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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Study on User data interworking, coexistence and migration

(Release 16)

** 

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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# 1 Scope

The objective of this Technical Report is to investigate scenarios for co-existence of subscription data pertaining to legacy system (EPS) with data pertaining to the 5G system, when the HSS+UDM defined in Rel-15 is separated and both UDM and HSS are independent, and will propose solutions to support this deployment where necessary.

NOTE 1: The subscription data referred to by this Technical Report comprises both static as well as dynamic data, including IMS, LCS, SMS data.

- study diverse scenarios related to the storage of subscription data including, but not limited to, those of common repository for subscription data from EPS and 5GS, as well as separate repositories for EPS and 5GS subscription data,

- investigate the relevant procedures in TS 23.502 [2] (for e.g. authentication, mobility, handover and procedures for IMS and SMS handling in interworking between 5G system and EPS),

- determine if there is a need for interaction between the consumers of EPS and 5GS data, in the different interworking cases and deployment scenarios.

Existing procedures in TS 23.502 [2] shall not be impacted.

Provisioning aspects are outside this study.

Direct interactions between the EPS UDR and the 5GS UDR are out of the scope of this TR (i.e. it is assumed that there is no direct interaction between these two repositories).

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.502: "Procedures for the 5G System".

[3] 3GPP TS 23.335: "User Data Convergence (UDC); Technical realization and information flows; Stage 2".

[4] 3GPP TS 29.335: "User Data Convergence (UDC); User data repository access protocol over the Ud interface; Stage 3".

[5] 3GPP TS 23.002: "Network architecture".

[6] 3GPP TS 23.501: "System Architecture for the 5G System".

[7] 3GPP TS 23.228: "IP Multimedia Subsystem".

[8] 3GPP TS 23.380: "IMS Restoration Procedures".

[9] 3GPP TS 29.505: "5G System; Usage of the Unified Data Repository services for Subscription Data".

[10] 3GPP TS 29.228: "IP Multimedia (IM) Subsystem Cx and Dx Interfaces; Signalling flows and message contents".

[11] 3GPP TS 29.328: "IP Multimedia (IM) Subsystem Sh interface; Signalling flows and message contents".

[12] 3GPP TS 33.501: "Security architecture and procedures for 5G System".

[13] 3GPP TS 33.401: "System Architecture Evolution (SAE) - Security architecture".

[14] 3GPP TS 23.794: "Study on Enhanced IMS to 5GC Integration".

[15] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[16] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[17] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3".

[18] 3GPP TS 29.214: "Policy and charging control over Rx reference point".

# 3 Definitions and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**5G Repository**: Repository hosting subscription data for 5G UEs.

**5GS UDR**: term used to identify the Unified Data Repository defined in TS 23.501 [6] (clause 4.2.5).

**EPS UDR**: term used to identify the User Data Repository defined in TS 23.335 [3] (clause 4.2.3).

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

5GC 5G Core

5GS 5G System

5GS UDR 5G Unified Data Repository

HSS FE Home Subscriber Server Front End

EPS Enhanced Packet core System

EPS UDR EPS User Data Repository

E-UTRAN Evolved Universal mobile telecommunications system Terrestrial Radio Access Network

UDM Unified Data Management

# 4 Architectural Assumptions and Principles

## 4.1 Architectural Assumptions

The 5GS data storage architecture defined in TS 23.501 [6], for structured data, is used as the baseline network architecture.

The User Data Convergence concept specified in TS 23.335 [3], is used for reference to EPS/legacy system architecture for data storage, when layered architecture is deployed (i.e. application front-end decoupled from data repository using the standard interface Ud defined in TS 29.335 [4]).

The Home Subscriber Server (HSS) architecture specified in clause 4.1.1 of TS 23.002 [5], is used for reference to EPS/legacy system architecture for data storage, when non-layered HSS architecture is deployed (i.e. monolithic deployment where user data are stored within the entity itself (or in an external entity via non-standard interfaces)).

## 4.2 Architectural Principles

In the UDC concept used for reference, HSS FE and EPS UDR defined in TS 23.335 [3] are assumed to interact for any data required by the study: no standardization will be considered for the interface between HSS FE and EPS UDR.

# 5 Key Issues

## 5.1 Key Issue 1: Interaction between UDM and HSS with separate repositories

### 5.1.1 Description

This key issue, which assumes the HSS is deployed using the UDC architecture in TS 23.335 [3], is to study how the UDM and HSS with separate repositories interact in the scenario that the HSS FE and UDM are separately deployed and the user data of 5G and 4G/3G/2G are also stored separately in different repositories (i.e. EPS UDR storing user data for 4G/3G/2G and IMS domains and 5GS UDR storing user data for 5G domain).

The interaction between UDM and HSS FE with separate repositories should be based on specific procedures that require data from one to the other.

The solutions to this key issue need to:

- Clarify what user data is involved for the interaction between UDM and HSS FE with separate repositories;

- Study the scenarios of interaction between UDM and HSS FE with separate repositories, specifically:

- IMS and 5GS interworking required for the following cases:

- Terminating Access Domain Selection (T-ADS).

When requested by IMS, the HSS+UDM shall be able to query the serving AMF for T-ADS related information (see clause 5.16.3.6 in TS 23.501 [6]).

- P-CSCF Restoration

As defined in clause 5.8.4 in TS 23.380 [8], upon request by IMS when P-CSCF failure is detected, the HSS+UDM shall send a P-CSCF restoration indication to either the SMF serving the IMS PDU session for the UE or to the AMF serving the UE.

- Network Provided Location Information (NPLI).

As defined in clause Y.6 in TS 23.228 [7], an IMS AS can trigger the retrieval of the user location and/or UE Time Zone information from the AMF via the HSS+UDM.

- EPS and 5GS interworking required for mobility cases from EPS to 5GS and from 5GS to EPS, including the impacts on SMS handling.

- Avoid the impact on existing procedures between HSS/UDM and the rest of the network.

## 5.2 Key Issue 2: Supporting a common repository for both HSS and UDM

### 5.2.1 Description

This key issue studies network deployments where a common repository (acting as EPS UDR and 5GS UDR) is shared between HSS and UDM, analyses the interactions between the HSS, UDM, & common repository, and examines the potential of shared data fields in the repository.

The solutions to this key issue need to:

- Study the scenarios of interaction between UDM and HSS FE with common repository, specifically:

- IMS and 5GS interworking required for the following cases:

- Terminating Access Domain Selection (T-ADS).

When requested by IMS, the HSS+UDM shall be able to query the serving AMF for T-ADS related information (see clause 5.16.3.6 in TS 23.501 [6]).

- P-CSCF Restoration

As defined in clause 5.8.4 in TS 23.380 [8], upon request by IMS when P-CSCF failure is detected, the HSS+UDM shall send a P-CSCF restoration indication to either the SMF serving the IMS PDU session for the UE or to the AMF serving the UE.

- Network Provided Location Information (NPLI).

As defined in clause Y.6 in TS 23.228 [7], an IMS AS can trigger the retrieval of the user location and/or UE Time Zone information from the AMF via the HSS+UDM.

- EPS and 5GS interworking required for mobility cases from EPS to 5GS and from 5GS to EPS, including the impacts on SMS handling.

# 6 Solutions

## 6.1 Solution #1: Retrieving subscription data from separate UDR repositories for EPS and 5GS subscription data using a UDR Translation Function (UTF)

### 6.1.1 Introduction

Solution #1 addresses Key Issue 1.

### 6.1.2 High-level Description

It is proposed to introduce a UTF (UDR Translation Function) to allow subscription data exchange between the HSS FE and the UDM when each function has a separate UDR repository. The UTF is a logical function that can be standalone or collocated with the UDM or HSS FE. The assumption with the proposed architecture is that the UDR database of the UDM contains the related 5G subscription data, whereas the UDR of the HSS FE contains the related EPS and IMS subscription data.

The UTF function contains a translation table that allows conversion of an Nudr to a Ud request and vice versa. If the UDM requires information from the EPS UDR , the UTF allows facilitating translation of an Nudr request to Ud request. If the HSS FE requires information from the UDM UDR the UTF is responsible to convert the Ud request to an Nudr request targeting specific subscription data based on the semantics defined in TS 29.505 [9].

NOTE: The UTF would require to implement a translation table supporting the HSS FE vendor specific Ud implementation.

The architecture is illustrated below:



Figure 6.1.2-1: UDM/HSS FE interworking architecture

### 6.1.3 Services and Illustrated Procedures

#### 6.1.3.1 General

When the HSS FE or UDM determine that subscription data needs to be fetched from a different UDR an Ud or Nudr message requesting subscription details is sent to UTF. The UTF translates the message into the corresponding message towards the HSS FE (Ud message) or UDM (Nudr message) that is proxied towards the UDR (Option 1). The UTF may also provide the translated message directly to the target UDR repository bypassing the target HSS FE or UDM (Option 2).

An example procedure is illustrated below:



Figure 6.1.3.1-1: Procedure to retrieve subscription data from separate UDR repository

The following cases have been identified where subscription data are retrieved from different UDR:

- 5GS to EPS interworking when no N26 is supported: In 5GS to EPS handover, the HSS FE retrieves from the 5GS UDR the PGW-C+SMF ID in order to establish a UE requested PDN connection. In EPS to 5GS handover the UDM retrieves from the EPS UDR the PGW-C+SMF ID in order to establish a PDU session.

- Support of T-ADS: When IMS core interfaces with the HSS FE and the UE is camped on a 5G network the HSS FE retrieves from the 5GS UDR the IMS over PS support and current RAT type.

#### 6.1.3.2 5GS to EPS Interworking when N26 is not supported

##### 6.1.3.2.1 5GS to EPS handover

During 5GS to EPS handover when the HSS FE receives the Update Location Request from the MME (as described in step 8 of Figure 4.11.2.2-1 of TS 23.502 [2] the HSS FE needs to retrieve the address of the combo PGW-C+SMF. The HSS FE is aware that the information is located at the 5G UDR as the UPDATE LOCATION REQUEST includes information that registration of an AMF shall not be cancelled. The HSS FE sends a vendor specific Ud request towards the UTF. The UTF must translate the vendor specific Ud request from the HSS FE to an Nudr\_DM\_Query service request including a Data Subset "UE Context in SMF data" towards the 5GS UDR (the Nudr request may be proxied via the UDM to the 5GS UDR).



Figure 6.1.3.2.1-1: HSS FE retrieves PGW-C + SMF ID from 5G UDR

If during 5GS to EPS interworking the UE indicates that dual registration is not supported the HSS needs to notify the UDM to deregister the UE from the 5G network. Such notification can be supported indirectly via the UDR. The steps required are:

- The HSS FE creates a vendor specific Ud request to delete the 5G subscription data of the UE from the 5G UDR

- The UTF translates the request into an Nudr\_DM\_Update message including information to remove all related 5G subscription data for the UE from the 5G UDR

- The 5G UDR deletes the subscription data and notify the UDM of the result using an Nudr\_DM\_Notify service operation

- The UDM notifies the AMF of the deregistration by invoking the Nudm\_UECM\_DeregistrationNotify service operation

The steps are shown in the Figure below:



Figure 6.1.3.2.1-1: Indirect procedure for the HSS to notify the UDM to deregister the UE from the 5G network

##### 6.1.3.2.2 EPS to 5GS handover

When the UDM requires the PGW-C+SMF ID the UDM sends an Nudr\_DM\_Query service request including a Data Subset "UE Context in SMF data" towards the UTF to retrieve the address. The UTF translates the Nudr request into a vendor specific Ud request in order to retrieve the same information from the EPS UDR. The UDM knows that the information required is located at the EPS UDR as the AMF sends an Update Location Request message to the UDM including the ULR-Flags indicating that registration of an MME shall not be cancelled.



Figure 6.1.3.2.2-1: UDM retrieves PGW-C + SMF ID from EPS UDR

If during EPS to 5G interworking the UE indicates that dual registration is not supported the UDM needs to notify the HSS to deregister the UE from the EPS network. The steps required are:

- The UDM creates an Nudr\_DM\_Update request to delete the EPS subscription data

- The UTF translates the request into a vendor specific Ud request

- The EPS UDR deletes the subscription data and notify the HSS of the result

- The HSS notifies the MME of the deregistration by invoking a Cancel Location request.

The steps are shown in the Figure below:



Figure 6.1.3.2.2-2: Indirect procedure for the UDM to notify the HSS to deregister the UE from the EPS network

#### 6.1.3.3 Terminating Access Domain Selection (T-ADS)

##### 6.1.3.3.1 Alternative 1

This alternative assumes the IMS network interfaces only with the HSS FE over Sh interface.

When the HSS FE requires the homogeneous IMS voice over PS supporting indication and the UE is camped on 5G network, the HSS FE constructs a Ud request to retrieve the subscription information from the 5G UDR

NOTE 1: It is assumed that the HSS FE first sends a request to retrieve the related information from the 4G UDR. When the 4G UDR responds that there is no 4G related subscription content the HSS FE determines that the user is camped on 5G access and re-sends the Ud message towards the UTF.

The UTF must translate the vendor specific Ud request from the HSS FE to an Nudr\_DR\_Get service request including a Data Subset "Amf3GPPAccessRegistration" towards the 5GS UDR (the Nudr request may be proxied via the UDM to the UDR).

