

PGW-C+SMF(or PCRF+PCF)

Maps EPS QoS parameters to 5GS QoS parameters: e.g. QCI=5 ↔ 5QI-1, QCI-5=5QI-5

Mappings stored in UE/PGW-C+SMF

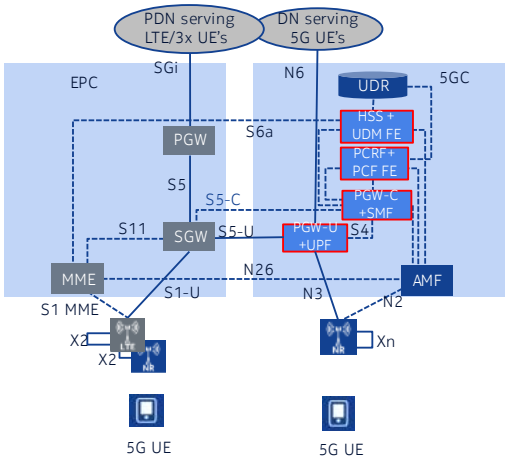
MME:

Provides MM/SM context to AMF

5G UE

Allocates PDU ID to PDN Connection, sends in PCO to PGW-C+SMF

Stores received 5G QoS Rules for use in 5GS(along with PDU ID)



5G UE & 5GC handles Interworking & QoS Mappings

When the UE is served by the EPC, during PDN connection establishment, the UE allocates the PDU Session ID and sends it to the PGW-C+SMF via PCO (Protocol Configuration Option). During PDN Connection establishment and dedicated bearer establishment, PGW-C+SMF performs EPS QoS mappings, from the 5G QoS parameters obtained from the PCF, and allocates TFT with the PCC rules obtained from the PCF if PCC is deployed. Otherwise, EPS QoS mappings and TFT allocation are mapped by the PGW-C+SMF locally.

Other 5G QoS parameters corresponding to the PDN connection, e.g. Session AMBR, and QoS rules and QoS Flow level QoS parameters if needed for the QoS Flow(s) associated with the QoS rule(s), are sent to UE in PCO.

The UE and the PGW-C+SMF store the association between the EPS Context and the PDU Session Context to use it in case of handover from EPS to 5GS.

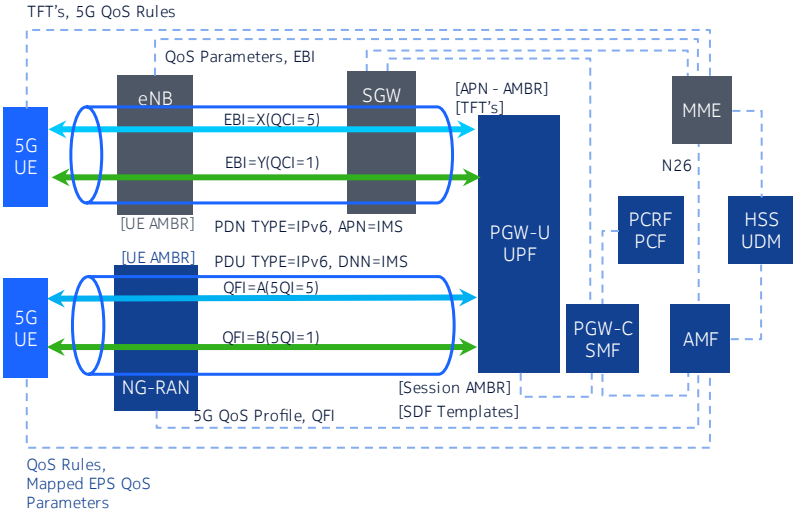
During the EPS bearer establishment/modification procedure, QoS rules corresponding to the related EPS bearers are allocated and sent to UE in PCO. The 5G QoS parameters are stored in the UE and are to be used when the UE is handed over from EPS to the 5GS. The 5G QoS parameters may be provided to PGW-C+SMF by the PCF, if PCC is deployed. On mobility from EPS to 5GS, the UE sets the SSC mode of the mapped PDU Session to SSC mode 1. The UE and the PGW-C+SMF store the association between the EPS bearer and the corresponding 5G QoS Rules and QoS Flow level QoS parameters if needed for the QoS Flow(s) associated with the QoS rule(s). When the EPS bearer is deleted e.g. due to EPS bearer status synchronization or bearer deactivation, the UE and the PGW-C+SMF delete any possibly existing 5G QoS Rule(s) and QoS Flow level QoS parameters if any for the QoS Flow(s) associated with the QoS rule(s) associated with the deleted EPS bearer.

Interworking Procedures with N26 Interface
QoS Related Parameter Mappings

[Mapped 5G QoS Rules]
EBI=X (Default Bearer)
QFI=A, 5QI=5,
EBI=Y
QFI=B, 5QI=1, MBR, GBR, Pkt Fltr

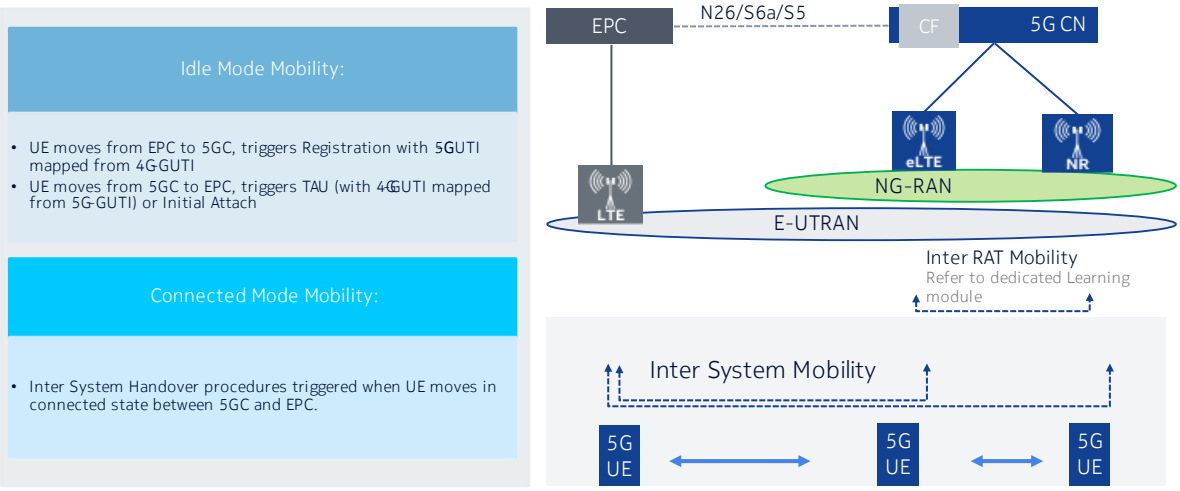
[UE mapping of 5GGUTI & EPC-GUTI]
(UE mapping of PDU & PDN Types]
[UE assignment of PDU ID]

[Mapped EPS QoS Parameters]
QFI=A(Default QFI)
EBI=X, QCI=5,
QFI=B
EBI=Y, QCI=1, MBR, GBR, TFT
Session AMBR=APN AMBR



Based on operator policies, an SMF can map all non-GBR QoS flows to default EPS bearer in which case it requests only one EBI for all the non-GBR QoS flows. Alternatively, an SMF can also map one non-GBR QoS flow to one dedicated EPS bearer in which case it requests a dedicated EBI for non-GBR QoS flow that should be mapped to dedicated EPS bearer.

