



Local Breakout-based Roaming Support

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Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	SMF
Applicable Platform(s)	SMI
Feature Default Setting	Enabled – Always-on
Related Changes in this Release	Not Applicable
Related Documentation	Not Applicable

Revision History

Table 1: Revision History

Revision Details	Release
First introduced.	2021.01.0

Feature Description

SMF supports local breakout based roaming with this release. Following roaming features are supported:

- Roaming for 5G sessions connected via NR
- Roaming for 4G/WiFi sessions connected via EUTRAN

- LI support
- Deployment model with/with out SEPP

**Important**

Refer "Multiple PLMN Support" section for Roaming Status of the subscriber and to determine the Serving PLMN in detail.

Architecture

How Roaming Status is Derived

CLI-based Roaming Status derivation

- Checking Subscriber Policy
- User reference for Multi PLMN
- If UE PLMN and serving PLMN both belong to SMF PLMN list, then it's a home subscriber.
If UE PLMN doesn't belong to SMF PLMN and serving PLMN belongs to PLMN list, then it's a visitor-lbo subscriber.

Roaming Status configuration has higher precedence.

LBO SMF

SMF supports local breakout functionality for in-roamers, following key features supported by SMF.

- Detection of in-roamers – based on local configuration and MCC/MNC in the SUPI received.
- N11
 - Determination of LBO (or HR) for the in-roamers, if LBO can't support, SMF sends Error to AMF so that AMF reinitiates the PDU session establishment procedure with HR.
 - Support of PCF ID that is V-PCF from AMF.
- N2
 - SMF provides S-NSSAI of VPLMN in the N2 SM Information.
- N7
 - Selection of PCF in VPLMN
 - vPCF interacts with AF in HPLMN for PCC rule generation (ex: IMS), however, PCC rules are otherwise generated using roaming policies and vPCF doesn't have access to the subscribed policies in HPLMN. Also vPCF doesn't interact with CHF for spending limits. Given this, PCC rules in LBO are expected to be restricted in capabilities.
- N40

- Selection of CHF in VPLMN, apart from selecting CHF from VPLMN, vSMF considers additional parameters of the HPLMN ID that CHF has to service the roamer status (in-roamer) of the UE.
- N10
 - Selection of UDM in HPLMN
- NRF
 - SMF uses the “chf-supported-plmn” in query parameters while discovering vCHF servicing HPLMN.
 - During EPS procedures, if the PGW-C+SMF supports more than one S-NSSAI and the APN is valid for more than one S-NSSAI, before the PGW-C+SMF provides an S-NSSAI to the UE, it has to use the Nnssf_NSSelection_Get service operation to retrieve a mapping of the Subscribed S-NSSAIs to Serving PLMN S-NSSAI values.