NOTE 2: For T-ADS it is not possible to obtain the most recent access network capabilities for domain selection. The T-ADS makes the decision based on whether IMS over PS session is supported homogeneously over all TAs served by the AMF.

If the network does not support N26 then the UE may operate in Dual Registration mode. In that case a UE may have an PDN connection for IMS over EPS core or an PDU session for IMS over 5G core. When the IMS AS requires the most recent access network capabilities for domain selection the IMS AS interrogates the HSS.

One method to support the case of UEs in Dual Registration mode is for the IMS AS to derive from the P-Access-Network-Info header the core network access path (i.e. via EPS or 5G core) via which the UE has established an IMS session. When the IMS AS requires T-ADS information, the IMS AS includes in the Sh request the information on the network node (MME or AMF) that needs to be triggered.

The IMS AS can derive the path (EPS or 5G core) via which a UE has established an IMS session from the "P-Access-Network-Info header when the following take place:

- P-CSCF adds within the PANI header the "access-class" field corresponding to the IP-CAN type provided by the PCRF as described in TS 24.229 [17]

- P-CSCF obtains from the PCRF via Rx the IP-CAN type when the PCRF subscribes to be informed of the IP-CAN type as described in TS 29.214 [18]

NOTE 3: The above procedure may require further normative work in stage 3

This is illustrated schematically below taking into account that the IMS AS supports an Sh interface only towards the HSS.



Figure 6.1.3.3.1-1: Support of T-ADS when the UE operates in Dual Registration mode (example of UE accessing IMS via 5G core)

1. UE registers with IMS including the PANI header as specified in TS 24.229 [17] via the 5G core network

2. IMS AS identifies from the PANI header that the UE is accessing the 5G core network access

3. When the IMS AS requires T-ADS information the IMS AS includes in the Sh request information on the node that contain the information

4. The HSS identifies from the Sh request that T-ADS information is available from the 5G UDR

5. HSS constructs a Ud message towards the UTF

6. UTF converts the Ud to a Nudr message

7. UTF sends the Nudr message to the UDR of the UDM

8. The UDR obtains the T-ADS info

9. The UDR provides the T-ADS info within the Nudr response to the UTF

10. The UTF translates Nudr response to a Ud response and sends to HSS

11. HSS provides the T-ADS info within the Sh response to the IMS AS.

##### 6.1.3.3.2 Alternative 2

This alternative assumes that the IMS AS can interface to both HSS and UDM over Sh interface. In such a case the IMS AS can obtain the most recent access network capabilities for domain selection by interrogating the HSS and UDM.

When the UE is in dual registration the IMS AS can derive from the P-Access-Network-Info header the core network access path for IMS (i.e. via EPS or 5G core) via which the UE has established an IMS session. When the IMS AS requires T-ADS information the IMS AS interrogates the HSS or the UDM based on the derived core network access path for IMS.

It is important to note that additional enhancements to UDM - IMS core network interaction will be defined by FS\_eIMS5G study where an SBI interface between the UDM and IMS AS will be supported. In such case support of lite Sh interface at the UDM will not be required and an SBI interface can be used instead.

#### 6.1.3.4 P-CSCF restoration

The P-CSCF restoration is an optional feature allowing the IMS network to notify the HSS or UDM to re-establish the IMS related PDU session in case of P-CSCF failure.

One approach to support this feature is the S-CSCF to support a Cx interface to both HSS and UDM. In case of P-CSCF failure, the S-CSCF reports failure to the UDM or HSS.

For networks that do not support N26, when the UE is in dual registration mode the S-CSCF can derive from the P-Access-Network-Info header the core network access path for IMS (i.e. via EPS or 5G core) via which the UE has established an IMS session. When the S-CSCF initiates P-CSCF restoration procedure the S-CSCF triggers the HSS or the UDM based on the derived core network access path for IMS.

The UDM would support limited Cx functionality to be notified by the S-CSCF of a P-CSCF failure. Once notified the UDF invokes the procedures described in clause 5.8 of TS 23.380 [8].

NOTE: The IMS network interfaces with the HSS (i.e. via Cx/Sh interfaces) for any IMS related subscription information.

It is important to note that additional enhancements to UDM - IMS core network interaction will be defined by FS\_eIMS5G study where an SBI interface between the UDM and S-CSCFwill be supported. In such case support of lite Cx interface at the UDM will not be required and an SBI interface can be used instead.

### 6.1.4 Impacts on existing services and interfaces

The impacts are as follows:

- HSS FE

- Identifies that subscription information is stored on a UDR repository containing 5GS subscription data

- For option 1: proxies a Ud request/answer from the UTF/UDR respectively

- UDM

- Identifies that subscription information is stored on a UDR repository containing EPS subscription data

- For Option 1: proxies an Nudr request/answer from the UTF/UDR respectively.

- S-CSCF

- When the network uses the P-CSCF restoration procedure via the AMF, the S-CSCF interrogates the HSS FE and the UDM in order to identify the serving network and report the P-CSCF failure

- For networks supporting no N26, where the UE operates in Dual Registration case, the S-CSCF uses the P-Access-Network-Info header to identify if the UE is accessing IMS via 5G or EPS access

- IMS AS

- For networks supporting no N26, where the UE operates in Dual Registration case, the IMS AS uses the P-Access-Network-Info header to identify if the UE is accessing IMS via 5G or EPS access

### 6.1.5 Evaluation

Solution 1 proposes an architecture that does not require direct interaction between the UDM and the HSS FE. The solution requires a new function (UTF) that translate subscription data exchange between the HSS FE and the UDM where each have a separate UDR repository. The solution assumes that the UDR of the HSS contains EPS and IMS subscription details whereas the UDR of the UDM contain 5G subscription details only. It is also assumed that the HSS contain all IMS subscription related information. The solution requires the standalone HSS to support the functionality to retrieve information from the UDR of the UDM in certain scenarios (e.g. T-ADS for IMS) as described in clause 6.1.3 of the present TR. The advantages of this solution is that:

- It avoids defining a new interface between the HSS and UDM which would require both legacy HSS and UDM to support a new interface.

- It is possible to introduce only UDM and 5G UDR when deploying a 5GS system, without having to update/upgrade either HSS FE or the EPS UDR, or having to introduce these functionalities in deployments with single core networks.

- Standardisation is minimised and restricted to potential incorporation of lite Sh/Cx interfaces for the UDM, or even not needed in case the FS\_eIMS5G study incorporates the needed interactions of UDM with IMS

- Introduction of a UTF does not affect other network functions that may be accessing the different repositories, while it provides the means to further split other network functions defined in Rel-15 (i.e. PCF/PCRF).

The disadvantage is that a new UTF is deployed in an operator's network that requires to support a vendor specific Ud implementation of the deployed HSS.

Limitations of the solution are as follows:

- Support of T-ADS: When the UE is camped on 5G core network the IMS AS can obtain T-ADS information only if there is homogeneous IMS voice over PS support.

- Support of P-CSCF restoration via HSS: When the UE is camped on 5G core network P-CSCF restoration is not possible via the HSS as the HSS cannot directly trigger the UDM to trigger P-CSCF restoration.

The limitations can be solved with the following additions:

- Support of T-ADS: UDM implements a lite Sh implementation. IMS AS triggers UDM directly for any T-ADS information. Requires the IMS AS to be aware of the core network access path for IMS sessions by inspecting the P-Access-Network-Identifier header.

- Support of P-CSCF restoration: Support of P-CSCF restoration is also supported via the PCRF/PCF which has no impacts on HSS/UDM. Alternatively, the UDM can implement a lite Cx implementation. S-CSCF triggers UDM directly for P-CSCF restoration. Requires the S-CSCF to be aware of the core network access path for IMS sessions by inspecting the P-Access-Network-Identifier header.

## 6.2 Solution #2: Direct SBA UDM-HSS Interworking

### 6.2.1 Introduction

This solution is applicable to key issues 1 and 2.

This solution proposes a new Service Based Interface between UDM and HSS.

### 6.2.2 High-level Description

This contribution proposes a service based interface between HSS and UDM. The architecture for this solution is outlined in the following figure:



Figure 6.2.2-1: Architecture for Direct UDM-HSS Interworking with independent UDRs



Figure 6.2.2-2: Architecture for Direct UDM-HSS Interworking with a common repository

A new reference point between UDM and HSS within the combined HSS/UDM (i.e. Nxx as depicted in Figures 6.2.2-1 and 6.2.2-2) is proposed. The new interface for interworking between HSS and UDM is proposed to be based on SBI principles.

NOTE: The UDM and the HSS may be deployed in a stand-alone manner and could be from different vendors.

### 6.2.3 Services and Illustrated Procedures

Figure 6.2.3-1 shows a high-level illustration of the EPS/IMS and 5GS interworking procedures that requires interworking via HSS/UDM for procedures triggered from the EPS/IMS.

#### 6.2.3.1 General



Figure 6.2.3-1: High Level Illustration of HSS-UDM Interworking

1. IMS/EPC interacts with HSS over existing interfaces for the purpose of e.g. Updating Location of an MME in HSS, and/or requesting HSS to execute some actions in the access network (e.g. P-CSCF restoration) or retrieve some information from the access network (e.g. TADS or NPLI information).

2. Depending on the type of request, the HSS may be able to serve the request and reply to the request with no interaction with UDM (e.g. for ULR from MME or P-CSCF restoration request from S-CSCF). In this case, the HSS replies the request as in step 6.

Otherwise, the HSS interacts with UDM over the new Nxx reference point proposed in this solution using new service operations under the Nudm service set. The definition of these new service operations is out of the scope of the description of this solution.

In either case, in a layered architecture, the HSS interacts with the 4G/IMS UDR (using Ud). The HSS does not need to retrieve any subscription data belonging to the 5G subscription profile.

3. UDM receives the request from HSS over the new Nxx reference point and interacts with the 5GC as needed using existing defined procedures. UDM interacts with the 5G UDR (using Nudr). The UDM does not need to retrieve any subscription data belonging to the 4G/IMS subscription profile.

Editor's note: Analysis on the existing defined procedures in UDM that are used is FFS.

Depending on the request, UDM may omit the request to the 5GC and reply to HSS as in step 5 based on information stored under the 5GC subscription profile (e.g. in case of a TADS requests for which the AMF has already informed UDM that "Homogeneous support for Voice over IP" is supported).

In case of P-CSCF restoration or AMF deregistration, the UDM does not wait for the acknowledgement from 5GC, it sends the response back like in step 5.

4. 5GC replies the request from UDM including the requested information (e.g. TADS, NPLI) or confirming the execution of the requested action (e.g. P-CSCF restoration, deregistration of the UE from the AMF).

5. UDM responds to HSS including the requested information (e.g. TADS, NPLI) or confirming the execution of the requested action (e.g. for the P-CSCF restoration request, it confirms the deregistration of the UE from the AMF).

6. HSS responds to EPC/IMS. Depending on the request, the response from HSS will include information received from 5GC via UDM (e.g. TADS, NPLI).

Figure 6.2.3-2 shows a high-level illustration of the 5GS and EPS/IMS interworking procedures that requires interworking via HSS/UDM for procedures triggered from the 5GC.



Figure 6.2.3-2: High Level Illustration of UDM-HSS Interworking

In this case, an interaction between the 5GC and the UDM (e.g. an AMF registration in UDM in the context of a mobility scenario from EPC to 5GC using interworking with N26 procedures) triggers a request from UDM to HSS over the new Nxx reference point proposed in this solution using new service operations under a new service set offered by the HSS, e.g. Nhss service set.

Similar interactions as described for the HSS-UDM interworking for procedures triggered from the EPC/IMS apply here too. Depending on the procedure, the interactions between the UDM and the 5GC, the UDM and HSS and HSS and the EPS, may be executed asynchronously (e.g. the UDM may not wait to the response from HSS, not even to trigger the request to HSS to send a response to the 5GC).

#### 6.2.3.2 Subscriber Profile Indications

Different subscriber types may exist in a network with Nxx interface. For example, some subscribers will use the full network, i.e. 5GC, the EPC and the IMS, while others might use 5G and IMS but no EPC, and legacy subscribers might just remain limited to EPC and IMS services without subscription to the 5GC. The different subscription types determine, whether the use of the Nxx interface is required for a subscriber. Thus, a "5GC subscription indication" is part of the HSS subscription data as well as a "SMS via 5G NAS support" indication. Similarly, an "EPC subscription indication" and an "IMS subscription" indication are stored in the UDM subscription data.

Editor's note: Requirement for "IMS subscription indication" to be confirmed.

#### 6.2.3.3 Authentication

If security credentials are stored in one single place in the system, there are multiple options for this storage. Some possibilities are analysed in this clause.

##### 6.2.3.3.1 Single AV Generation Engine in HSS(AuC) and Credentials stored in EPC-UDR

As an option, 5G and EPC users'credentials may be stored in the EPC-UDR, (i.e. credentials for existing and users with a 2/3/4G/5G subscriptions and also credentials for users with only 5G subscription) and the authentication vectors are generated in HSS(AuC). In this case, the UDM needs to retrieve the authentication vectors from the HSS. The collocation of the 5G and 4G/3G/2G credentials is required to avoid distributed vectors generation lacking coordinated Sequence numbers.