Interworking Procedures with N26 Interface
Inter System Mobility with Single Registration

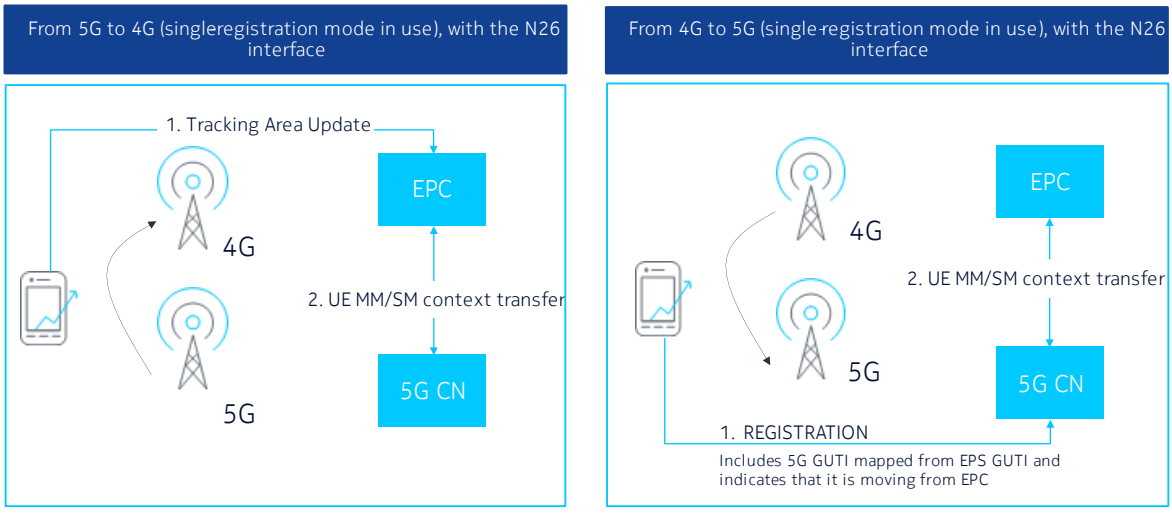


Interworking procedures using the N26 interface, enables the exchange of MM and SM states between the source and target network. When interworking procedures with N26 is used, the UE operates in single-registration mode. The network keeps only one valid MM state for the UE, either in the AMF or MME. Either the AMF or the MME is registered in the HSS+UDM.

The UE's subscription may include restriction for Core Network Type (EPC) and RAT restriction for E-UTRA. If so, the UDM provides these restrictions to the AMF. The AMF includes RAT and Core Network type restrictions in the Handover Restriction List to the NR. The AMF and NR use these restrictions to determine if mobility of the UE to EPS or E-UTRA connected to EPS should be permitted. When the UE moves from 5GS to EPS, the SMF determines which PDU Sessions can be relocated to the target EPS, e.g. based on capability of the deployed EPS, operator policies for which PDU Session, seamless session continuity should be supported etc. The SMF can release the PDU Sessions that cannot be transferred as part of the handover or Idle mode mobility. However, whether the PDU Session is successfully moved to the target network is determined by target EPS.

Similarly, the UE's subscription may include restriction for Core Network Type (5GC) and RAT restriction for NR. If so, the HSS provides these restrictions to the MME. The MME includes RAT and Core Network type restrictions in the Handover Restriction List to the E-UTRAN. The MME and E-UTRAN use these restrictions to determine if mobility of the UE to 5GS or NR connected to 5GS should be permitted. When the UE moves from EPS to 5GS, for the case when the MME has selected P-GW-C+SMF even for PDN connections that cannot be relocated to the target 5GS, the P-GW+SMF determines which PDN Connections can be relocated to the target 5GS, e.g. based on capability of the deployed 5GS, subscription and operator policies for which PDN Connection, seamless session continuity should be supported etc. The P-GW+SMF and NG-RAN can reject the PDN Connections that cannot be transferred as part of the handover or Idle mode mobility.

Interworking Procedures with N26 Interface
Idle Mode Mobility



Here, we assume that UE supports single-registration mode and network supports interworking procedure with the N26 interface.

In case of idle mode mobility from EPS to 5GS, and single-registration mode is in use, the UE moving from 4G to 5G Cell performs Registration procedure with 5G-GUTI mapped from 4G-GUTI.

In case of idle mode mobility from 5GS to EPS, the UE performs either TAU or Attach procedure with EPS GUTI mapped from 5G-GUTI sent as old Native GUTI, and indicates that it is moving from 5GC.

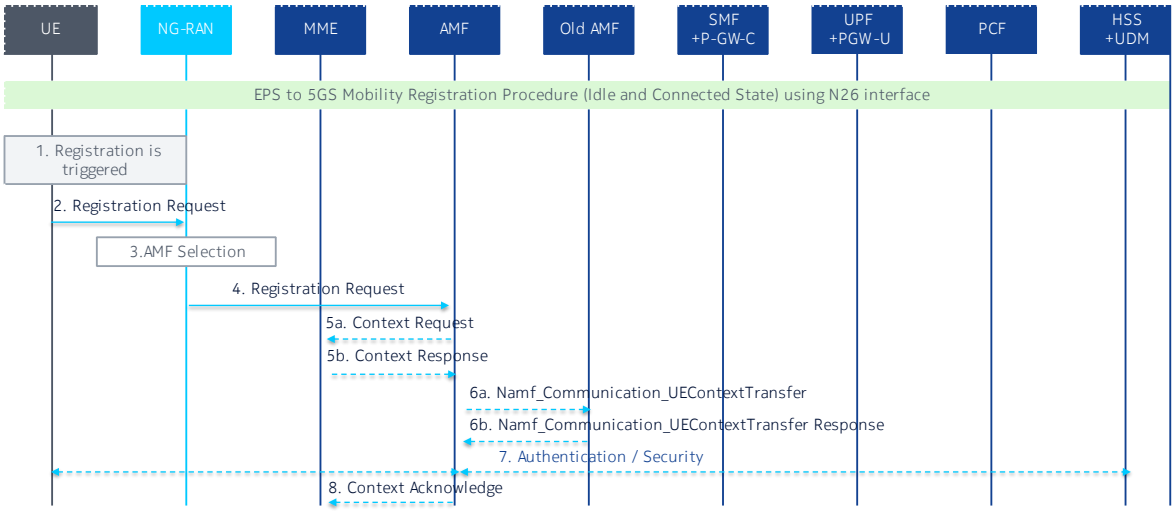
When it moves from 5G to 4G Cell, the UE initiates a Tracking Area Update procedure with 4G-GUTI mapped from 5G-GUTI. The UE performs an attach procedure if the UE is registered without PDU session in 5GC and the UE or the EPC does not support attach without PDN connectivity. UE usage type included in the MM context sent to MME from AMF.

5G-GUTI : 5G Globally Unique Temporary Identifier:

When interworking procedures with N26 are used and the UE performs idle-mode mobility from 5GC to EPC the following mapping from 5G-GUTI to 4G-GUTI applies:

- 5G <MCC> maps to EPS <MCC>
- 5G <MNC> maps to EPS <MNC>
- 5G <AMF Region ID> maps to EPS <MMEGI>
- 5G <AMF Set ID> and 5G <AMF Pointer> map to EPS <MMEC>
- 5G <5G-TMSI> maps to EPS <TMSI>.

Interworking Procedures with N26 Interface
EPS to 5GS Idle Mode Mobility



EPS to 5GS Idle mode mobility for single-registration mode with N26 interface:

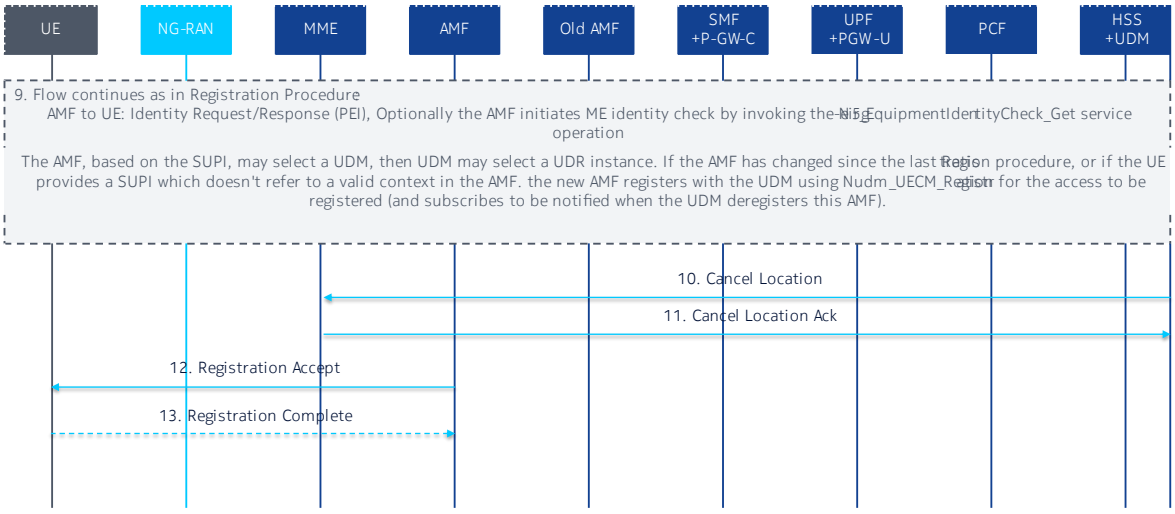
This protocol flow describes the registration procedure from EPS to 5GS when N26 is supported for idle and connected states.