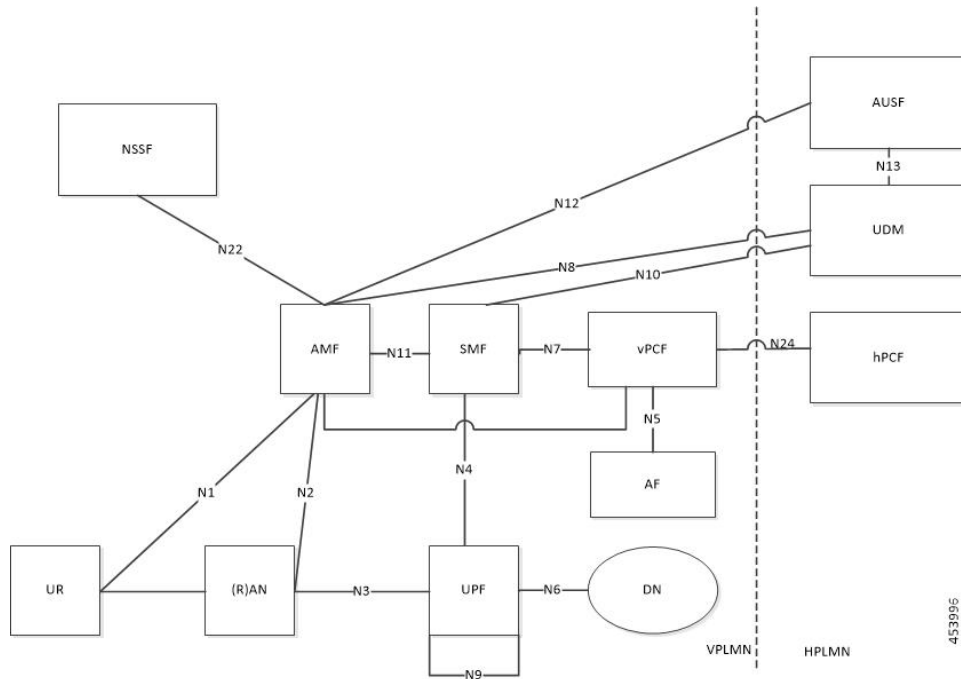
Node Selection considerations

- When roaming is enabled, each SMF registers interPlmnFqdn with NRF. This helps AMF to select hSMF in a different PLMN.
- SMF supports target-plmn-list and requester-plmn-list as part of query parameters.
- All NF discovery queries happen to NRF in the serving PLMN.

5G-NR LBO Scenario

The following diagram shows a 3GPP reference point for nodes in VPLMN and HPLMN for a local breakout case for the 5G sessions:

Figure 1: Local Breakout Roaming Architecture for 5G Sessions

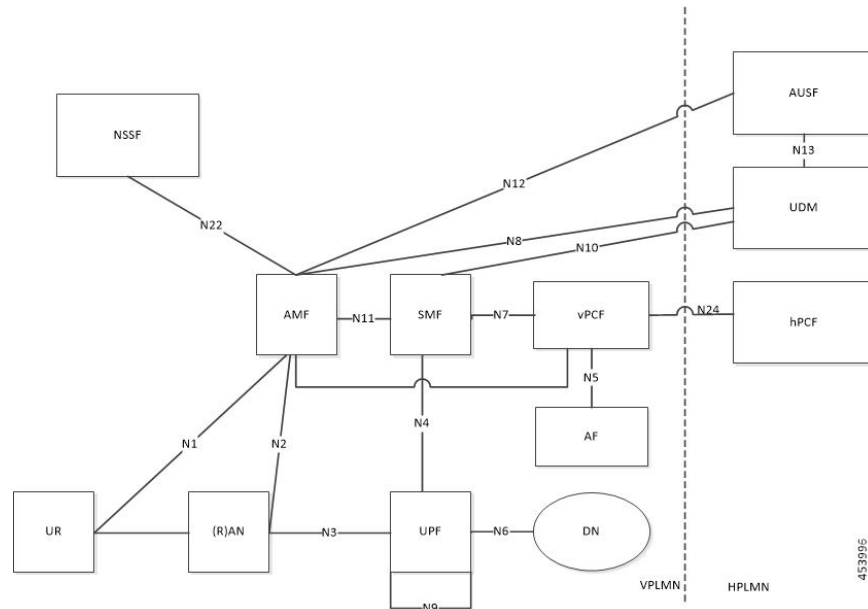


As shown in the preceding diagram, the SMF resides in the VPLMN. Only AUSF and UDM are the NFs in the HPLMN. The PCF in the VPLMN can communicate with PCF in the HPLMN over N24 interface to get the policies related to the subscriber session and pass them to SMF.