Figure 6.2.3.3.1-1 shows the interaction in an interworking scenario with N26 interface, when the UE attaches to the 5GC, but authentication data are stored in the EPC-UDR and authentication vectors are generated in HSS(AuC).



Figure 6.2.3.3.1-1: Authentication in 5GC with generation of AV in HSS

1. The UDM receives a Nudm\_UEAuthentication\_Get Request, containing the SUPI of the user.

2. The UDM queries the UDR for the user profile belonging to the SUPI.

3. The UDM receives the user profile, which includes the IMSI, the authentication method, an EPC subscription indication, but no authentication data.

4. The UDM sends a Nhss\_UEAuthentication\_Get request to the HSS, containing the IMSI, Serving network information, and the Authentication Method (which specifies whether the 5G AKA or the EAP-AKA authentication methods is used)

5. If the EPC UDR is used, the HSS reads the IMSI, SQN and other data from the EPC-UDR.

6. The AuC as part of the HSS generates the 5G AKA or EAP-AKA authentication vectors.

7. If the EPC UDR is used, the HSS updates the SQN in the EPC-UDR.

8. The HSS provides the authentication vectors to the UDM in the Nhss\_UEAuthentication Response.

9. The UDM proceeds with the authentication.

##### 6.2.3.3.2 Single AV Generation Engine in UDM and Credentials stored in UDR

As an option, 5G and EPC users' credentials may be stored in the UDR (i.e. credentials for users with a 4G subscription and credentials for users with a 5G subscription) and the authentication vectors are generated in UDM(ARPF). In this case, the HSS needs to retrieve the authentication vectors from the UDM.

Figure 6.2.3.3.2-1 shows the interaction in an interworking scenario, when the UE attaches to EPC, but authentication data is stored in the UDR.



Figure 6.2.3.3.2-1: Authentication in EPC with generation of AV in UDM

1. The HSS receives an Authentication-Information-Request, containing the identification of the user.

2. The HSS sends a Nudm\_UEAuthentication\_Get request to the UDM, containing the user identification, Service Network Id (SNI) and the Authentication Method (e.g. EPS-AKA).

NOTE: Whether one or multiple services are required, and specific naming for the operation, could be taken during normative phase.

3,4. If the UDR is deployed, the UDM reads the credentials and related authentication data stored in the UDR.

5. The AuC/ARPF as part of the UDM generates the authentication vectors as requested.

6,7. If the UDR is used, the UDM updates the SQN in the UDR.

8. The UDM provides the authentication vectors to the HSS in the Nudm\_UEAuthentication\_Get response.

9. The HSS proceeds with the authentication.

#### 6.2.3.4 Mobility Scenarios

##### 6.2.3.4.1 Mobility from 5GC to EPC, single registration, with N26 Interface

In a single registration scenario, the attachment in an MME triggers a cancellation of the AMF address in the UDM/UDR.

Figure 6.2.3.4.1-1shows the interaction in an interworking scenario with N26 interface, when the UE attaches to the EPC.



Figure 6.2.3.4.1-1: Mobility from 5GC to EPC

1. The HSS receives an S6a ULR request containing the IMSI of the subscriber.

2. If the EPC UDR is used, the HSS reads the subscription information related to the IMSI from the EPC-UDR. In particular, it receives the 5GC subscription information.

3. If the EPC-UDR is used, the HSS updates the EPC-UDR with the new MME address.

4. The HSS responds to the MME with an S6a-ULA.

5. If the 5GC subscription indication is received in step 2, i.e. if there is an 5GC subscription for the user, then the HSS uses the Nudm\_UECM\_Deregister service of the HSS for the IMSI of the user. This does not include the AMF address as when a AMF triggers that hence this is marked with a \*.

6. The UDM responds to the HSS.

7. The UDM uses the Nudr\_DM\_Query service to retrieve the AMF address previously assigned to the UE, if any. If the UE is registered at an AMF, steps 8 and 9 are executed.

8. If there is an AMF address found for the user, the UDM cancels the attachment by sending a Nudm\_UECM\_DeregistrationNotification to the AMF.

9. In this case, the UDM also updates the UDR entry using the Nudr\_DM\_Update service.

##### 6.2.3.4.2 Mobility from EPC to 5GC, single registration, with N26 Interface

In a single registration scenario, the attachment in an AMF triggers a cancellation of the MME address in the HSS.

Figure 6.2.3.4.2-1 shows the interaction in an interworking scenario with N26 interface, when the UE attaches to the 5GC.



Figure 6.2.3.4.2-1: Mobility from EPC to 5GC

1. The UDM receives an Nudm\_UECM\_Registration request containing the SUPI of the subscriber.

2. The UDM queries the UDR with an Nudr\_DM\_query for the old AMF address and the EPC subscription indication belonging to the SUPI.

3. The UDR provides the requested data to the UDM.

4. The UDM updates the UDR with the new AMF registration data using the Nudr\_DM\_Update service.

5. If the EPC subscription indication is received in step 3, i.e. if there is an EPC subscription for the user, then the UDM uses the Nhss\_UECM\_Deregister service of the HSS for the IMSI of the user.

6. The HSS responds to the UDM.

7. If the EPC UDR is used, The HSS reads the MME mobility information in the EPC-UDR. If the UE is registered at an MME, steps 8 and 9 are executed.

8. If there is an MME address found for the user, the HSS cancels the attachment of the IMSI in the MME by sending a CLR via the S6a interface.

9. IF step 8 was executed, and EPC UDR is used, the HSS also updates the EPC-UDR entry to remove the MME assignment.

##### 6.2.3.4.3 Interworking without N26 Interface

For interworking without the N26 interface in Rel-15, IP address preservation is provided to UEs on inter-system mobility by storing and fetching PGW-C+SMF and corresponding APN/DDN information via the HSS+UDM, see TS 23.501 [6] clause 5.17.2.3.1. In an architecture with Nxx interface between HSS and UDM, this information must be exchanged via the Nxx interface.

For mobility from 5GC to EPC, the HSS can use the Nudm\_SubscriberDataManagement (SDM) service for "UE context in SMF" data.

For mobility from EPC to 5GC, the HSS Nhss\_SubscriberDataManagement service for the "UE context in PGW" provides the PDN-GW address per subscriber and APN. The UDM can use this service.

This service is also applicable for interworking with non-3GPP access if IP address preservation is requested.

#### 6.2.3.5 T-ADS

Figure 6.2.3.5-1 shows the interaction when the SCC-AS sends a T-ADS query to the HSS, and the user is subscribed to 5GC as well.



Figure 6.2.3.5-1: Terminating Access Domain Selection

1. The HSS receives a UDR T-ADS query from the SCC-AS over the Sh interface.

2. If EPC-UDR is used, the HSS reads the MME, SGSN, T-ADS related information and the 5G subscription indication from the EPC-UDR.

3. Depending on registration state, the HSS queries the MME and/or SGSN for IMS over PS session support.

4. If the user has a 5G subscription, the HSS requests 5GC-related T-ADS information from the UDM, using the Nudm\_MT\_ProvideDomainSelectionInfo service provided by the UDM. The HSS includes an indication, whether a time stamp of last attachment is required.

5. On receipt of the request, the UDM queries the UDR for the AMF registration state and the stored T-ADS related information (e.g. homogenous support).

6. If the user is registered in an AMF and there is no information regarding homogenous support or non-support, or if a time stamp has been requested by the HSS, the UDM sends an Namf\_MT\_ProvideDomainSelectionInfo service request to the AMF.

7. The AMF responds with the T-ADS information.

8. The UDM passes the T-ADS information to the HSS - in the response to the Nudm\_MT\_ProvideDomainSelectionInfo request.

9. The HSS combines the information related to SGSN, MME and AMF and provides it to the SCC-AS in the Sh-UDA message.

#### 6.2.3.6 P-CSCF Restoration

Figure 6.2.3.6-1 shows the interaction when the S-CSCF initiates a P-CSCF restoration at the HSS, and the user is attached to 5GC. In this example the AMF based restoration is shown. The procedure for the SMF follows the same approach and same method across the Nxx interface.



Figure 6.2.3.6-1: P-CSCF Restoration

1. The HSS receives a Cx-SAR (Server Assignment Request) message from the S-CSCF, which includes the P-CSCF restoration indication.

2. If the EPC-UDR is used, the HSS reads the subscriber data from the EPC-UDR.

3. If applicable, the HSS sends a P-CSCF restoration information towards the supporting nodes (SGSN, MME) and performs the unregistration/deregistration of the UE in IMS, as described in step 5 of TS 23.380 [8], clause 5.4.2.1. This includes the necessary updates in the EPC-UDR.

4. The HSS replies with a Cx SAA (Server Assignment Answer) to the S-CSCF.

5. In case of 5GC subscription indication, the HSS uses the enhanced Nudm\_UECM\_PcscfRestoration service of the UDM to trigger the P-CSCF restoration indication in the 5GC.

6. The UDM reads the subscriber profile in the UDR to retrieve the relevant AMF address and callback-URI.

7. (copy of step 6 in TS 23.380 [8], clause 5.8.4.3) The UDM sends Nudm\_UECM\_PcscfRestoration notification to the AMF serving the UE, using the received callback URI for P-CSCF restoration notifications. The AMF accepts the Nudm message and sends a response message to the UDM.

8. The UDM responds to the HSS. Note: Message 8 may be sent at the same time like message 7 and need not wait for the response to message 7.

#### 6.2.3.7 SMS support

The interworking between EPS and 5GC, as described in clause 6.2.3.4, also has an impact on SMS handling. For example, if an SMS cannot be delivered to a subscriber which is not attached to the mobile network at all, it cannot be predicted how the subscriber will be reachable for SMS next. The subscriber may attach in 2G/3G only, in LTE/EPC or in 5G via NR - the network must be prepared to deliver the SMS anyway. In the following clauses we focus on the SMS message flows initiated towards the HSS. Similar flows apply for the SMS delivery described in TS 23.502 [2].

##### 6.2.3.7.1 Terminating SMS location query

Figure 6.2.3.7-1 shows the interaction when the SMSC or IP-SM-GW queries the HSS for SMS routing information.



Figure 6.2.3.7-1: SMS Location Query

1. The SMSC queries the HSS for routing information for SMS.

2. If the EPC-UDR is used, the HSS reads the necessary information from the EPC-UDR.

3. The HSS uses the Nudm\_UECM\_Get request to query the UDM for the serving SMSF address(es).

4. The UDM queries the UDR with an Nudr\_DM\_query for the SMSF address(es).

5. The UDR provides the SMSF address(es) to the UDM.

6. The UDM passes the SMSF address(es) to the HSS in the Nudm\_UECM response.

7. The HSS replies to the SMSC with a list of supporting nodes.

##### 6.2.3.7.2 Terminating SMS delivery failure

After delivery of an SMS failed, the HSS stores message waiting information. In order to enable message delivery via 5G NAS, the HSS subscribes to the UDM (and indirectly AMF) for UE availability. Figure 6.2.3.7-2 shows the related interaction; it is assumed that there was no previously waiting message before.



Figure 6.2.3.7-2: SMS Delivery Failure

1. The SMSC informs the HSS about the delivery failure.

2. The HSS reads the necessary information from the EPC-UDR.

3. The HSS updates the Message Waiting status in UDR.

4. The HSS acknowledges the receipt of the delivery status to the SMSC.

5. The HSS subscribes for UE reachability information at the UDM, using the Nudm\_EventExposure service.

6. The UDM requests the relevant subscriber information from the UDR.

7. The UDR provides the requested information.

8. The UDM subscribes for UE reachability information at the AMF, using the Namf\_EventExposure service.

9. The AMF acknowledges the subscription by the UDM.

10. UDM updates the subscriber specific event subscription information in the UDR.

11. The UDR acknowledges the update to the UDM.

12. The UDM acknowledges the subscription by the AMF.

##### 6.2.3.7.3 SMS Alerting

Once the UE becomes available again, the SMSC(s) will be informed about the availability. Figure 6.2.3.7-3 shows the related interaction if the UE becomes reachable in 5G. This assumes the existence of a subscription as described in clause 6.2.3.7.2.



Figure 6.2.3.7-3: SMS Alerting

1. The AMF informs the UDM about the UE reachability.

2. The UDM reads the necessary information from the UDR.

3. The UDM acknowledges the receipt of the Notification to the AMF.

4. The UDM updates the AMF-URRP flag in the UDR.

5. The UDM informs the HSS about the UE availability.

6. The HSS may read the subscriber related information in the EPC-UDR.

7. The HSS acknowledges the receipt of the notification to the UDM.

8. The HSS alerts all relevant SMSCs regarding the UE availability. Only one such SMSC is shown in the figure for simplicity.

9. The HSS may update the subscriber information in the EPC-UDR.

10. The SMSC replies to the alerting.

### 6.2.4 Impacts on existing services and interfaces

Following impacts are identified:

a) Impacts in HSS:

New SBA service at least with one operation Request/Response, at described in figure 6.2.3-2.

This SBA service has to follow registration/discovery/selection procedures (by means of interaction with NRF or by configuration) as defined for Rel‑15 or its evolution/adaptation to Rel‑16.