1. The UE performs mobility Registration procedure with the 5G GUTI mapped from EPS GUTI and indicates that it is moving from EPC. The UE derives GUAMI (Globally Unique AMF Identifier) from the native 5G-GUTI (if available) and includes GUAMI in the RRC message to enable RAN to route to the corresponding AMF.

- The UE includes the native 5G-GUTI as an additional GUTI in the Registration request; the AMF uses the native 5G-GUTI to retrieve MM context identified by the 5G-GUTI from old AMF or from UDSF (if UDSF is deployed and the old AMF is within the same AMF set).
- If the UE holds no native 5G-GUTI, then the UE provides in the RRC message a GUAMI mapped from the EPS GUTI and indicates it as "Mapped from EPS". The AMF and SMF retrieve the UE's MM and SM context from EPC. During the Registration procedure, the HSS+UDM cancels any MME registration.

2. The UE sends Registration Request with registration type set to "Mobility Registration Update“. The UE includes 5G-GUTI mapped from EPS GUTI as the old GUTI, the native 5G-GUTI (if available) as additional GUTI and indicating that the UE is moving from EPC.
3. AMF Selection
4. gNB forwards the Registration Request message to AMF
5. (a) The target AMF derives the MME address and 4G GUTI from the old 5G-GUTI and sends Context Request to MME including EPS GUTI mapped from 5G-GUTI and the TAU request message. (b) The AMF converts the received EPS MM Context into the 5GS MM Context. The received EPS UE context includes IMSI, ME Identity, UE EPS security context, UE Network Capability, and EPS Bearer context(s).
6. (a) If the UE includes the 5G-GUTI as Additional GUTI in the Registration Request message, the target AMF sends message to the old AMF. The target AMF retrieves UE's SUPI and MM Context, event subscription information by each consumer NF and the list of SM PDU Session ID/associated SMF ID for the UE. (b) the response for old AMF is performed
7. Authentication and security procedures may be performed (e.g. If the target AMF can not obtain the UE MM context from AMF or other reasons)
8. The target AMF sends Context Acknowledge (Serving GW change indication) to MME.

Interworking Procedures with N26 Interface
EPS to 5GS Idle Mode Mobility



9. Subsequently, signaling flow continues as in Registration Procedure described in UE States and 5GS Signaling Module:

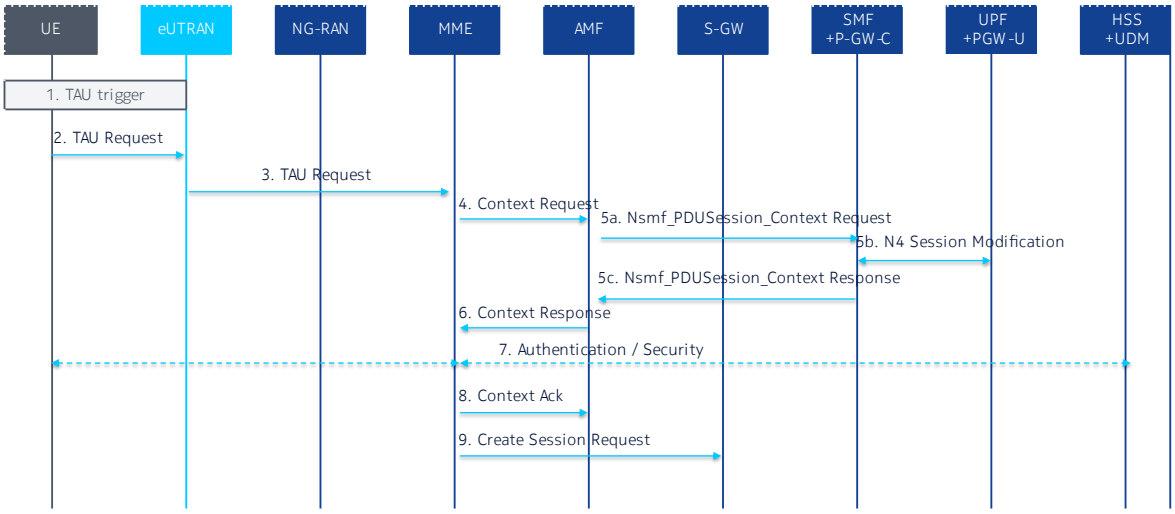
   UDM Registration, AM and SMF Selection Subscription Data Fetching, Subscription to AM Data Notfication, De-registration from Old AMF:

   - 3GPP Access Registration with UDM
   - Fetching Access and Mobility Subscription Data from UDM
   - Fetching SMF Selection Subscription Data from UDM
   - Subscribing to Access and Mobility Subscription Data notification
   - De-registering the UE from old AMF (if old AMF Registration info exists in UDM).

10/11. HSS+UDM cancels the location of the UE in the MME

12/13. The Registration Accept message shall include the updated 5G-GUTI to be used by the UE in that PLMN over any access.

Interworking Procedures with N26 Interface
5GS to EPS Idle Mode Mobility



This call flow is for idle mode mobility from 5GS to EPS:

1-3. The UE performs TAU procedure with EPS GUTI mapped from 5G-GUTI sent as old Native GUTI, and indicates that it is moving from 5GC. The UE includes in the RRC message a GUMMEI (Globally Unique Mobility Management Entity Identifier) mapped from the 5G-GUTI and indicates it as a native GUMMEI and should in addition indicate it as "Mapped from 5G-GUTI".

4. The MME retrieves the UE's MM and SM context from 5GC.

5. (a) The AMF verifies the integrity of the TAU request message and requests the PGW-C+SMF to provide SM Context. (b) If CN Tunnel Info is allocated by the PGW-U+UPF, the SMF sends N4 Session Modification Request to PGW-U+UPF to establish the tunnel for each EPS bearers, and PGW-U+UPF provides the PGW-U Tunnel Info for each EPS bearers to PGW-C+SMF. (c) SMF returns mapped EPS bearer contexts. which includes PGW-C control plane tunnel information of the PDN connection corresponding to the PDU session, EBI for each EPS bearer, PGW-U tunnel information for each EPS bearer, and EPS QoS parameters for each EPS bearer.

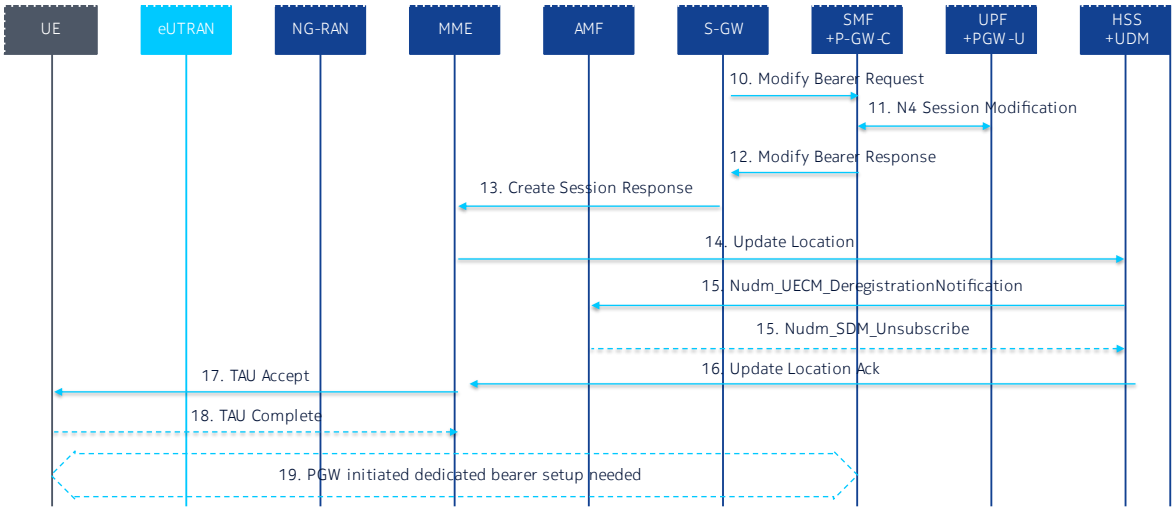
6. The AMF responds with a Context Response message carrying mapped MM context (including mapped security context), Return preferred and SM EPS UE Context (default and dedicated GBR bearers) to the MME.