EPC LBO

The following diagram displays the local roaming architecture breakout for the 4G sessions connected to the SMF + PGW-C in EPC interworking case:

Figure 2: Local Breakout Roaming Architecture for 4G Sessions



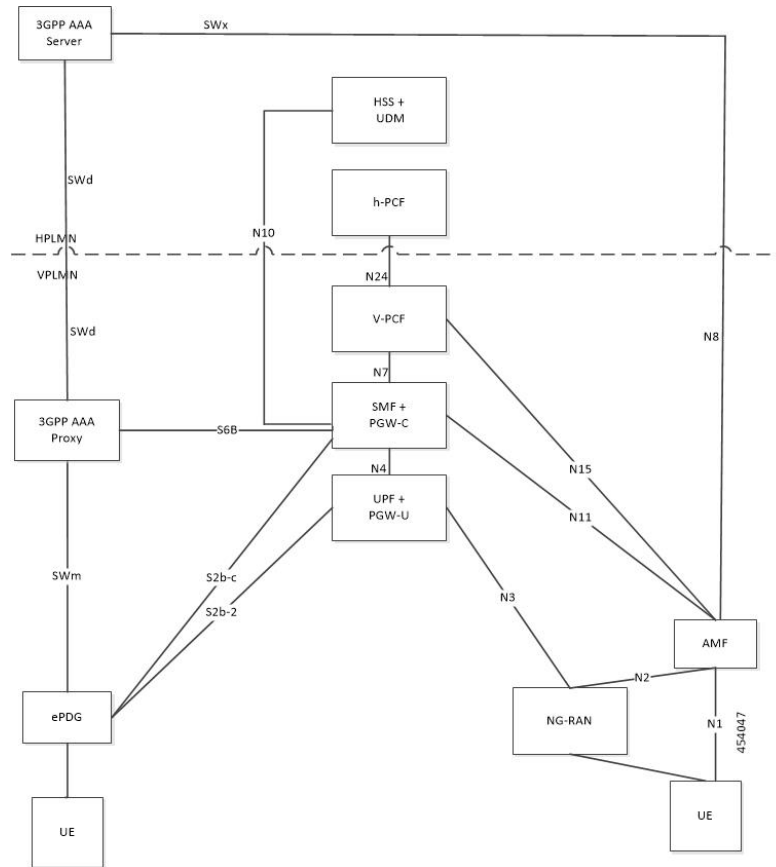
During LBO roaming for 4G sessions, the SGW and the SMF+PGW-C both reside in VPLMN. All northbound SBI interfaces are common for 4G and 5G case.

- SMF-IWK resides in vPLMN
- SMF-IWK interacts with vPCF, vCHF
- SMF-IWK interacts with UDM (in hPLMN).
- SMF-IWK supports S5-c interface towards SGW.

ePDG LBO

The following diagram displays the local roaming architecture breakout for the Wi-Fi sessions connected to the SMF + PGW-C in EPC interworking case:

Figure 3: Local Breakout Roaming Architecture for Wi-Fi Sessions



- SMF+IWK resides in vPLMN.
- SMF-IWK interacts with vPCF, vCHF.
- SMF-IWK interacts with UDM (in hPLMN).
- SMF-IWK doesn't support S6b towards 3GPP AAA proxy, instead N10 is used (N10->SWx->SWd).

5G PDU Establishment During LBO

This section describes the requirements on SMF for PDU session establishment in LBO roaming case:

1. If SMF at vSMF isn't able to handle or process any parameter in the NAS PDU SESSION ESTABLISHMENTT REQUEST it would send a SmContextCreateError back to AMF with cause HOME_ROUTED_ROAMING_REQUIRED so that AMF can reinitiate the process with home routed roaming. The example for this is when NAS PDU SESSION ESTABLISHMENTT REQUEST has requested SSC mode as 3 and allowed SSC mode in vSMF doesn't support this.
2. SMF receives both hplmnSnsai and sNssai. The validation of Nssai against the vSMF's supported Nssai is done using sNssai.
3. On N40 interface:

- a. vSMF will fill the PDUSessionChargingInformation □ userInformation □ roamerInOut attribute value towards CHF in the CDR message. The value should be filled as IN_BOUND for in-roamers and OUT_BOUND for out-roamers.
 - b. vSMF fills the PDUSessionInformation □ chargingCharacteristicsSelectionMode IE with appropriate value (HOME_DEFAULT, ROAMING_DEFAULT and VISITING_DEFAULT) for non-roaming and roaming cases.
 - c. hPlmnId and servingCNPlmnId fields in the PDUSessionInformation IE must be filled as per the roaming status of the UE.
4. During N1N2MessageTransfer the sNSSAI provided in N2 content should be the VPLMN sNSSAI.
 5. For LBO roaming scenario, the PDU Session Establishment Accept includes the S-NSSAI from the Allowed NSSAI for the VPLMN and also it includes the corresponding S-NSSAI of the HPLMN from the Mapping Of Allowed NSSAI that SMF received from AMF.
 6. For an emergency session, even if the local configuration allows UDM registration for authenticated UE, vSMF shouldn't do it for roaming cases.
 7. SMF uses HPLMN for UDM discovery for LBO Roaming.

4G PDN Establishment During LBO

The SGW sends Serving Network IE to the PGW with the PLMN id where the SGW belongs. SMF uses that PLMN as VPLMN for validation, node selection and passing on the VPLMN to other north bound interfaces.

The N40 interface related requirements and the emergency session related requirements applicable for 5G session creation, also apply for the 4G and Wi-Fi sessions.

Session Management

- With roaming considerations, SMF sessions can be categorized into the following flavors.
 - Non-roaming sessions
 - LBO Sessions
 - vSMF-HO sessions
 - hSMF-HO sessions
- SMF supports all flavors of sessions in the same network function deployment, also the SMF service pods service sessions of all the mentioned flavors.
- UE1 – in-bound roamer, LBO (262-06)
- UE2 – in-bound roamer, HR (302-610)
- UE3 – out-bound roamer, HR (310-310)
- UE4 – homer (310-240)
- SMF – Operator's SMF
 - List of home PLMNs – configured under service profile. When multiple PLMNs are configured, one is marked as primary home PLMN.

- 310-310, 310-240*(primary)
- List of (roaming) serving PLMNs (excluding home PLMNs), optional – configured under service profile
 - 262-06, 302-610
- AMF1 – Operator’s AMF serving 310-240
- AMF2 – Operator’s AMF serving 310-310
- AMFp – Partner’s AMF serving 262-06; 302-610
- SMFp – Partner’s SMF serving Operator’s 310-310; 310-240

PLM Usage

Interface	Attribute	Home(UE4)	In-roamer(LBO)(UE1)	Out-roamer(HR)(UE3)	In-roamer(HR)(UE2)
	UE PLMN	310-240	262-06	310-310	302-610
NRF	plmn-list in nrf Discover to discover UDM (queryParam)	310-240(UE plmn)	262-06(UE plmn)	310-310 (UE plmn)	NA
NRF	plmn-list in nrf Discover to discover RCH (queryParam)	310-240(UE plmn)	310-310(serving plmn)	310-310(UE plmn)	310-310(serving plmn)
N10	plmn in smfRegistration IE in N10 registration	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA
N10	plmn in GET subscription URI	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA
N10	plmn in sdmSubscription IE in N10 subscription	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA
N40	plmn in N40 charging data request	310-240(primary home plmn)	310-240(primary home plmn)	310-240(primary home plmn)	310-240(primary home plmn)