No impacts to existing interfaces or procedures.

b) Impacts in UDM

New SBA service at least with one operation Request/Response, at described in figure 6.2.3-1.

### 6.2.5 Evaluation

This solution identifies an approach that can work for both layered and not layered architectures of HSS.

In addition, it supports all the procedures that have been defined on EPS and 5GS without any impact on any other interface than the one between HSS and UDM this solution defines.

If this solution is adopted, it requires standardisation of the interface between HSS and UDM.

## 6.3 Solution #3: UDM/HSS FE interaction reusing legacy protocol

### 6.3.1 Introduction

This solution addresses Key Issue #1: Interaction between UDM and HSS with separate repositories.

The assumption of this solution is that 5GS UDR and EPS UDR are separate, between which there is no interface for direct interactions. The EPS and IMS profiles are stored in EPS UDR and the 5GS profile is stored in 5GS UDR.

UDM and HSS FE interacts to retrieve or update the required user data for the following procedures:

- Authentication procedure, i.e. initial attach/registration.

- Network Provided Location Information (NPLI).

- Procedure on IP address continuity of interworking without N26 from 5GS to EPS.

- T-ADS query for IMS voice.

- IMS related procedures related to Cx/Dx and Sh interfaces.

- SMS over NAS.

To avoid the impact on legacy HSS, the interactions for retrieving or updating user data are initiated by UDM through reusing existing HSS supported protocol and procedures, i.e. this solution only requires UDM to retrieve or update user data stored in EPS UDR via HSS FE. The interface between HSS FE and EPS UDR is also not impacted.

### 6.3.2 High-level Description

#### 6.3.2.1 Authentication

A new interface, Shu, between UDM and HSS FE is introduced, by which UDM initiates interactions with HSS FE to retrieve or update user data stored in EPS UDR. Shu is a Point-to-Point reference point.

UDM is the only access point both to 5GC and EPC.



Figure 6.3.2.1.1: Solution architecture

In some 5G deployment, when a 4G subscriber is updated to 5G subscriber, the 4G subscription profile keeps stored in EPS UDR while the new 5G subscription data is provisioned in 5GS UDR. In this case it is assumed that the authentication data is only stored in EPS UDR and is reused by 5GS authentication.

For new 5G subscriber, all the subscription data is stored in 5GS UDR. Therefore, the solution described in this clause does not apply.

In this scenario, when a UE with 5GS subscription registers on 5GS, the UDM needs to interact with HSS FE to retrieve authentication information data stored in EPS UDR.

NOTE: The UDM is a combo node which simultaneously supports UDM and HSS FE functionality.

In case of single registration in 5G, in order to cancel the registration in the other RAT, the UDM supports to perform a fake 4G registration in the HSS, as shown in Figure 6.3.3.1-2. This trigger the HSS to cancel the 4G registration. When the UE moves back to 4G, the HSS sends cancel location to UDM which trigger the UDM to deregister the UE in 5G.

#### 6.3.2.2 IP address continuity of interworking without N26 from 5GS to EPS

Shu interface defined in clause 6.3.2.1 is reused.

UDM is the only access point both to 5GC and EPC.



Figure 6.3.2.2-1: Solution architecture

When a UE initially registers in 5GC, the FQDN for the S5/S8 interface of the PGW-C+SMF is registered into UDM via Nudm as specified in clause 4.11.2 of TS 23.502 [2].

When UE attaches in EPS due to interworking without N26, the procedure specified in clause 4.11.2 of TS 23.502 [2] applies. When MME sends Update Location Request to UDM, after forwarding the request to HSS FE, UDM needs to retrieve the stored PGW-C+SMF FQDN and add it into the Update Location Ack message returned from HSS FE.

The MME use PGW-C+SMF FQDN received from the Update Location Ack message to determine the address of PGW-C+SMF.

#### 6.3.2.3 T-ADS for IMS voice

Shu interface defined in clause 6.3.2.1 is reused.

UDM is the only access point both to 5GC, EPC and IMS, i.e. UDM supports S6a and Sh interfaces along with Nudm.



Figure 6.3.2.3-1: Solution architecture

SCC AS initiates T-ADS query towards UDM via Sh interface as specified in TS 29.328 [11].

To handle T-ADS query, the UDM queries T-ADS information towards HSS FE to get T-ADS information related to EPS and UMTS. HSS FE may query MME and SGSN to get information as specified in TS 23.401 [16] and TS 23.060 [15].

After receiving response of T-ADS query from HSS FE, UDM responds T-ADS query to SCC AS based on the T-ADS information received from HSS FE and T-ADS information in UDM. UDM may query AMF to get necessary information as specified in TS 23.501 [6].

#### 6.3.2.4 Supporting IMS related procedures

Shu interface defined in clause 6.3.2.1 is reused.

UDM, which is a combo node supporting UDM and HSS functionalities, is the only access point both to 5GC, EPC and IMS.



Figure 6.3.2.4-1: Solution architecture

Since IMS profile is stored in EPS UDR, the UDM needs to forward all the requests received from IMS via Cx/Dx or Sh interfaces to HSS FE to handle, and further forwards all the responses from HSS FE to IMS.

For some scenarios that HSS FE and EPS UDR may generate requests to IMS, the UDM needs to forward all the requests received from HSS FE to IMS via Cx/Dx or Sh interfaces to handle, and further forwards all the responses from IMS to HSS FE.

#### 6.3.2.5 SMS over NAS

Shu interface defined in clause 6.3.2.1 is reused.

UDM is the only access point both to SMSF, SMS router and SMSC/SM GMSC.



Figure 6.3.2.5-1: Solution architecture

### 6.3.3 Services and Illustrated Procedures

#### 6.3.3.1 Authentication

The procedure of the interaction between UDM and HSS FE for Authentication Information Retrieval is shown in Figure 6.3.3.1-1.



Figure 6.3.3.1-1: Authentication Info Retrieval Procedure between UDM and HSS FE

1a. When the UE attaches from EPS, MME sends Authentication-Information-Request to UDM to get authentication information for the UE. The MME message is sent to UDM by DRA routing (i.e., based on IMSI range).

1b. When the UE registers from 5GS, AMF invokes Nausf\_UEAuthentication\_authenticate service operation to AUSF to get authentication information for the UE.

1b'. AUSF invokes Nudm\_UEAuthentication\_Get service operation.

2. When UDM receives Nudm\_UEAuthentication\_Get, it determines to generate and send S6a Authentication-Information-Request message to HSS-FE based on local configuration, if the authentication information is stored in EPS UDR due to operator's deployment.

3. HSS FE interacts with EPS UDR to retrieve authentication information of the UE via legacy UDC architecture.

4. HSS FE returns Authentication-Information-Answer with authentication vectors to UDM.

5a. UDM forwards Authentication-Information-Answer with authentication vectors to MME.

5b'. UDM generates the respond to Nudm\_UEAuthentication\_Get service operation invocation with authentication vectors received in Authentication-Information-Answer, and sends the respond to AUSF.

5b. AUSF response the AMF invoked Nausf\_UEAuthentication\_authenticate service.

Editor's note: This procedure may be modified based on SA WG3 LS response.

The procedure of the interaction between UDM and HSS FE for single Registration is shown in Figure 6.3.3.1-1.



Figure 6.3.3.1-2: Single Registration Procedure between UDM and HSS FE

1. The UE is registered in 5G. The AMF perform UE registration in UDM. The AMF indicates whether it requires single registration or dual registration.

2. If the AMF requires single registration then the following steps are performed. Otherwise the procedure stops.

3. The UDM selects the HSS FE based on the SUPI and sends Update Location Request to HSS FE. In this message a dedicated MME Identity is included. This dedicated MME Identity is pointing to the UDM. From HSS FE point of view, the UDM is now acted as a MME. This message also includes an indication to indicate single registration and an indication to indicate the skip of subscription data so the HSS FE will not send the UE 4G subscription data.

4. The HSS FE stores the dedicated MME Identity into EPS UDR via Ud interface.

5. The HSS FE sends Update Location Response to UDM.

6. If the UE has been registered in an old MME, the HSS FE sends Cancel Location Request towards this old MME. This message will be routed to MME directly based on the old MME Identity.

7. The old MME deregisters the UE and sends Cancel Location Response to the HSS FE.

8. After the UE reselects 4G and performs Tracking Area Update procedure in 4G, the new MME sends Update Location Request towards the HSS FE. As the UDM is the only access point both to 5GC and EPC, this message is sent to UDM and the UDM relays this message to HSS FE.

9. The HSS stores the new MME information into EPS UDR via Ud interface.

10. The HSS sends Update Location Response to new MME via UDM including the UE 4G subscription.

11. Because the UE has been registered in 5G and a dedicated MME Identity pointing to the UDM is stored in the EPS UDR, the EPS UDR triggers the HSS FE to send Cancel Location Request towards the UDM. This message will be routed to UDM based on the dedicated MME Identity.

12. UDM sends Cancel Location Response to HSS FE.

13. Upon receiving Cancel Location Request from HSS FE targeting to deregister the UE in 5G, the UDM initiated Deregistration procedure to deregister the UE in 5G.

#### 6.3.3.2 IP address continuity of interworking without N26 from 5GS to EPS

The procedure of the interaction between UDM and HSS FE is shown in Figure 6.3.3.2-1.



Figure 6.3.3.2-1: IP continuity procedure for interworking without N26 from 5GS to EPS

0. PGW-C+SMF registers its FQDN in UDM during registration procedure. UDM stores the FQDN in 5GS UDR.

1. When the UE attaches in EPS due to interworking without N26 from 5GS to EPS, during the procedure, MME sends Update Location Request to UDM.

2. UDM forwards Update Location Request to HSS FE for further handling.

3. HSS FE interacts with EPS UDR to handle Update Location Request.

4. HSS FE returns Update Location Ack to UDM.

5. after receiving Update Location Ack, UDM retrieve PGW-C+SMF FQDN from 5GS UDR.

6. UDM generates a new Update Location Ack to add PGW-C+SMF FQDN into the message and forwards the message to MME.

NOTE: the other signalling interactions not related to the solution are not present in this figure for simplification.

#### 6.3.3.3 T-ADS for IMS voice

The procedure of the interaction between UDM and HSS FE is shown in Figure 6.3.3.3-1.



Figure 6.3.3.3-1: T-ADS Procedure between UDM and HSS FE

1. SCC AS initiates T-ADS query towards UDM by sending a User-Data-Request message via Sh interface.

2. UDM forwards this User-Data-Request message to get T-ADS information related to EPS and UMTS.

3. HSS FE may query MME to get more T-ADS information as specified in TS 23.401 [16].

4. HSS FE may query SGSN to get more T-ADS information as specified in TS 23.060 [15].

5. HSS FE returns T-ADS information based on the information it derives by sending a User-Data-Answer message.

6. after receiving T-ADS information from HSS FE, UDM may query AMF for more T-ADS information as specified in TS 23.501 [6].

7. UDM determines T-ADS result based on T-ADS information received from HSS FE and AMF and responds to SCC AS with the T-ADS information by sending a User-Data-Answer message.

NOTE: the other signalling interactions not related to the solution are not present in this figure for simplification.

For the single registration case the following message flow in figure 6.3.3.3-2 applies:



Figure 6.3.3.3-2: T-ADS Procedure with Single registration and UE is 5GS registered

In Figure 6.3.3.3-2 it is clear that due to the fake registration concept, the HSS is the entity that is in charge of taking T-ADS decisions, and not the UDM, even when the UE is registered in the 5GS with the UDM.

#### 6.3.3.4 Supporting IMS related procedures

The procedure of the interaction between UDM and HSS FE is shown in Figure 6.3.3.4-1.



Figure 6.3.3.4-1: IMS procedures between UDM and HSS FE

1a or 1b. UDM receives Cx/Dx requests or Sh requests from IMS.

2. UDM identifies these requests are for IMS procedures, and forwards the requests to HSS FE.

3. HSS FE interacts with EPS UDR to handle the requests.

4. HSS FE sends responses to the requests to UDM.

5a or 5b. UDM forwards the received responses to IMS accordingly.

6. EPS UDR and HSS FE may generates requests to IMS, e.g. PNR to IMS AS or RTR to S-CSCF.

7. HSS FE sends the requests to UDM.

8a or 8b. UDM forwards the requests to IMS accordingly.

9a or 9b. IMS sends responses to the requests to UDM.

10. UDM forwards the responses to HSS FE.

NOTE: the other signalling interactions not related to the solution are not present in this figure for simplification.

#### 6.3.3.5 SMSF address storage and retrieval

The procedure of the interaction between UDM and HSS FE is shown in Figure 6.3.3.5-1.



Figure 6.3.3.5-1: SMSF address storage and retrieval between UDM and HSS FE

1. SMSF invokes Nudm\_UECM\_Registration service operation to register its address in UDM.

2. UDM interacts with 5GS UDR to store the SMSF address.

3. When SMS-SC or SMS GMSC initiates MT SMS delivery procedure, SMS-SC or SMS GMSC send MAP request i.e. Send Routing Information for SM request, to UDM.