7. If MME determines that authentication needs to be initiated, the Authentication and Security function procedure is performed.

8. MME sends Context Acknowledge (Cause, Indication) to AMF. The SGW Change Indication flag in Indication IE is set to indicate SGW change.

9. MME sends a Create Session Request message (IMSI, Serving Network, RAT Type, MME Address and F-TEID for Control Plane, PGW Address and F-TEID for C-plane, APN, PDN Type, Linked EPS Bearer Identity (LBI), Bearer Context(s) [EBI, PGW F-TEID for user plane, EPS QoS]).

Interworking Procedures with N26 Interface
5GS to EPS Idle Mode Mobility

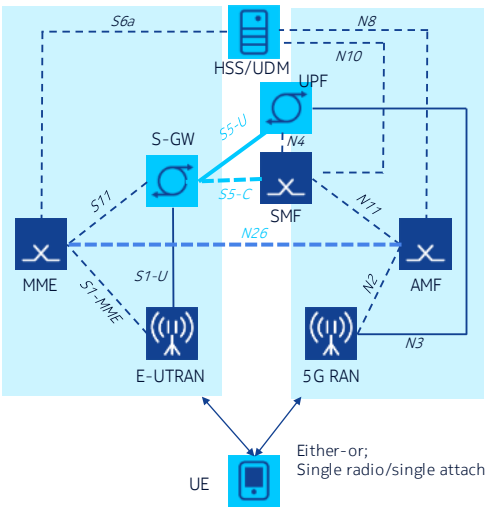


10. SGW sends a Modify Bearer Request (RAT type, Serving Network, Sender F-TEID for Control Plane, Bearer Contexts to be modified [EBI, S5/S8-U SGW F-TEID]) message to SMF
11. Session Modification Request and Session Modification Response: SMF initiates a N4 Session Modification procedure towards the UPF to establish the tunnel for the EPS bearer.
12. SMF responds with Modify Bearer Response (Cause, Bearer Contexts Modified [EBI, Cause]) to SGW
13. SGW allocates its local resources and returns them in a Create Session Response (Cause, Sender F-TEID for Control Plane, APN Restriction, Bearer Context(s) Created [EPS Bearer ID, Cause, S1-U SGW F-TEID]) message to MME
14. MME sends the Update Location Request (MME Identity, IMSI, ULR-Flags, MME Capabilities, Homogeneous Support of IMS Voice over PS Sessions, UE SRVCC capability) to UDM/HSS
15. UDM notifies AMF about its deregistration. The request contains the callback URI for deregistration notification as received by the UDM during registration, and Deregistration reason as 5GS to EPS Mobility
16. UDM/ HSS acknowledges by sending an Update Location Answer (IMSI, Subscription Data) message to MME
17. MME sends a TAU Accept (GUTI, TAI list, EPS bearer status, NAS sequence number, NAS-MAC, IMS Voice over PS session supported, Emergency Service Support indicator, LCS Support Indication, Supported Network Behavior, Service Gap Time, Enhanced Coverage Restricted) message to the UE
18. UE returns a TAU Complete message to MME to acknowledge the received GUTI
19. PGW initiated dedicated bearer setup needed.

Interworking Procedures with N26 Interface
Quiz 2

1. Which of the following in NOT a correct statement?
   a. For 5GS and EPS interworking, SMF and PGW-C are deployed as combined Functions
   b. For 5GS and EPS interworking, UPF and PGW-U are deployed as combined Functions
   c. For 5GS and EPS interworking, MME and AMF are deployed as combined Functions
   d. For 5GS and EPS interworking, SGW, MME and AMF are deployed independently
2. Which operation is performed by the UE when it moves from EPC to 5GC in Idle mode?
   a. It always performs Tracking Area Update
   b. It triggers an Initial Attach
   c. It always performs Registration procedure
3. Which operation is performed by the UE when it moves from 5GC to EPC in Idle mode?
   a. It performs either Tracking Area Update or Initial Attach
   b. It always triggers Tracking Area Update
   c. It always performs Registration procedure

Interworking Procedures with N26 Interface
Connected Mode Mobility



N26 interface is used to provide seamless session continuity for single registration mode UE

- Mandatory for the UE, optional for the network
- UPF is the IP anchor: IP address is preserved (SSC mode 1)
- UE is served by either E-UTRAN/EPC or 5G RAN/5GC
- Common subscription data base: HSS/UDM
- Source core provides the target core with the UE context via N26 interface (subset of S10)
- UPF / SMF are regarded as PGW-U / PGW-C respectively, from the viewpoint of S-GW
- Without support for N26, IP address change is expected upon mobility
- No direct interworking with 2G/3G

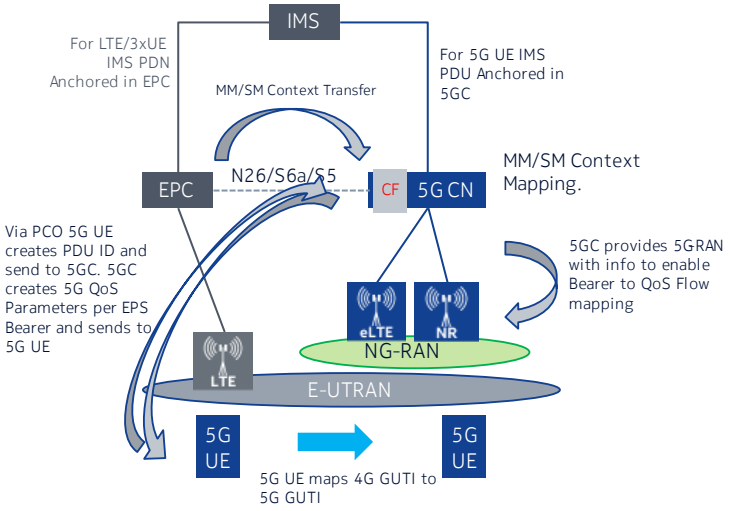
In Connected Mode mobility, Interworking between EPS and 5GS is supported with IP address preservation by assuming Session and Service Continuity mode 1 (SSC mode 1). As outlined previously, N26 interface is used to provide seamless session continuity for single registration mode UE.

For connected mode mobility from EPC to 5GC, either inter-system handover or RRC Connection Release with Redirection to NG-RAN is performed. At inter-system handover, the MME selects target AMF based on TAC used in the Target ID. During the Registration procedure, the HSS+UDM cancels any MME registration

For connected mode mobility from 5GS to EPS, either inter-system handover or RRC Connection Release with Redirection to E-UTRAN is performed. At inter-system handover, the AMF selects target MME based on 2 octet TAC format used in the Target ID. During the TAU or Attach procedure the HSS+UDM cancels any AMF registration associated with the 3GPP access (but not AMF registration associated with the non-3GPP access): an AMF that was serving the UE over both 3GPP and non-3GPP accesses does not consider the UE as deregistered over non 3GPP access.