Interface	Attribute	Homer(UE4)	In-roamer(LBO)(UE1)	Out-roamer(HR)(UE3)	In-roamer(HR)(UE2)
N40	hPlmnId In PDUSession IE in plmnChange in chargingDataRequest	310-240(UE plmn)	262-06(UE plmn)	310-310 (UE plmn)	302-610(UE plmn)
N40	Servingplmn in PDUSession IE in plmnChange in chargingDataRequest	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	310-310(serving plmn)
N7	plmn in pcf notify for ACN trigger	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA
N7	plmn in create request to PCF	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA
Radius	plmn in 3GPP ue location IE radius authentication	310-240(serving plmn)	310-310(serving plmn)	NA	
Radius	plmn in 3GPP GGSN MCCMNC in radius authentication	310-240(primary home plmn)	310-240(primary home plmn)	NA	
N4	plmn in Xheader of N4 requests	310-240(serving plmn)	310-310(serving plmn)	310-240(primary home plmn)	NA

Roaming Status Determination

SMF home PLMN supported values:

(home PLMNs)310+310

310+320 (Opr-1 (SMF profile)

(Partner PLMN) 600+300 (Opr 2/Opr-1 that require roaming treatment) (Subscriber policy – 600+300)

1. UE – 310+310 comes from 310+320 => homer (my UE + my serving network).
2. UE – 600+300 comes from 310+310 => in-LBO or in-hrt based on policy/subscription (other UE + my serving network) WRONG CASE.

3. UE – 310+310 comes from 600+300 => out-hrt (my UE + other serving network).
4. UE- 600+300 comes from 600+300=> In-LBO or In-HRT.

HO Scenarios



Note Once roamer status is determined, there wont be change to the status even if the configuration or PLMN values change post HO.

Local Policies

In HO scenarios, vSMF has to support local policy for the following attributes to enable vPLMN operators to override the signaled parameter from hPLMN domain as per the roaming agreements.

- To allow always-on session requests.
- Paging policy differentiation feature
- PDU session setup in HR or LBO mode
- Subscriber QoS as per the roaming agreement
- Allow ARP priority levels 1-8 for HO roaming sessions.
- Secondary RAT usage support towards vCHF (LBO), towards hSMF (HO)

In case of home routed roaming, as per the local QoS policies governed by roaming agreements and/or SLAs, if vSMF can't accept the requested QoS from hSMF, it performs the following:

- If the vSMF doesn't accept the PDU Session, the vSMF triggers the vSMF initiated PDU Session Release procedure during PDU setup or modifications.
- When the vSMF accepts at least one QoS flow, it transfers (via the AMF) the corresponding N2 (and NAS) request towards the 5G AN (and the UE) but doesn't issue requests for the QoS Flow(s) it has rejected due to these policies. The vSMF notifies the hSMF about the rejected QoS Flows.

Other Procedures

Paging Policy Differentiation (PPD): SMF needs a config per PLMN to allow different PPD profile for different roaming partners. The vSMF picks the appropriate config for the HPLMN and applies the same for the roaming session.

PCF and UDM Selection:

1. In case of roaming the AMF may select both vPCF and hPCF and can send the vPCF Id to SMF and hPCF Id to the vPCF during policy association. SMF selects the PCF using the received vPCF Id. Later during AMF relocation, target AMF may select a new vPCF and hPCF. When this happens SMF may receive a redirection indication with PCF ID from the existing PCF for the PDU session, the SMF shall terminate the current SM Policy Control association and reselects a PCF based on the received PCF ID. The SMF shall then establish an SM Policy Control association with the reselected PCF.

2. For selection of PCF and UDM based on local configuration the locally configured addresses should map to the VPLMN and HPLMN respectively since the PCF is in VPLMN and UDM is in HPLMN for roaming with LBO case.
3. For NRF-based discovery of PCF and UDM, the query criteria should include VPLMN for PCF discovery and HPLMN for UDM discovery. The AMF can also send the UDMGroup Id to enable SMF select UDM based on UDM group Id. The S-NSSAI used by SMF to select PCF should be the VPLMN S-NSSAI received from AMF. It should be HPLMN N-SSAI for the UDM selection.

Lawful Interception: For IRI events reporting from SMF, the sNSSAI information is sent in the message to mediation device. The sNSSAI of the VPLMN is used for roaming cases.