4. UDM interacts with 5GS UDR to retrieve stored SMSF address.

5. UDM responds with SMSF address.

Editor's note: How other procedures is supported, e.g. UDM and HSS support MT SMS domain selection to provide other available SMS delivery addresses, is FFS.

### 6.3.4 Impacts on existing services and interfaces

#### 6.3.4.1 Authentication impacts

UDM supports:

- generating Diameter S6a Authentication-Information-Request message based on Nudm\_UEAuthentication\_Get service operation;

- forwarding Diameter S6a Authentication-Information-Answer message with authentication vectors to MME;

- generating the respond to Nudm\_UEAuthentication\_Get service operation invocation with authentication vectors received in Authentication-Information-Answer, and sends the respond to AMF;

- generating and sending Location Update Request message to perform fake 4G registration in HSS FE when the UE is registered in 5G;

- de-registering the UE in 5G when it receives Cancel Location request with dedicated MME Identity from the HSS FE.

HSS FE: No impact.

5GS UDR: No impact.

EPS UDR: No impact.

#### 6.3.4.2 IP address continuity impacts

UDM supports:

- forwarding Diameter S6a Update Location Request message to HSS FE;

- retrieving PGW-C+SMF FQDN from 5GS UDR after receiving Update Location Ack from HSS FE;

- generating new Update Location Ack to add PGW-C+SMF FQDN into the message and forwarding the message to MME.

HSS FE: No impact.

5GS UDR: No impact.

EPS UDR: No impact.

#### 6.3.4.3 T-ADS for voice impacts

UDM supports:

- forwarding User-Data-Answer message to HSS FE;

- determine T-ADS result based on T-ADS information received from HSS FE and AMF.

HSS FE: No impact.

5GS UDR: No impact.

EPS UDR: No impact.

#### 6.3.4.4 Supporting IMS related procedures

UDM supports:

- forwarding requests for IMS procedures received from IMS to HSS FE and further forwarding responses from HSS FE to IMS;

- forwarding requests for IMS procedures received from HSS FE to IMS and further forwarding responses from IMS to HSS FE.

HSS FE: No impact.

5GS UDR: No impact.

EPS UDR: No impact.

### 6.3.5 Evaluation

The Solution does not provide the possibility to deploy a pure UDM without HSS functionality.

The EPS and 5GS UDRs both need to keep up to date registration status for the UE, i.e. the EPS UDR has to know the registration status of the UE also when the UE is in the 5GS (due to the fake registration concept). This means that there is duplication of registration data in EPS and 5GS UDR, which is adding load and storage requirement to the system

Due to the fake registration concept, the T-ADS master node is always the legacy HSS, not the UDM, even when the UE is 5GS registered. So, the functional allocation between 5GS and EPS specific entities is blurred for as long as there are combined 4G/5G subscribers.

S6a specification impact where the 5G authentication vectors need to be carried and also 5G vectors need to be requested.

NOTE: The above authentication related issue should be evaluated by SA WG3.

## 6.4 Solution #4: Use of a Data Access Layer for interaction between HSS FE and UDM with common repository

### 6.4.1 Introduction

This solution applies to Key Issue 2 and describes how HSS FE and UDM interact when data repositories are common.

### 6.4.2 High-level Description

#### 6.4.2.1 Assumptions

It is assumed that:

- UE 4G and 5G profiles in the common repository may be a common record for the UE or be split into different records.

- The solution leverages EPS UDR to become the common repository for 4G and 5G subscription profiles to be accessed by means of the Ud reference point.

- Technologies and protocols to access the data stored in the common repository are assumed to be database specific or proprietary, but exposing Ud operations to query, create, delete and update of data, as well as subscriptions/notifications to modifications of such data.

- 5G UEs are assumed to be provisioned in the repository and able to use 4G networks (with the corresponding limitations). 4G UEs are provisioned in the repository, as of today, but not assumed to be able to use 5G core services.

- From an authentication perspective, this proposal assumes ARPF to be a separate entity from UDM, collocated with or incorporated to the HE/AuC specified in TS 33.401 [13], and it does not specifically address separation of ARPF logic from ARPF storage, in which case the interface would remain unspecified as it is for HE(AuC). This implies that each system will retrieve authentication data from the same subscriber credentials storage and vectors generation will be performed without SQN reuse. For handovers security with and without N26 for single and dual registration modes, the same procedures as described in TS 33.501 [12] clause 8 are assumed. - The IMS data for the UEs is assumed to be stored in the same common repository.

- From an IMS interaction perspective, it is assumed that IMS HSS/SLF is a logical entity that can act as an application front end making use of the common repository, following the specification TS 23.335 [3] and implementing Cx/Dx and Sh/Dh interfaces that remain untouched. The colocation of IMS HSS/SLF and HSS FE is an operator option.

NOTE: This is considered as a temporary solution in order to cope with the transition of legacy IMS towards a service based IMS, work in progress in TR 23.794 [14].

#### 6.4.2.2 Architectural proposal

This solution makes use of a layer that separates the applications front end logic from the database technology/protocol used, leveraging the authorisation and policing capabilities from Rel-15 data storage architecture, and incorporating additional features to serve interworking with legacy systems.

Hence, in addition to access control for application front ends, policing and offering a common view of the information irrespective of where it is stored, the solution adds protocol conversion between application front ends and the repository, as well as a notifications engine to mimic the relevant notifications that will trigger specific procedures at the different front end applications and related to handovers between one system and the other.

The solution facilitates keeping existing deployments of application front ends and their repositories without modification, and provides a flexible model to introduce new application front ends without having to impact existing deployments and procedures.

With few updates compared to what is reflected in the next clauses, the solution also facilitates migration of 4G users to be able to receive services from the 5G core, with the limitations imposed by 4G subscriptions, as when e.g. accessing the 5GC from a E-UTRAN radio access (option 5 type of deployment).



Figure 6.4.2.2-1: High level architecture for interaction of HSS FE and UDM with common repository



Figure 6.4.2.2-2: High level architecture for interaction of HSS FE, IMS HSS/SLF and UDM with common repository

### 6.4.3 Services and Illustrated Procedures

#### 6.4.3.1 General description

The proposed data access layer will subscribe to changes performed in the repository, issuing some notifications towards the UDM or the HSS FE for specific UEs that may maintain profiles for 4G and 5G.



Figure 6.4.3.1-1: General procedure for notifications via the Data Access Layer

#### 6.4.3.2 5GS procedures

The procedures specified in TS 23.502 [2] for Registration (clause 4.2.2.2), Deregistration (clause 4.2.2.3), UE Configuration Update (clause 4.2.4), Reachability procedures (clause 4.2.5), Session Management (clause 4.3), and User profile Management (clause 4.2.5) do not change when introducing this solution.

Authentication procedures at registration (step 9 in clause 4.2.2.2 of TS 23.502 [2]) does not change either when introducing this solution.

Any potential query of information related to the 4G subscription profile of the UE, would imply a mapping/translation of the NUdr\_DM\_Query in the Data Access Layer to be converted into a Ud query.

#### 6.4.3.3 EPS procedures

EPS procedures, including authentication ones, are not expected to be affected from the point of view of network signalling.

The Data Access Layer will subscribe to changes in the common repository related to 5G subscribers having also 4G profiles. When any action is performed at the level of 4G data for the particular UE (like attachment, detachment, etc), the Data Access Layer will issue a notification towards the UDM. UDM will perform any action needed depending on the status of the UE, interworking needed, etc.

This is intended to facilitate the tracking of the subscriber in either system, in order to execute the relevant deregistration in case the subscriber moves from one to the other.



Figure 6.4.3.3-1: Notification to UDM when UE attaches to EPS

The Ud Request expected to trigger a notification is Update Data as specified by TS 23.335 [3]. There is no need to notify any query of data performed by HSS FE.

Any potential query of information related to the 5G subscription profile of the UE, would imply a mapping/translation of the Ud Query in the Data Access Layer to be converted into a query to the common repository.

As the technologies and protocols used to access the data stored in the common repository are operator deployment choices, the mapping of the response depicted in the previous chart to the Nudr\_DM\_Notify operation towards the UDM is left as an operator deployment choice in agreement with its vendors.

#### 6.4.3.4 Handover procedures

##### 6.4.3.4.0 General

For handover procedures, three cases are differentiated according to TS 23.501 [6] and TS 23.502 [2]:

- Single registration mode with N26 support.

- Single registration mode without N26 support.

- Dual registration.

For single registration mode with N26 support, any registration/attachment shall convey a cancelation of the location in the source system.

For single registration without N26 support, registration/attachment shall also convey a cancelation of the location in the source system if simultaneous registration of both MME and AMF is not supported, according to TS 23.501 [6] clause 5.17.2.3.1.

NOTE 1: Since UDM and HSS FE are split but common repository exists, the support of simultaneous registration of MME and AMF should be configurable in UDM, HSS FE and in the proposed Access Data Layer

This solution proposes that, in single registration modes with and without N26, the PGW-C+SMF with corresponding APN/DNN is stored in the common repository, either in a single record or separate ones, and updated/queried by either party in the different handover scenarios.

NOTE 2: Storing of PGW-C+SMF and APN/DNN information in the same EPS UDR record will preclude the possibility of proper behaviour of dual registration procedures.

This can be achieved as follows:



Figure 6.4.3.4.0-1: Storage of PGW-C+SMF and APN/DNN with UE camping in EPS in single registration mode

While for 5GS, it is stored as following:



Figure 6.4.3.4.0-2: Storage of PGW-C+SMF and APN/DNN with UE camping in 5GS in single registration mode

For handover procedures in dual registration mode, the information needs to be stored in different records of the EPS UDR. The UE will remain registered/attached to the two system simultaneously with valid subscription data for both systems at the same time. Moving sessions between systems remains a UE implementation option.

##### 6.4.3.4.1 5GS to EPS with N26

In 5GS to EPS handovers, the attach in the EPS will generate a Ud Request to modify data by HSS FE followed by a Response by the repository and a notification to the Data Access Layer. This will trigger a notification to the UDM to indicate the UE is now under EPS control. UDM should in turn modify the location data in the 5G profile and will proceed to deregister the AMF the UE moved from.



Figure 6.4.3.4.1-1: Notification to the UDM at UE attachment to EPS

No other action is expected to be performed by the UDM, and the control by the EPS will proceed as specified in the TS 23.502 [2], clause 4.11.1.2.1, with the difference that the HSS FE will not cancel the location of the AMF during the TAU procedure. Instead, the HSS FE will acknowledge the location update to the new MME and proceed as normal.

##### 6.4.3.4.2 EPS to 5GS with N26

In EPS to 5GS handovers, the registration in the 5GS will generate a Nudr request and subsequent notification when data is stored in the common repository. The Data Access Layer will capture that and generate a notification towards the HSS FE indicating the UE has left the EPS.



Figure 6.4.3.4.2-1: Notification to the HSS FE at UE registration in 5GS

NOTE: HSS FE subscribed to changes in the common repository when UE data was stored.

The procedure follows the specification in TS 23.502 [2] clause 4.11.1.2.2 with the modification that it is the HSS FE the one initiating the relevant cancel location towards the MME node the UE has moved from.

##### 6.4.3.4.3 5GS to EPS without N26 - single registration

For single registration without N26, HSS FE will be configured as not supporting dual registration. Thus, the attach to the EPS when UE moves from 5GS to EPS, will imply a cancelation of location in the AMF from where the UE moved.

This procedure is aligned with what is described in clause 6.4.3.4.1 of this solution.

The EPS attach is expected to trigger a Ud Update operation towards the EPS UDR, and a response to HSS FE including the PGW-C+SMF address (together with APN/DNN information) being used.

##### 6.4.3.4.4 EPS to 5GS without N26 - single registration

For single registration without N26, UDM will be configured as not supporting dual registration. Thus, the registration to the 5GS when UE moves from EPS to 5GS, will imply a cancelation of location in the MME from where the UE moved.

The registration in the 5GS, would trigger a notification to the Access Data Layer that, in turn, would imply a Ud notification to the HSS FE to cancel the location in the MME. This procedure is aligned with what is described in clause 6.4.3.4.2 of this solution.

##### 6.4.3.4.5 Handovers without N26 - dual registration

For handover procedures in dual registration mode, the UE will remain registered/attached to the two system simultaneously with valid subscription data for both systems at the same time, including valid session information for both systems. Moving sessions between systems remains as a UE implementation option.

Attachment/Registration of the UE in either system does not convey any cancellation in the source system. This is achieved by analysing the UDM and HSS FE configuration to support or not dual registrations.

#### 6.4.3.5 IMS interaction

##### 6.4.3.5.1 Access to IMS data

Access to IMS data for creation, deletion, query and modification follows the specification in TS 23.228 [7] and TS 23.335 [3] by IMS making use of the IMS HSS/SLF functionality (either as a stand-alone application front end or collocated with HSS FE).

It is not expected that any of the IMS entities need to interact with UDM, with the exception of the P-CSCF restoration mechanism invoked by S-CSCF, and the T-ADS information retrieval by the IMS AS.

For these specific cases, it is proposed to use the SLF functionality for UE identity to UDM identity or HSS FE identity resolution, according to TS 23.228 [7] clause 5.8.