Interworking Procedures with N26 Interface

EPS to 5GS Handover using N26 Interface



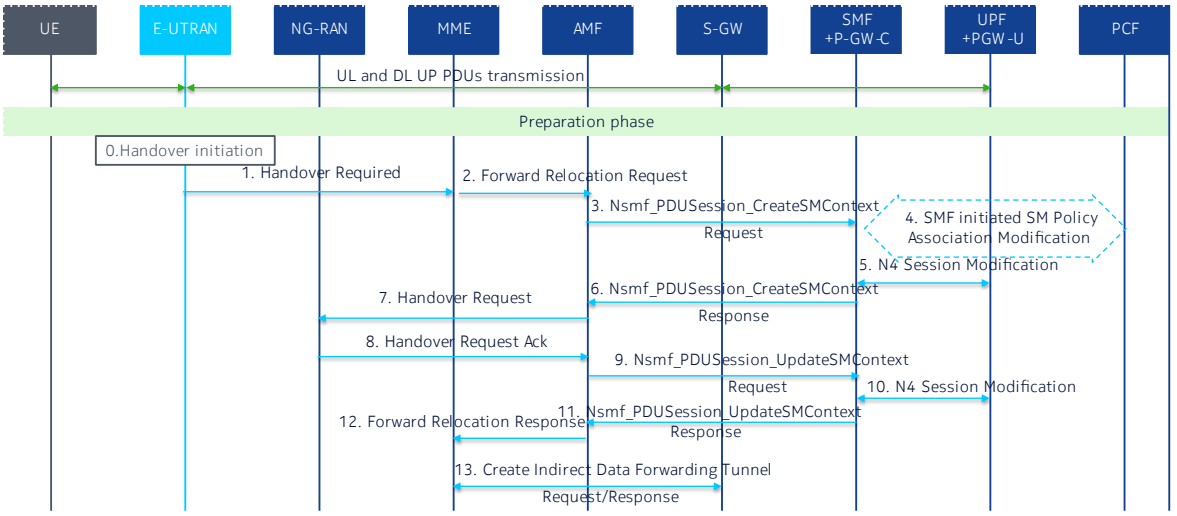
- During PDN Session Establishment 5G UE generates PDU Session ID and send via PCO to 5GC. 5GC generates 5G QoS Parameters and sends to 5G UE via PCO.
- EPS Bearer Establishment/Modification trigger 5GC to send 5G QoS parameters to 5G UE.
- During Handover from EPS to 5GS, the LTE RAN provides NG-RAN with Bearers to be handed over and NG-RAN creates QoS Flows for these bearers based on mappings from 5GC

EPS to 5GS handover procedure involves a handover to 5GS and setup of QoS Flows in 5GS.

The PGW-C+ SMF receives the PDU Session ID from UE and provides other 5G QoS parameters to UE. The IP address continuity can't be supported, if PGW-C+SMF doesn't provide the mapped QoS parameters.

Interworking Procedures with N26 Interface

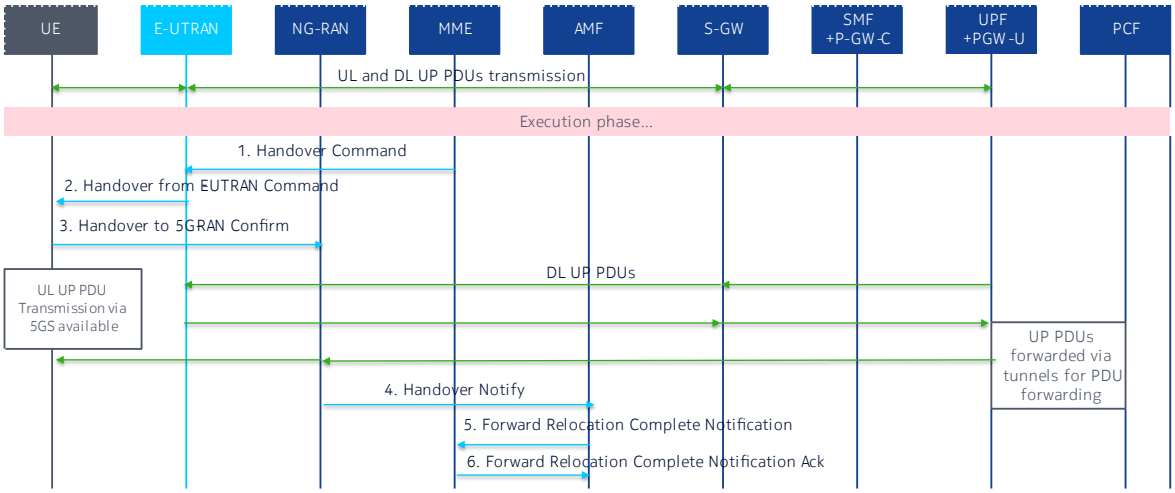
EPS to 5GS Handover using N26 Interface



1. eNB decides to initiate a handover to the gNBeNB sends to MME a Handover Required (MME UE S1AP ID, eNB UE S1AP ID, Target ID (Global RAN Node ID, Selected TAI), HO Type (=LTEtoNR), Cause (=S1 inter system Handover triggered), Source to Target Transparent Container (See TS 36.413), Direct Forwarding Path Availability (=not available)
2. Forward Relocation Request: MME selects AMF (based on TAC used in the Target ID).
3. AMF initiates SM Context creation in SMF using Nsmf_PDUSession_CreateSMContext Request service.
4. SMF initiated SM Policy Association Modification
5. SMF initiates N4 Session Modification procedure with the F-SEID to establish the CN Tunnel for the PDU Session. CN (UL) Tunnel info is allocated by UPF and UPF sends the tunnel info for PDU Session to the SMF. At this time UPF is ready to receive the uplink packets from gNB
6. SMF creates an SM context and acknowledges to AMF about SM context creation. SmContextCreatedData contains: PDU Session ID (corresponding to the default EPS bearer ID of the EPS PDN connection), S-NSSAI, HO State (=HO Preparation), Allocated EBI List, N2 SM Information (PDU Session ID, S-NSSAI, QFI(s), QoS Profile(s), EPS Bearer Setup List, CN (UL) Tunnel-Info, cause code).
7. AMF sends a Handover Request (AMF UE NGAP ID, HO Type (=EPSto5GS), Cause (=NG inter system handover triggered), UE-AMBR, UE Security Capabilities, Security Context, Source to Target Transparent Container, Per PDU Session (PDU Session ID, S-NSSAI, N2 SM Information)
8. gNB sends a Handover Request Acknowledge message with AMF UE NGAP ID, RAN UE NGAP ID, Target to Source Transparent Container, Per PDU Session (PDU Session ID, N2 SM response (PDU Session ID, list of accepted QFI(s), DL AN Tunnel Info, DL Forwarding Tunnel Info)
9. AMF initiates SM Context update in SMF using Nsmf_PDUSession_UpdateSMContext Request service to set up indirect data forwarding tunnels. Information included in SmContextUpdateData: GUAMI, Serving NF Id, Serving Network, N2 SM Information, HO State (=preparing). N2 SM Information contains what was received in N2 SM response in Step 9.
10. SMF initiates N4 Session Modification procedure with the F-SEID to establish the CN Tunnel for Data Forwarding. DL Forwarding Info is included in Session Modification Request. CN Forwarding Tunnel info is allocated by UPF and UPF sends the tunnel info for forwarding to SMF
11. SMF returns an Nsmf_PDUSession_UpdateSMContext Response (PDU Session Id, CN tunnel Info for Data Forwarding, EPS Bearer Setup List for forwarding) for creating indirect data forwarding
12. AMF responds to MME with Forward Relocation Response (Cause, AMF F-TEID for Control Plane, EPS Bearers setup list, Target to Source Transparent Container, SGW change indication, CN Tunnel Info for data forwarding).
13. MME sends a Create Indirect Data Forwarding Tunnel Request message (Bearer Contexts [EBI, CN Forwarding Tunnel info]) to the SGW. The Source SGW responds with a Create Indirect Data Forwarding Tunnel Response (Cause, Bearer Contexts [EBI, Cause, S1-U SGW F-TEID]) message to the Source MME.

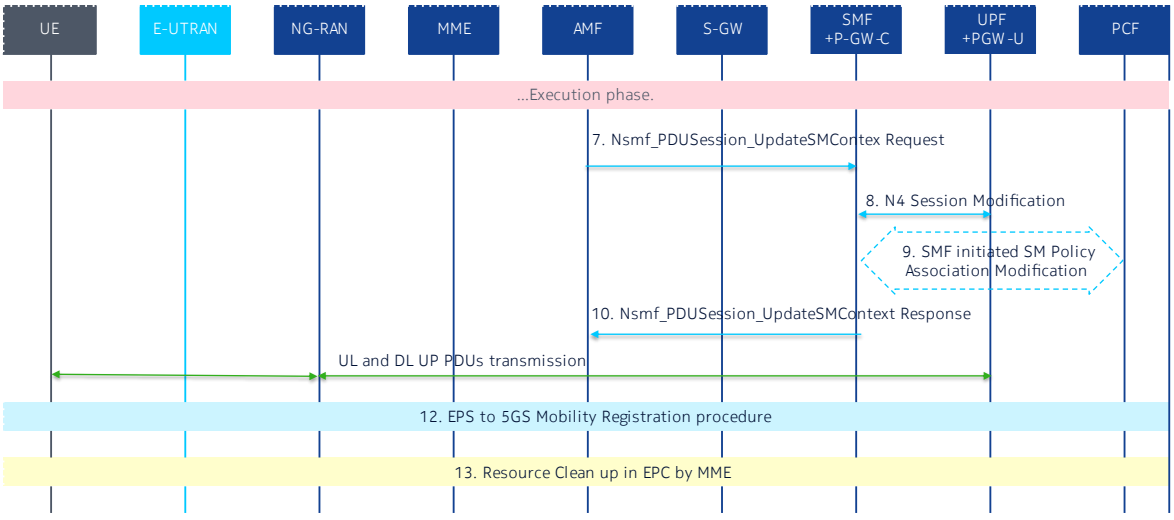
Interworking Procedures with N26 Interface

EPS to 5GS Handover using N26 Interface



1. MME sends the Handover Command (MME UE S1AP ID, eNB UE S1AP ID, Target to Source transparent container, CN tunnel info for data forwarding per PDU Session, E-RABs subject to forwarding, [E-RABs to Release]) to eNB. E-RABs subject to forwarding includes list of addresses and TEIDs allocated for forwarding.
2. eNB commands the UE to handover to the target access network by sending the Handover Command. The UE correlates the ongoing EPS Bearer IDs with the indicated QoS Flows to be setup in the HO command. UE gets the necessary parameters for target gNB in the Target to Source transparent container
3. After UE has successfully synchronized to the target cell, it sends Handover Confirm message (RRC Reconfiguration Complete) to gNB. Downlink packets forwarded from source eNB can be sent to UE. Also, uplink packets can be sent from UE to UPF
4. gNB sends Handover Notify message to AMF. It includes the N2 SM Information (DL AN Tunnel Info). A timer in AMF is started to supervise when data forwarding resources in UPF shall be released
5. AMF sends Forward Relocation Complete Notification message to MME.
6. MME in response sends a Forward Relocation Complete Acknowledge message to AMF. MME starts a timer to supervise when resources in eNB and data forwarding resources in SGW are released.

Interworking Procedures with N26 Interface
EPS to 5GS Handover using N26 Interface

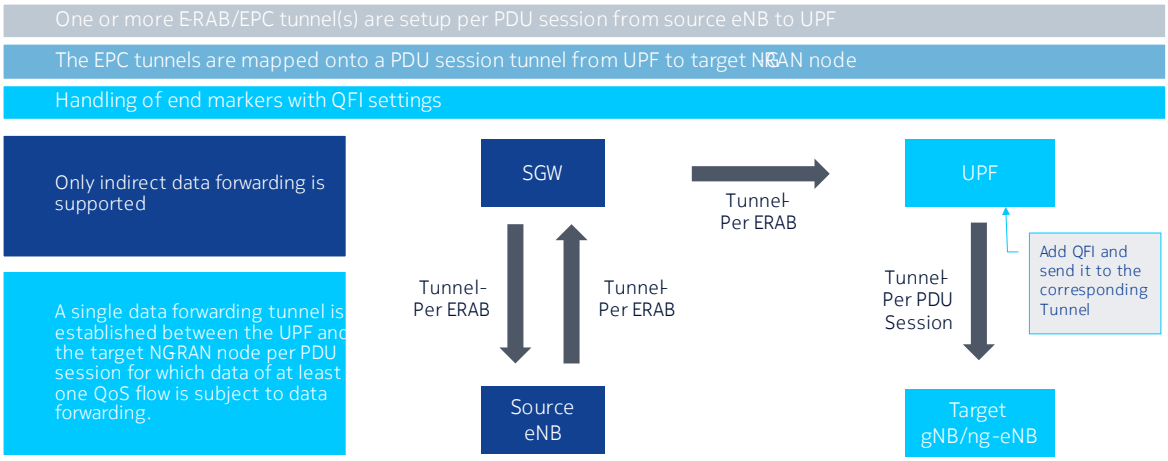


7. AMF invokes Nsmf_PDUSession_UpdateSMContext Request service operation to indicate the success of the N2 Handover. SmContextUpdateData contains – HO State (=completed), N2 SM Information (DL AN Tunnel Info).
8. SMF updates UPF with the DL AN Tunnel Info, indicating that DL User Plane for the indicated PDU Session is switched to gNB and the CN tunnels for EPS bearers corresponding to the PDU session can be released
9. SMF invokes Npcf_SMPolicyControl_Update service operation to request updating SM Policy. This is triggered by RAT Type trigger condition being met. SmPolicyUpdateContextData: PolicyControlRequestTrigger= Access/RAT Type Change, RAT Type = NR.
10. SMF returns an Nsmf_PDUSession_UpdateSMContext Response. SmContextUpdateData contains – HO State (=executing). Now both UL and DL N3 connection is established between UE and UPF via gNB
11. UE performs the EPS to 5GS Mobility Registration Procedure
12. MME sends UE Context Release Command (MME UE S1AP ID, eNB UE S1AP ID, Cause) to eNB. eNB responds to the MME with UE Context Release Complete message releasing the S1 connection between eNB and MME for the UE

- MME to SGW: Delete Indirect Data Forwarding Tunnel Request
- SGW to MME: Delete Indirect Data Forwarding Tunnel Response

Since indirect forwarding was applied, the expiry of the timer at MME started before triggers MME to send a Delete Indirect Data Forwarding Tunnel Request message to SGW. The Operation Indication flag shall not be set. This allows SGW to release the temporary resources used for indirect forwarding that were allocated earlier. SGW responds with Delete Indirect Data Forwarding Tunnel Response (Cause) to MME.

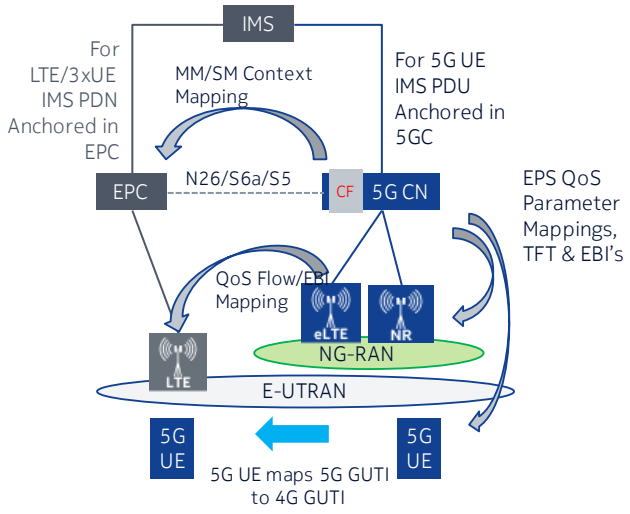
Interworking Procedures with N26 Interface
EPS to 5GS Handover using N26 Interface



Key principles for 4G to 5G data forwarding (5GS adapts to EPS)

- 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.
- 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.
- A single data forwarding tunnel is established between the UPF and the target NG-RAN node per PDU session for which data of at least one QoS flow is subject to data forwarding.