NOTE 1: It is proposed to introduce SLF functionality since the split of UDM and HSS FE will imply multiple addressable location servers for the 5G UEs and these IMS procedures.

NOTE 2: Since the I-CSCF, S-CSCF and IMS AS will always interrogate the SLF to find the location server serving the UE, the SLF needs to be configured to return the IMS HSS address in first place since it is the front end able to return the IMS profile for the UE.

Any Cx or Sh operation triggered by CSCF or IMS AS, except restoration and T-ADS information retrieval, will be handled by the IMS HSS front end (either stand alone or collocated with the HSS FE).

When UE is registered to IMS, the common repository will contain the indication regarding the UE being served by 5GS or EPS. This is proposed to be done as per the description in the common procedures, regardless the UE re-registers or not to IMS when moving between the systems (according to clause 5.2.2.4 of TS 23.228 [7]). This indication is proposed to be checked when either P-CSCF restoration or T-ADS information retrieval is received by UDM or HSS FE (see next clauses).

In principle, both UDM and HSS FE would not require any additional action than what is described before for the general procedures.

##### 6.4.3.5.2 P-CSCF Restoration procedures

The P-CSCF restoration procedure via UDM is an optional mechanism according to TS 23.380 [8].

The following two options are considered regardless the support of N26 and UE mode of operation (single or dual registration).

**- Option 1:** When UDM and HSS FE are split, the preferred P-CSCF restoration procedure would be that performed by detection of the failure by SMF/UPF according to TS 23.380 [8] clause 5.8.3, or using the PCF based P-CSCF restoration as specified in clause 5.8.5 of TS 23.380 [8].

NOTE 1: The adaptation of IMS to service based architecture, making use of proper virtualisation/cloud mechanisms for e.g.self-healing, high availability, redundancy, etc, would most likely make unnecessary the use of the current restoration procedures.

**- Option 2:** To enable the P-CSCF restoration via either the UDM or the HSS FE, the SLF functionality is invoked in order to perform a user identity to HSS FE identity or UDM identity resolution.

The SLF will return the list of different servers (UDMs and HSS FEs) that may be in charge of the UE at that point in time, for the S-CSCF to request the relevant P-CSCF restoration mechanism to the relevant entity. This procedure is according to TS 29.228 [10] clause 6.4.



Figure 6.4.3.5.2-1: User identity to HSS FE identity or UDM identity resolution for S-CSCF

NOTE 2: This assumes that UDM implements the Cx operations SAR/SAA to trigger the P-CSCF restoration. Potential conversion of Diameter Cx operation to an Nudm service operation is out of the scope of this study.

NOTE 3: It is assumed that S-CSCF is aware of the IMS registration status of the UE prior to request P-CSCF restoration.

Both HSS FE and UDM will check the UE registration status in the corresponding network (either 5GS or EPS) in order to either execute the procedure (according to TS 23.380 [8]) or reject it.

No other impact is expected for restoration.

##### 6.4.3.5.3 Terminating domain selection information for IMS voice

According to TS 23.501 [6], clause 5.16.3.6, the UDM/HSS shall be able to query the serving AMF for T-ADS related information, and AMF shall respond to the query with the relevant information unless the UE is detached:

- whether or not IMS voice over PS Session is supported in the registration area(s) where the UE is currently registered;

- whether or not IMS voice over PS Session Supported Indication over non-3GPP access is supported in the WLAN where the UE is currently registered;

- the time of the last radio contact with the UE; and

- the current Access Type and RAT type.

Retrieval of T-ADS information is initiated by the IMS AS.

To retrieve the T-ADS information from either the UDM or the HSS FE, the SLF functionality is invoked in order to perform a user identity to HSS FE identity or UDM identity resolution.

The SLF will return the list of different servers (UDMs and HSS FEs) that may be in charge of the UE at that point in time, for the IMS AS to request the information for access domain selection. This procedure is according to TS 29.328 [11] clause 6.5.

If the UE is attached to IMS via 5GS, the T-ADS information request to the IMS HSS/SLF will end up in a Sh request (UDR/UDA) to UDM, which in turn will invoke the AMF service Namf\_MT\_ ProvideDomainSelectionInfo as specified in TS 23.501 [6] clause 5.16.3.6 and TS 23.228 [7] annex Y.

To translate IMPU to SUPI, for the cases in which the Sh request is based on IMPU, the 5G UDR can incorporate a new data key (=IMPU) for the Subscription Data data set to be used for the Nudr\_DM\_Query operation, in order to request identifier translation from IMPU to SUPI.:

The query to the 5G UDR is simply converted by the Access Data Layer into a Ud request to the EPS UDR repository hosting the IMS data, in order to retrieve the IMSI that is associated with the IMPU received in the Sh request.

The request from IMS AS, when the UE is attached to the EPS, should follow the same procedures as defined in TS 23.228 [7] clause 4.2.4a.

NOTE 1: It is assumed that IMS AS is aware of the IMS registration status of the UE prior to request T-ADS information.

Both UDM and HSS FE will check the registration status in the corresponding network in order to either execute the procedure (according to TS 23.228 [7]) or reject it.

In case of dual registration, and according to annex D of TS 29.328 [11], the IMS AS will expect the T-ADS information containing 0 or 1 RAT types, depending on whether IMS Voice over PS is supported or not. So, in order to avoid impacts on the IMS AS, this solution proposes that UDM and HSS FE are configured with indication regarding being the default system for IMS voice. Both will inspect this default indication, in order to execute the T-ADS information retrieval procedure, or reject it.



Figure 6.4.3.5.3-1: User identity to HSS FE identity or UDM identity resolution for IMS AS

NOTE 2: This assumes that UDM implements the Sh operations UDR/UDA to trigger the T-ADS retrieval procedure. Potential conversion of Diameter Sh operation to an Nudm service operation is out of the scope of this study.

### 6.4.4 Impacts on existing services and interfaces

#### 6.4.4.1 General

This solution addresses scenarios in which the operator deployment is already a layered architecture according to TS 23.335 [3] or when user data are stored in an external entity via non-standard interfaces, according to TS 23.002 [5], clause 4.1.1. Purely monolithic scenarios, in which the user data are stored within the HSS itself, would need to migrate towards a layered architecture.

The solution is basically an operator choice restricted to the introduction of a Data Access Layer with the capabilities described in clauses 6.4.3.1 to 6.4.3.4, and does not impact the specified interfaces with new operations.

The solution is also based on network configuration, by including SLF functionality for every IMS operation directed towards a location server (either HSS FE, IMS HSS or UDM). The SLF is configured as the contact point for I-CSCF, S-CSCF and IMS AS, and needs to be provisioned with the list of location servers serving the UEs in the network.

The solution proposes to add information regarding the system registration status, i.e. the system serving the UE:

- For 5G profile, this extension can be handled as the resources Amf3GppAccessRegistration and AmfNon3GppAccessRegistration in the Nudr\_DM\_Update service operation as specified in TS 29.505 [9].

- For 4G profile, this extension can be mapped to the repository field where MME reference is held. Since the organisation of data in the EPS UDR is not standardised, this mapping would be left for implementation.

Finally, the solution proposes adding the Sh pair UDR/UDA (Diameter) to UDM as a temporary solution until IMS is adapted to service based architecture or any other solution is specified for T-ADS information retrieval by IMS.

It also proposes to add a new data key (=IMPU) to the Subscription Data data set in the Nudr\_DM\_Query operation.

#### 6.4.4.2 Summary of impacts on UDM

- For handovers without N26 support:

- Add configuration indication regarding support or not of dual registrations

- For T-ADS information retrieval: Add Sh pair UDR/UDA in case of single and dual registrations:

- Add indication regarding default system for IMS Voice over PS for dual registration mode of operation.

- For P-CSCF restoration:

- For Option 1, no impact (i.e. make use of PCF based restoration or detection of failure by SMF/UPF)

- For Option 2: Add Cx pair SAR/SAA for P-CSCF restoration

#### 6.4.4.3 Summary of impacts on HSS FE

No impact for procedures with N26 support.

For handovers without N26 support:

- Add configuration indication regarding support or not of dual registrations.

For T-ADS information retrieval in dual registration mode of operation:

- Add indication regarding default system for IMS Voice over PS.

#### 6.4.4.4 Summary of impacts on EPS UDR

The impacts on the EPS UDR are left for implementation, since the protocols to access and the organisation of data is implementation specific.

### 6.4.5 Evaluation

Solution 4 proposes an architecture that does not require direct interaction between the UDM and the HSS FE.

The solution makes use of an adaptation layer, named Access Data Layer, that separates the applications front end logic from database technology/protocol in the back end repositories.

The solution addresses all interworking scenarios depicted in TS 23.501 [6] and TS 23.502 [2], including support for IMS procedures.

The advantages of this solution is that:

- It addresses effective separation of HSS FE and UDM to enable multivendor deployments

- It avoids new interface and new operations specification between the HSS and UDM

- It is possible to introduce only UDM when deploying a 5GS system, without having to update/upgrade the HSS FE, or having to introduce this functionality in deployments with single core network.

- Standardisation effort is minimised and restricted to potential incorporation of Sh/Cx operations for UDM, in case FS\_eIMS5G study (TS 23.794 [14]) does not incorporate the changes needed for P-CSCF restoration and T-ADS information retrieval.

- Introduction of this solution does not impact other network functions that may be accessing the different repositories, while it provides the means to further split other network functions defined in Rel-15 (i.e. PCF/PCRF).

The disadvantage of this solution is to making use of SLF functionality for IMS when some deployments may not be using it.

This solution would not be possible if a monolithic HSS is deployed, unless this monolithic HSS becomes the shared subscriptions repository that interfaces to the Data access layer.

In a scenario where a layered architecture is used, taking into account that Ud data model is not standardised, this would require that the Data Access Layer is aware of the structure of the Ud notifications deployed by the operator, i.e. the Data Access Layer needs to be implemented in alignment with the existing EPS UDR implementations.

## 6.5 Solution #5: Use of a Data Access Layer for interaction between HSS FE and UDM with separate repositories

### 6.5.1 Introduction

This solution applies to Key Issue 1 and describes how HSS FE and UDM interact when data repositories are separate.

### 6.5.2 High-level Description

#### 6.5.2.1 Assumptions

It is assumed that:

- Technologies and protocols to access the data stored in the 5G repository are assumed to be database specific or proprietary, but exposing operations to query, create, delete and update of data, as well as subscriptions/notifications to modifications of such data..

- 5G UEs are assumed to be provisioned in the 5G repository and able to use 4G networks (with the corresponding limitations). 4G UEs are provisioned in the EPS UDR, as of today, but not assumed to be able to use 5G core services.

- From an authentication perspective, this proposal assumes ARPF to be a separate entity from UDM, collocated with or incorporated to the HE/AuC specified in TS 33.401 [13], and it does not specifically address separation of ARPF logic from ARPF storage, in which case the interface would remain unspecified as it is for HE(AuC). This implies that each system will retrieve authentication data from the same subscriber credentials storage and vectors generation will be performed without SQN reuse. For handovers security with and without N26 for single and dual registration modes, the same procedures as described in TS 33.501 [12] clause 8 are assumed.

- The IMS data for the UEs is assumed to be stored in the EPS UDR.

- From an IMS interaction perspective, it is assumed that IMS HSS/SLF is a logical entity that can act as an application front end making use of the EPS UDR, following the specification TS 23.335 [3] and implementing Cx/Dx and Sh/Dh interfaces that remain untouched. The colocation of IMS HSS/SLF and HSS FE is an operator option.

NOTE: This is considered as a temporary solution in order to cope with the transition of legacy IMS towards a service based IMS, work in progress in TR 23.794 [14].

#### 6.5.2.2 Architectural proposal

This solution makes use of a layer that separates the applications front end logic from the database technology/protocol used, leveraging the authorisation and policing capabilities from Rel-15 data storage architecture, and incorporating additional features to serve interworking with legacy systems.

Hence, in addition to access control for application front ends, policing and offering a common view of the information irrespective of where it is stored, the solution adds protocol conversion between application front ends and the repository, as well as a notifications engine to mimic the relevant notifications that will trigger specific procedures at the different front end applications and related to handovers between one system and the other.

The solution uses similar concepts as the current Solution #1 ("Retrieving subscription data from separate UDR repositories for EPS and 5GS subscription data using a UDR Translation Function (UTF)"), but makes use of different procedures for IMS interactions.



Figure 6.5.2.2-1: High level architecture for interaction of HSS FE and UDM with separate repositories



Figure 6.5.2.2-2: High level architecture for interaction of HSS FE, IMS HSS/SLF and UDM with separate repositories

### 6.5.3 Services and Illustrated Procedures

#### 6.5.3.1 General description

The proposed data access layer will subscribe to changes performed in the EPS UDR and 5G repository, issuing some notifications towards the UDM or the HSS FE for specific UEs that may maintain profiles for 4G and 5G. When needed, the Data Access layer translates Nudr operations issued by UDM into Ud requests towards the EPS UDR and vice-versa.



Figure 6.5.3.1-1: General procedure for notifications via a Data Access Layer

#### 6.5.3.2 5GS procedures

The procedures specified in TS 23.502 [2] for Registration (clause 4.2.2.2), Deregistration (clause 4.2.2.3), UE Configuration Update (clause 4.2.4), Reachability procedures (clause 4.2.5), Session Management (clause 4.3), and User profile Management (clause 4.2.5) do not change when introducing this solution.