Interworking Procedures with N26 Interface
5GS to EPS Handover using N26 Interface

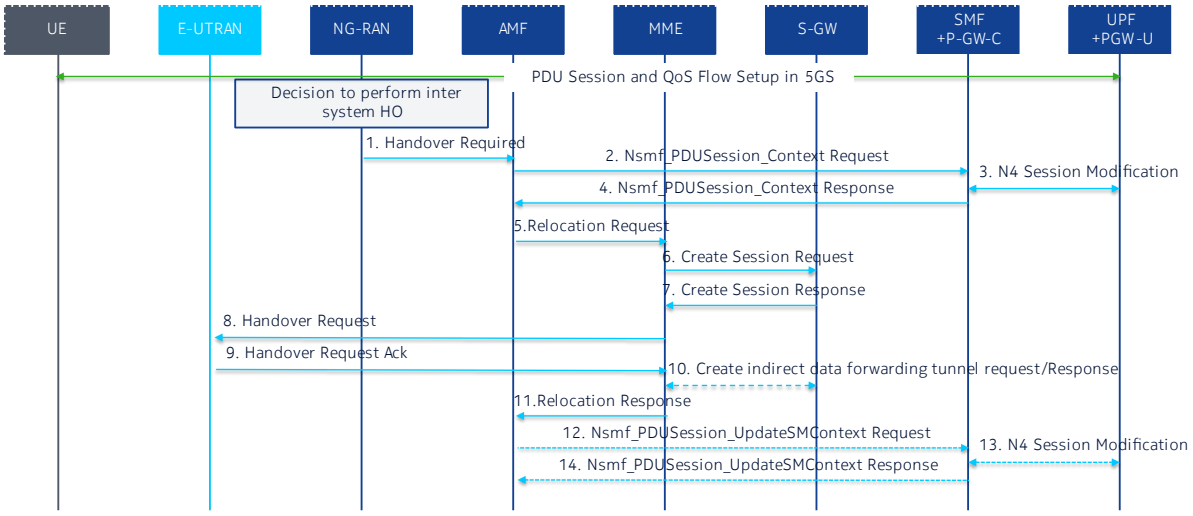


- During PDU Session/GBR Flow Establishment/Modification Mapped EPS QoS Parameters, TFT's & EPS Bearer ID's are generated in 5GC and provided to both UE and NGRAN.
- EPS Bearer ID's allocated to Default QoS Flow(nGBR) and GBR Flows.
- During Handover from 5GS to EPC, NGRAN provides QoS Flows and corresponding EPS Bearer ID's to LTE RAN & 5GC provides mapped UE MM & SM Contexts(via N26). Indirect Packet Forwarding Tunnels established between NGRAN/5GC/EPC/LTE.
- Default EPS Bearer Established to which Default QoS Flow & other Non GBR Flows are mapped. Dedicated EPS Bearer(s) Established to which GBR QoS Flows are mapped
- After HO completed Location Update triggered to register new and cancel old serving nodes plus 5GC ma establish Dedicated Bearers for the Non GBR Flows
- HO only supported for SSC Mode 1 PDU's. SCC Mode 2 &3 need to be reestablished.

5GS/UE manages QoS mapping between 5GS & EPS.

Interworking Procedures with N26 Interface

5GS to EPS Handover using N26 Interface



This protocol flow describes the 5GS to EPS handover procedure for single-registration mode with N26 interface

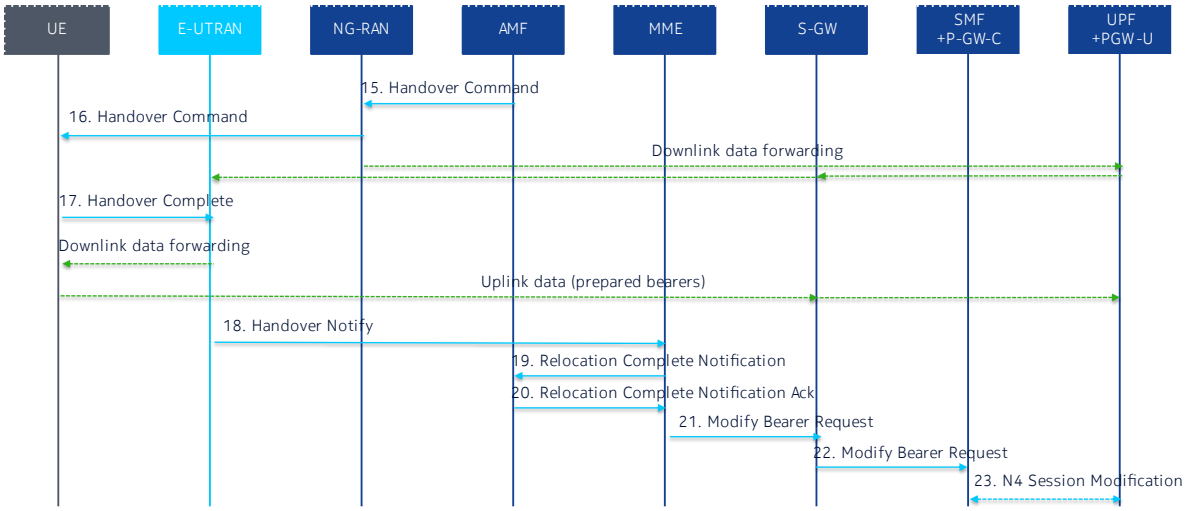
The procedure involves a handover to EPC and setup of default EPS bearer and dedicated bearers for GBR QoS Flows in EPC and re-activation, if required, of dedicated EPS bearers for non-GBR QoS Flows. This procedure can be triggered, for example, due to new radio conditions, load balancing or in the presence of QoS Flow for normal voice or IMS emergency voice, the source NG-RAN node may trigger handover to EPC.

gNB decides to initiate inter-system handover to target eNB

1. gNB sends to AMF a Handover Required (AMF UE NGAP ID, RAN UE NGAP ID, Target ID (Global eNB ID, Selected EPS TAI), HO Type (=5GStoEPS), Cause (=NG inter system Handover triggered), Source to Target Transparent Container (See TS 36.413), Direct Forwarding Path Availability (=Not Available), A list of PDU Sessions with PDU Session Id. AMF determines from the 'Target eNB Identifier' IE that the type of handover is Handover to E-UTRAN. AMF will select an MME for the Selected EPS TAI
2. AMF invokes Nsmf_PDUSession_Context Request service operation to retrieve an SM context of a PDU session from SMF
3. SMF sends N4 Session modification to UPF to establish the CN tunnel for each EPS bearer. UPF is ready to receive the uplink packet from E-UTRAN
4. SMF returns the SM context for the PDU session that also includes the mapped EPS Bearer Contexts. Mapped EPS Bearer Context: {EPS Bearer Identity (EBI), S1-U eNB F-TEID, PGW F-TEID for user plane, EPS QoS}.
5. AMF selects MME. AMF sends Forward Relocation Request (IMSI, AMF F-TEID for Control Plane, MME UE EPS PDN Connections (Per PDN). SGW address and TEID for control signaling, UE MM Context)
6. MME sends a Create Session Request message (IMSI, Serving Network, RAT Type (=EUTRAN), MME F-TEID for Control Plane, PGW Address and F-TEID for C-plane, APN, PDN Type, Maximum APN Restriction, Linked EPS Bearer Identity (LBI), Bearer Context(s) [EBI, S1-U eNB F-TEID, PGW F-TEID for user plane, EPS QoS]).
7. SGW allocates its local resources and returns them in a Create Session Response (Cause, Sender F-TEID for Control Plane, APN Restriction, Bearer Context(s) Created [EPS Bearer ID, Cause, S1-U SGW F-TEID], Bearer contexts marked for removal [EPS Bearer ID, Cause]) message to MME
8. MME sends Handover Request (MME UE S1AP ID, HandoverType, Cause, UE AMBR, E-RABs To Be Setup List [E-RAB ID, Transport Layer Address, GTP TEID, E-RAB Level QoS Parameters]], Source to Target Transparent Container, UE Security Capabilities, Security Context) message to target eNB.