Authentication procedures at registration (step 9 in clause 4.2.2.2 of TS 23.502 [2]) does not change either when introducing this solution.

Any potential query of information related to the 4G subscription profile of the UE, would imply a mapping/translation of the NUdr\_DM\_Query in the Data Access Layer to be converted into a Ud query to the EPS UDR.

#### 6.5.3.3 EPS procedures

EPS procedures, including authentication ones, are not expected to be affected from the point of view of network signalling.

The Data Access Layer will subscribe to changes in the EPS UDR related to 5G subscribers having also 4G profiles in the EPS UDR. When any action is performed at the level of 4G data for the particular UE (like attachment, detachment, etc), the Data Access Layer will issue a notification towards the UDM. UDM will perform any action needed depending on the status of the UE, interworking needed, etc.

This is intended to facilitate the tracking of the subscriber in either system, in order to execute the relevant deregistration in case the subscriber moves from one to the other.



Figure 6.5.3.3-1: Notification to UDM when UE attaches to EPS

The Ud Request expected to trigger a notification is Update Data as specified by TS 23.335 [3]. There is no need to notify any query of data performed by HSS FE.

Any potential query of information related to the 5G subscription profile of the UE, would imply a mapping/translation of the Ud Query in the Data Access Layer to be converted into a query to the 5G repository.

As the technologies and protocols used to access the data stored in the repositories are operator deployment choices, the mapping of the Ud Notify depicted in the previous chart to the Nudr\_DM\_Notify operation towards the UDM is left as an operator deployment choice in agreement with its vendors.

#### 6.5.3.4 Handover procedures

##### 6.5.3.4.0 General

For handover procedures, three cases are differentiated according to TS 23.501 [6] and TS 23.502 [2]:

- Single registration mode with N26 support.

- Single registration mode without N26 support.

- Dual registration.

For single registration mode with N26 support, any registration/attachment shall convey a cancelation of the location in the source system. The UE subscription data, with the exception of the Intersystem Continuity Data, will be valid in only one of the systems at a time.

For single registration without N26 support, registration/attachment shall also convey a cancelation of the location in the source system if simultaneous registration of both MME and AMF is not supported, according to TS 23.501 [6] clause 5.17.2.3.1.

NOTE 1: Since UDM and HSS FE are split and separate repositories exist, simultaneous registration of MME and AMF should always be possible, unless it is disabled by configuration in UDM, HSS FE and in the proposed Access Data Layer.

This solution proposes that, in single registration modes with and without N26, the PGW-C+SMF with corresponding APN/DNN is replicated in both repositories and updated/queried by either party from their associated back-end repository. I.e. at handover 5GS-EPS, HSS FE will query from EPS UDR and at EPS-5GS, UDM will query the 5G UDR.

This replication, together with an indication regarding the UE being served by 5GC or EPC facilitates all handover scenarios with single registration.

This can be achieved as follows:



Figure 6.5.3.4.0-1: Storage of PGW-C+SMF and APN/DNN with UE camping in EPS in single registration mode

While for 5GS, it is stored as following:



Figure 6.5.3.4.0-2: Storage of PGW-C+SMF and APN/DNN with UE camping in 5GS in single registration mode

NOTE 2: To avoid impacts on HSS FE and its related procedures, the data is written directly by the Data Access Layer. HSS FE will find the information available when UE camps back in EPS and requests continuity for single registration without N26

For handover procedures in dual registration mode, the UE will remain registered/attached to the two system simultaneously with valid subscription data in both systems at the same time. Moving sessions between systems remains as a UE implementation option.

##### 6.5.3.4.1 5GS to EPS with N26

In 5GS to EPS handovers, the attach in the EPS will generate a Ud Request to modify data by HSS FE followed by a Ud Response by the EPS UDR and a Ud notification to the Data Access Layer. This will trigger a Nudr\_DM\_Notify to the UDM to indicate the UE is now under EPS control. UDM should in turn modify the location data in the 5G profile and will proceed to deregister the AMF the UE moved from.



Figure 6.5.3.4.1-1: Notification to UDM at UE attachment to EPS

No other action is expected to be performed by the UDM, and the control by the EPS will proceed as specified in the TS 23.502 [2], clause 4.11.1.2.1, with the difference that the HSS FE will not cancel the location of the AMF during the TAU procedure.

Instead, the HSS FE will acknowledge the location update to the new MME and proceed as normal and it will be the UDM the one deregistering the AMF following the flow shown before.

##### 6.5.3.4.2 EPS to 5GS with N26

In EPS to 5GS handovers, the registration in the 5GS will generate a Nudr request and subsequent notification when data is stored in the 5G repository. The Data Access Layer will capture that and generate a notification towards the HSS FE indicating the UE has left the EPS.



Figure 6.5.3.4.2-1: Notification to HSS FE at UE registration in 5GS

NOTE 1: HSS FE subscribed to changes regarding UEs having 4G and 5G profiles.

The procedure follows the specification in TS 23.502 [2] clause 4.11.1.2.2 with the modification that it is the HSS FE the one initiating the relevant cancel location towards the MME node the UE has moved from.

NOTE 2: The mapping of the acknowledgement from the 5G repository to the Ud Notify towards the HSS FE depicted in the previous chart is left for implementation based on operator deployment.

As an alternative to the previous flow, the Data Access Layer can modify the UE data in the EPS UDR, which in turn would trigger a notification towards the HSS FE (HSS FE would have subscribed to changes in the EPS UDR). This alternative would save impacts in the HSS FE that would only need to subscribe to changes in the EPS UDR and be notified when the data is updated.

##### 6.5.3.4.3 5GS to EPS without N26 - single registration

For single registration without N26, HSS FE will be configured as not supporting dual registration. Thus, the attach to the EPS when UE moves from 5GS to EPS, will imply a cancelation of location in the AMF from where the UE moved.

This procedure is aligned with what is described in clause 6.5.3.4.1 of this solution.

The EPS attach is expected to trigger a Ud Update operation towards the EPS UDR, and a response to HSS FE including the PGW-C+SMF address (together with APN/DNN information) being used.

The proposal with this solution is to replicate the information in both repositories. This way EPS UDR will contain the information about PGW-C+SMF needed for the handover cases and will return it to the MME in the Update Location Response. See general clause 6.5.3.4.0 of this solution.

##### 6.5.3.4.4 EPS to 5GS without N26 - single registration

For single registration without N26, UDM will be configured as not supporting dual registration. Thus, the registration to the 5GS when UE moves from EPS to 5GS, will imply a cancelation of location in the MME from where the UE moved.

The registration in the 5GS, would trigger a notification to the Access Data Layer that, in turn, would imply a Ud notification to the HSS FE to cancel the location in the MME. This procedure is aligned with what is described in clause 6.5.3.4.2 of this solution.

##### 6.5.3.4.5 Handovers without N26 - dual registration

For handover procedures in dual registration mode, the UE will remain registered/attached to the two system simultaneously with valid subscription data in both systems at the same time. Moving sessions between systems remains as a UE implementation option.

Attachment/Registration of the UE in either system does not convey any cancellation in the source system. This is achieved by analysing the UDM and HSS FE configuration to support or not dual registrations.

#### 6.5.3.5 IMS interaction

##### 6.5.3.5.1 Access to IMS data

Access to IMS data for creation, deletion, query and modification follows the specification in TS 23.228 [7] and TS 23.335 [3] by IMS making use of the IMS HSS/SLF functionality (either as a stand alone application front end or collocated with HSS FE).

It is not expected that any of the IMS entities need to interact with UDM, with the exception of the P-CSCF restoration mechanism invoked by S-CSCF, and the T-ADS information retrieval by the IMS AS.

For these specific cases, it is proposed to use the SLF functionality for UE identity to UDM identity or HSS FE identity resolution, according to TS 23.228 [7] clause 5.8.

NOTE 1: It is proposed to introduce SLF functionality since the split of UDM and HSS FE will imply multiple addressable location servers for the 5G UEs and these IMS procedures.

NOTE 2: Since the I-CSCF, S-CSCF and IMS AS will always interrogate the SLF to find the location server serving the UE, the SLF needs to be configured to return the IMS HSS address in first place since it is the front end able to return the IMS profile for the UE.

NOTE 3: The evolution of IMS can also imply the IMS profile of the 5G UEs to be moved into the 5G repository. This can impact the way some procedures are executed for the different UEs.

Any Cx or Sh operation triggered by CSCF or IMS AS, except restoration and T-ADS information retrieval, will be handled by the IMS HSS front end (either stand alone or collocated with the HSS FE).

When UE is registered to IMS, EPS UDR will contain the indication regarding the UE being served or not by EPS, and 5G repository will contain the indication regarding the UE being served by 5GS. This is proposed to be done as per the description in the common procedures, regardless the UE re-registers or not to IMS when moving between the systems (according to clause 5.2.2.4 of TS 23.228 [7]).

These indications are proposed to be checked when either P-CSCF restoration or T-ADS information retrieval is received by UDM or HSS FE (see next clauses).

In principle, both UDM and HSS FE would not require any additional action than what is described before for the general procedures.

##### 6.5.3.5.2 P-CSCF Restoration procedures

The P-CSCF restoration procedure via UDM is an optional mechanism according to TS 23.380 [8].

The following two options are considered regardless the support of N26 and UE mode of operation (single or dual registration).

**- Option 1:** When UDM and HSS FE are split, the preferred P-CSCF restoration procedure would be that performed by detection of the failure by SMF/UPF according to TS 23.380 [8] clause 5.8.3, or using the PCF based P-CSCF restoration as specified in clause 5.8.5 of TS 23.380 [8].

NOTE 1: The adaptation of IMS to service based architecture, making use of proper virtualisation/cloud mechanisms for e.g.self-healing, high availability, redundancy, etc, would most likely make unnecessary the use of the current restoration procedures.

**- Option 2:** To enable the P-CSCF restoration via either the UDM or the HSS FE, the SLF functionality is invoked in order to perform a user identity to HSS FE identity or UDM identity resolution.

The SLF will return the list of different servers (UDMs and HSS FEs) that may be in charge of the UE at that point in time, for the S-CSCF to request the relevant P-CSCF restoration mechanism to the relevant entity. This procedure is according to TS 29.228 [10] clause 6.4.



Figure 6.5.3.5.2-1: User identity to HSS FE identity or UDM identity resolution for S-CSCF

NOTE 2: This assumes that UDM implements the Cx operations SAR/SAA to trigger the P-CSCF restoration. Potential conversion of Diameter Cx operation to an Nudm service operation is out of the scope of this study.

NOTE 3: It is assumed that S-CSCF is aware of the IMS registration status of the UE prior to request P-CSCF restoration.

Both HSS FE and UDM will check the UE registration status in the corresponding network in order to either execute the procedure (according to TS 23.380 [8]) or reject it.

No other impact is expected for restoration.

##### 6.5.3.5.3 Terminating domain selection information for IMS voice

According to TS 23.501 [6], clause 5.16.3.6, the UDM/HSS shall be able to query the serving AMF for T-ADS related information, and AMF shall respond to the query with the relevant information unless the UE is detached:

- whether or not IMS voice over PS Session is supported in the registration area(s) where the UE is currently registered;

- whether or not IMS voice over PS Session Supported Indication over non-3GPP access is supported in the WLAN where the UE is currently registered;

- the time of the last radio contact with the UE; and

- the current Access Type and RAT type.

Retrieval of T-ADS information is initiated by the IMS AS.

To retrieve the T-ADS information from either the UDM or the HSS FE, the SLF functionality is invoked in order to perform a user identity to HSS FE identity or UDM identity resolution.

The SLF will return the list of different servers (UDMs and HSS FEs) that may be in charge of the UE at that point in time, for the IMS AS to request the information for access domain selection. This procedure is according to TS 29.328 [11] clause 6.5.

If the UE is attached to IMS via 5GS, the T-ADS information request to the IMS HSS/SLF will end up in a Sh request (UDR/UDA) to UDM, which in turn will invoke the AMF service Namf\_MT\_ ProvideDomainSelectionInfo as specified in TS 23.501 [6] clause 5.16.3.6 and TS 23.228 [7] Annex Y.

To translate IMPU to SUPI, for the cases in which the Sh request is based on IMPU, the 5G UDR can incorporate a new data key (=IMPU) for the Subscription Data data set to be used for the Nudr\_DM\_Query operation, in order to request identifier translation from IMPU to SUPI.:

The query to the 5G UDR is simply converted by the Access Data Layer into a Ud request to the IMS data repository, in order to retrieve the IMSI that is associated with the IMPU received in the Sh request.

The request from IMS AS, when the UE is attached to the EPS, should follow the same procedures as defined in TS 23.228 [7] clause 4.2.4a.

NOTE 1: It is assumed that IMS AS is aware of the IMS registration status of the UE prior to request T-ADS information.

Both UDM and HSS FE will check the registration status in the corresponding network in order to either execute the procedure (according to TS 23.228 [7]) or reject it.