Interworking Procedures with N26 Interface

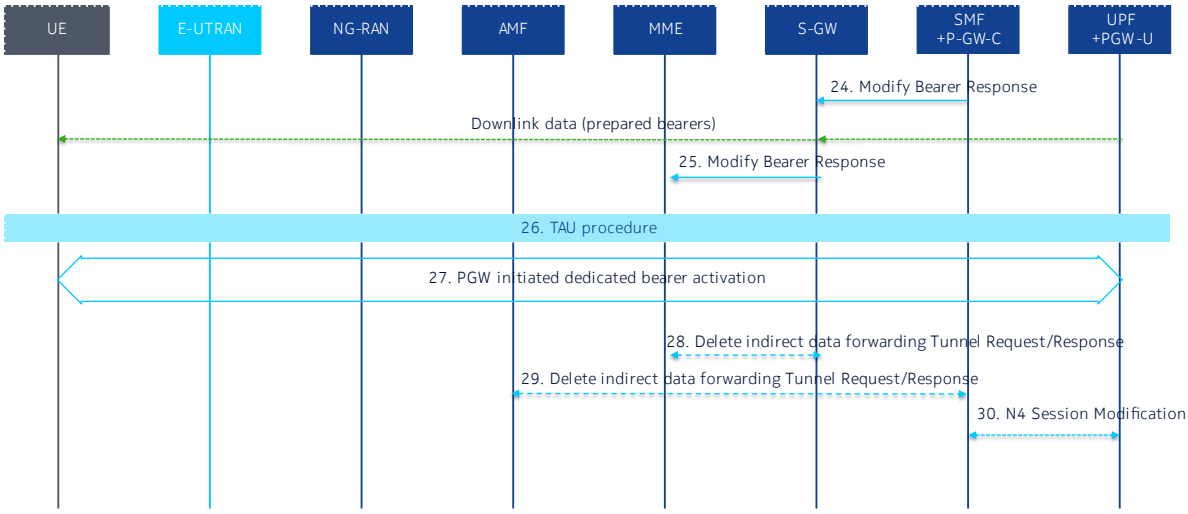
5GS to EPS Handover using N26 Interface



9. eNB sends Handover Request Acknowledge (MME UE S1AP ID, eNB UE S1AP ID, E-RABs Admitted List [E-RABs Admitted Item IEs [E-RAB ID, Transport Layer Address, GTP-TEID, DL Transport Layer Address (optional), UL Transport Layer Address (optional), UL GTP TEID (optional)]]
10. MME sends a Create Indirect Data Forwarding Tunnel Request message (Bearer Contexts [EBI, eNB F-TEID for data forwarding]) to the SGW. SGW returns a Create Indirect Data Forwarding Tunnel Response (Cause, Bearer Contexts [EBI, Cause, S1-U SGW F-TEID]) message to MME
11. MME responds to AMF with Forward Relocation Response (Cause, MME F-TEID for Control Plane, EPS Bearers setup list, List of Setup RABs, Target to Source Transparent Container, SGW Change Indication)
12. AMF invokes Nsmf_PDUSession_UpdateSMContext Request service operation for creating indirect data forwarding tunnel.
13. SMF initiates N4 Session Modification procedure with the F-SEID to prepare the CN Tunnel Info for each EPS bearer
14. SMF returns an Nsmf_PDUSession_UpdateSMContext Response (Cause, CN tunnel Info for Data Forwarding, QoS flows for Data Forwarding) for creating indirect data forwarding
15. AMF sends the Handover Command (Target to Source transparent container, CN tunnel info for data forwarding per PDU Session, QoS flows for Data Forwarding) to gNB
16. gNB sends UE the Handover Command to the UE. The UE correlates the ongoing QoS Flows with the indicated EPS Bearer IDs to be setup in the HO command
17. After UE has successfully synchronized to the target cell, it sends Handover Confirm message (RRC Reconfiguration Complete) to eNB
18. eNB sends Handover Notify (ECGI, TAI) message to MME. A timer in MME is started to supervise when resources in eNB and data forwarding resources in SGW shall be released.
19. MME sends Forward Relocation Complete Notification message to AMF
20. AMF in response sends a Forward Relocation Complete Acknowledge message to MME. AMF starts a timer to supervise when resources in gNB and data forwarding resources in SMF are released.

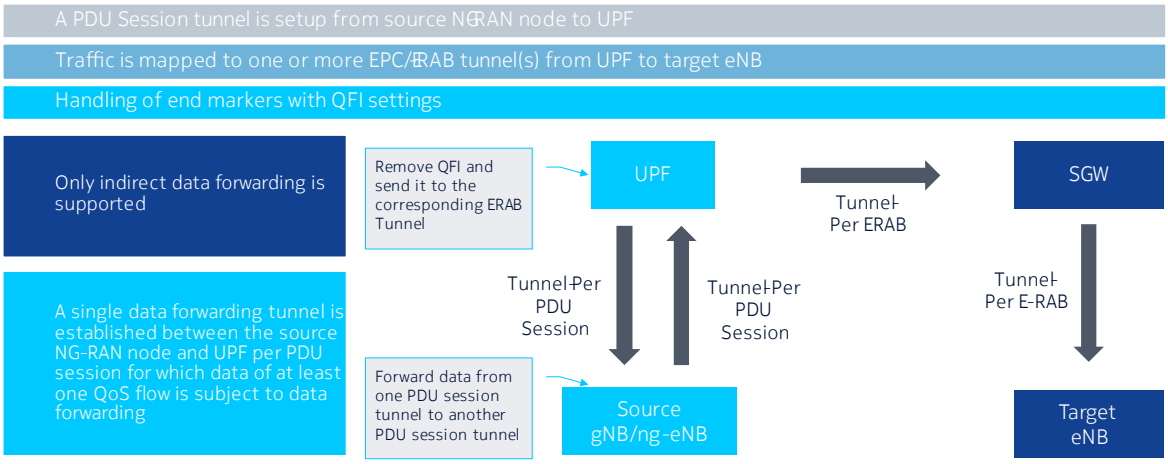
Interworking Procedures with N26 Interface

5GS to EPS Handover using N26 Interface



21. MME sends a Modify Bearer Request message (Bearer Contexts to be modified [EBI, S1 eNB F-TEID], Bearer Contexts to be removed (if any)) message to SGW
22. SGW sends a Modify Bearer Request (SGW F-TEID for Control Plane, Bearer Contexts to be modified [EBI, S5/S8-U SGW F-TEID]) to SMF
23. SMF initiates a N4 Session Modification procedure towards the UPF to update the User Plane path. The SMF releases the resource of the CN tunnel for PDU Session in UPF
24. SMF responds with Modify Bearer Response (Cause, MSISDN, Bearer Contexts Modified [EBI, Cause]) to SGW
25. SGW sends a Modify Bearer Response (Cause, Bearer Contexts modified [EBI, S1-U SGW F-TEID], Bearer Contexts removed [EBI, Cause] (if any)) message to MME. Bearer Contexts marked for removal IE is included in mobility cases, where any of the bearers will be deactivated as consequence of mobility procedure
26. UE initiates connected mode Tracking Area Update Procedure.
27. SMF initiates dedicated bearer activation procedure for non-GBR QoS Flows by mapping the parameters of the non-GBR Flows to EPC QoS parameters
28. Since indirect forwarding was applied, the expiry of the timer at MME started earlier triggers MME to send a Delete Indirect Data Forwarding Tunnel Request message to SGW
29. The AMF to invoke Nsmf_PDUSession_UpdateSMContext Request service operation with an indication to release the forwarding tunnels of the V-SMF, in order to release temporary resources used for indirect forwarding that were allocated earlier.
30. SMF initiates N4 Session Modification procedure towards UPF with the F-SEID to remove the CN Tunnel Info created for data forwarding.

Interworking Procedures with N26 Interface
5GS to EPS Handover using N26 Interface



Key principles for 5G to 4G data forwarding:

- 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 (received earlier at PDU Session Setup).
- At handover preparation, the source NG-RAN node will 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 data of at least one QoS flow is subject to data forwarding.

Interworking Procedures with N26 Interface
Quiz 3

1. When does PGW -C+SMF perform 5GS -EPS QoS mappings for a UE served by the 5GC?
   a. during PDU Session establishment
   b. during GBR QoS Flow establishment
   c. PDN connection establishment
   d. during non-GBR QoS Flow establishment
2. When does PGW -C+SMF perform EPS -5GS QoS mappings for a UE served by the EPC?
   a. during PDN Connection establishment
   b. during dedicated bearer establishment
   c. during PDU Session establishment
   d. during GBR QoS Flow establishment

Wrap-up

In this module we have covered the following items:

- Describe the Architecture for the interworking between 5GS and EPC.
- Explain Single registration and Dual registration.
- Describe EPS to 5GS Idle mode mobility.
- Describe 5GS to EPS Idle mode mobility.
- Describe EPS to 5GS handover using N26 interface.
- Describe 5GS to EPS handover using N26 interface.