In case of dual registration, and according to annex D of TS 29.328 [11], the IMS AS will expect the T-ADS information containing 0 or 1 RAT types, depending on whether IMS Voice over PS is supported or not. So, in order to avoid impacts on the IMS AS, this solution proposes that UDM and HSS FE are configured with indication regarding being the default system for IMS voice. Both will inspect this default indication, in order to execute the T-ADS information retrieval procedure, or reject it.



Figure 6.5.3.5.3-1: User identity to HSS FE identity or UDM identity resolution for IMS AS

NOTE 2: This assumes that UDM implements the Sh operations UDR/UDA to trigger the T-ADS information retrieval procedure. Potential conversion of Diameter Sh operation to an Nudm service operation is out of the scope of this study.

### 6.5.4 Impacts on existing services and interfaces

#### 6.5.4.1 General

This solution addresses scenarios in which the operator deployment is already a layered architecture according to TS 23.335 [3]. Non-layered scenarios would need to migrate towards a layered architecture prior to deploying this solution.

The solution is basically an operator choice restricted to the introduction of a Data Access Layer with the capabilities described in clauses 6.5.3.1 to 6.5.3.4, and does not impact the specified interfaces with new operations.

The solution is also based on network configuration, by including SLF functionality for every IMS operation directed towards a location server (either HSS FE, IMS HSS or UDM). The SLF is configured as the contact point for I-CSCF, S-CSCF and IMS AS, and needs to be provisioned with the list of location servers serving the UEs in the network.

The solution proposes to add information regarding the system registration status, i.e. the system serving the UE:

- For 5G profile, this extension can be handled as the resources Amf3GppAccessRegistration and AmfNon3GppAccessRegistration in the Nudr\_DM\_Update service operation as specified in TS 29.505 [9].

- For 4G profile, this extension can be mapped to the repository field where MME reference is held. Since the organisation of data in the EPS UDR is not standardised, this mapping would be left for implementation.

Finally, the solution proposes adding the Sh pair UDR/UDA (Diameter) to UDM as a temporary solution until IMS is adapted to service based architecture or any other solution is specified for T-ADS information retrieval by IMS.

#### 6.5.4.2 Summary of impacts on UDM

- For handovers without N26 support:

- Add configuration indication regarding support or not of dual registrations.

- For T-ADS information retrieval: Add Sh pair UDR/UDA in case of single and dual registrations:

- Add indication regarding default system for IMS Voice over PS for dual registration mode of operation.

- For P-CSCF restoration:

- For Option 1, no impact (i.e. make use of PCF based restoration or detection of failure by SMF/UPF).

- For Option 2: Add Cx pair SAR/SAA for P-CSCF restoration.

#### 6.5.4.3 Summary of impacts on HSS FE

No impact on network procedures.

For handovers without N26 support:

- Add configuration indication regarding support or not of dual registrations

For T-ADS information retrieval in dual registration mode of operation:

- Add indication regarding default system for IMS Voice over PS.

Depending on operator choice either:

- A new subscription/notification interaction between HSS FE and the Data Access Layer in order to be informed when a 5G UE that camped in the EPS has moved back to 5GS system (in order to trigger a cancel location procedure), or

- No impact expected, if alternative depicted in clause 6.5.3.4.2 is decided.

#### 6.5.4.4 Summary of impacts on EPS UDR or 5G repository

The impacts on the EPS UDR or 5G repository are left for implementation, since the protocols and technologies to access their data is implementation specific.

### 6.5.5 Evaluation

Solution 5 proposes an architecture that does not require direct interaction between the UDM and the HSS FE or interaction between EPS UDR and 5G UDR.

The solution makes use of an adaptation layer, named Access Data Layer, that separates the applications front end logic from database technology/protocol in the back end repositories.

The solution addresses all interworking scenarios depicted in TS 23.501 [6] and TS 23.502 [2], including support for IMS procedures.

The advantages of this solution is that:

- It addresses effective separation of HSS FE and UDM and EPS UDR from 5G UDR to enable multivendor deployments

- It avoids new interface and new operations specification between the HSS and UDM

- It is possible to introduce only UDM and 5G UDR when deploying a 5GS system, without having to update/upgrade either HSS FE or the EPS UDR, or having to introduce these functionalities in deployments with single core network.

- Standardisation effort is minimised and restricted to potential incorporation of Sh/Cx operations for UDM, in case FS\_eIMS5G study (TS 23.794 [14]) does not incorporate the changes needed for P-CSCF restoration and T-ADS information retrieval.

- Introduction of this solution does not impact other network functions that may be accessing the different repositories, while it provides the means to further split other network functions defined in Rel-15 (i.e. PCF/PCRF).

The disadvantage of this solution is to making use of SLF functionality for IMS when some deployments may not be using it.

Additionally, the Ud interaction which terminates on the 5GS UDR means that the structure of the notifications carried in Ud for this particular case remains proprietary, implying that the Data Access Layer needs to be implemented in alignment with the existing HSS FE and EPS UDR implementations.

## 6.6 Solution #6: Deployment and coexistence without interworking between UDM and existing HSS

### 6.6.1 Introduction

This solution is applicable to Key Issue 1 and Key Issue 2.

This solution proposes a deployment and coexistence alternative which avoids the need of specification of interworking procedures between UDM and the existing HSS.

### 6.6.2 High-level Description

This solution proposes an alternative for coexistence between UDM and HSS based on:

- Deploying HSS and UDM in a single network entity, referred as Combined HSS/UDM, supporting interfaces and procedures specified for 5GC, EPC and IMS.

- UDM and HSS deployed in the Combined network entity may interact with a 5GS UDR that stores 4G/IMS/5G subscription data for 5G enabled users (when using a common repository). Alternatively, the Combined HSS/UDM may also use separate repositories for subscription data of 5G enabled users.

- The functions of the Combined HSS/UDM are provided by a single network entity, so that the interactions between HSS and UDM within the Combined entity are performed internally and therefore it is not required to define such interworking.

- The existing HSS and EPS UDR keep serving only 4G users.

- A routing solution routes Diameter EPC/IMS requests to either the Combined HSS/UDM for 5G enabled users or the existing HSS for 4G only users. This kind of solution can be achieved e.g. by using a network entity that provides SLF/DRA functionality and/or by local configuration in network entities interacting with HSS (e.g. configuring IMSI ranges in MME), and other alternatives may be possible. The routing solution includes redundancy mechanisms to prevent single point of failure issues.

- There is no need of interworking between UDM and existing HSS out of the Combined network entity.

- The different options regarding deployment of subscription data repository are described below, gathering the considerations described previously.

- **Option 1**: A common repository is used for the Combined HSS/UDM. Subscription data of new 5G enabled users is directly provisioned in 5GS UDR. Subscription data of existing 4G users that becomes 5G enabled is relocated from existing EPS UDR to 5GS UDR. When and how the subscription data relocation is performed depends on the overall migration plan and the procedure designed for that purpose, and it is out of scope of the description of this solution.

This option may be considered the most appropriate for a multivendor deployment, while providing centralization of subscription data, allowing consolidation of user profiles for a given user in a single repository. This consolidation simplifies provisioning process, providing a single point of provisioning and ensuring data consistency.

It minimizes deployment impacts, providing a flexible network evolution to 5G while users become 5G enabled through subscription relocation according to plans and speed chosen by the operator.

Additionally, this option may be considered to follow a smooth evolution of the subscription data repository used for 5G enabled users to a cloud native deployment.

The figure 6.6.1-1 shows the network architecture using a common repository for the Combined HSS/UDM:



Figure 6.6.1-1: Coexistence of existing HSS and Combined HSS/UDM with common repository used by the Combined entity

- **Option 2**: Separate repositories are deployed for subscription data of 5G enabled users accessed by the Combined HSS/UDM. In this case, provisioning and/or subscription relocation to EPS UDR used by the Combined HSS/UDM is also needed.

This option allows multivendor deployment for 5G enabled users and legacy users, as well as keeping open the way for the evolution of the subscription data repository used for 5G enabled users to a cloud native deployment. However, subscription data centralization is not achieved, and deployment, management and provisioning of subscription repositories becomes not optimal and complex.

The figure 6.6.1-2 shows the network architecture using separate repositories for the Combined HSS/UDM:



Figure 6.6.1-2: Coexistence of existing HSS and Combined HSS/UDM with separate repositories deployed for the Combined entity

- **Option 3**: Separate repositories are used and the existing EPS UDR keeps storing 4G/IMS subscription data for 5G enabled users as well as 4G only users, as shown in figure 6.6.1-3. Subscription relocation is not required in this option.

Both the existing HSS and the HSS within the Combined entity interact with the EPS UDR using the same proprietary Ud interface, implying that a multivendor deployment will require integration of the non-standard Ud interface with the HSS in the Combined HSS/UDM.

This option does not allow centralization of user profiles for a given user in a single repository, making provisioning more complex as multiple subscription repositories are required to be populated for the same user.

It enables evolution of subscription repository to cloud native technology only for the 5G profiles. EPC and IMS profiles are assumed to be kept in the existing EPS UDR using legacy repository technology.



Figure 6.6.1-3: Coexistence of existing HSS and Combined HSS/UDM with separate repositories using existing EPS UDR for 4G/IMS subscription data

- **Option 4**: Another option is to deploy a single repository to store subscription data for all domains used by the Combined HSS/UDM and the existing HSS, as depicted in figure 6.6.1-4. This option may not require subscription relocation either.

This alternative allows user profiles centralization, although in a multivendor deployment it will require integration of the non-standard Ud interface with the HSS in the Combined HSS/UDM.



Figure 6.6.1-4: Coexistence of existing HSS and Combined HSS/UDM using a common repository

### 6.6.3 Services and Illustrated Procedures

The interactions between UDM and HSS within the Combined network entity are internal, so it is not required to define such interworking.

### 6.6.4 Impacts on existing services and interfaces

This solution has no impact on existing services and interfaces.

### 6.6.5 Evaluation

Solution 6 proposes a coexistence scenario where a Combined HSS/UDM network entity serving 5G enabled users can coexist without interaction with any existing HSS supporting EPC and IMS for 4G only users. Since there is no interaction needed between UDM and the existing HSS out of the Combined entity, this solution does not require any standardization effort. Additionally, this solution avoids any impact on existing nodes (HSS, EPS UDR), services, protocols and interfaces. Some options require migration of subscriber data.

For IMS and EPC services, the solution requires the use of a routing solution which can be based on standard functions (e.g. DRA/SLF) and it is normally deployed in the operator's network for different purposes. Impacts are limited to provisioning/configuration updates for the routing function to route Diameter EPC/IMS requests to either the Combined HSS/UDM for 5G enabled users or the existing HSS for 4G only users. Supporting SMS and the relevant routing capabilities during normative phase

This solution offers different UDR deployment alternatives, from which option 1 as described previously is considered the option providing the most future proof benefits in terms of centralization/consolidation of subscription data for 5G enabled users, management of subscription data, multivendor support and network evolution.

However, an operator may find among the different alternatives proposed the option that fits better its network evolution plans, based on the current deployment and evaluation of the aspects the operator considers as most relevant.

# 7 Evaluation

## 7.1 Evaluation of solutions

This study has emerged from the need of a multivendor approach for UDM and HSS nodes, currently not allowed by Release 15 specifications for 5GS, and facilitate scenarios in which introducing only UDM and UDR is an effective way to introduce 5GS.

According to the Study Item objectives, this technical report has focused on scenarios involving co-existence of EPS subscriber data and 5GS subscriber data with common or separate storages, determining whether interaction between UDM and HSS is needed in the different interworking cases and deployment scenarios.

Thus, the evaluation of the solutions focus on the following technical and deployment requirements:

- Decoupling of UDM and HSS - with common/separate repository.

- Interworking scenarios fulfilment.

- Impacts (standardisation, deployment, etc.

- Limitations.

In addition, and considering that specific scenarios exist in which UDM and/or HSS provide support to IMS procedures, the evaluation should as well take into account these interactions, considering that the evolution of IMS work in progress is independent from this study, but may incorporate additions to specific solutions addressed in this document.

The following graph shows how the different solutions address the different key issues:



Figure 7.1-1: Solutions vs Key Issues

### 7.1.1 Evaluation of solutions with separation of FEs and repositories

Solutions 1, 2 and 5 address key issue #1 for separation of repositories and front ends.

- Solution #1 provides an implementation option not requiring standardisation for separating the front ends and to access the back end repositories independently. The implementation is based on a translation function used to access data from the different repositories in order to execute different network procedures in EPS or 5GS.

For IMS procedures, it proposes implementing a lite Sh interface by UDM in order to support T-ADS information retrieval when UE is camped in the 5GS and, as an alternative for P-CSCF restoration via UDM, a lite Cx interface by UDM.

**EVALUATION:** the solution can be considered an option for deployments with separate 5GS UDR and EPS UDR, accessed by UDM and HSS respectively. It can be suitable for scenarios of interworking in which full separation of front ends exist; however, for IMS interaction, the AS and S-CSCF impacts may not be feasible/acceptable in some deployments and a different solution may be selected.

- Solution #2 implies standardisation of a service based interface between HSS and UDM, for separation of front ends, that access the back end repositories independently.

The solution addresses separation of UDM from HSS, where HSS contains as well IMS logic.

For IMS procedures, the solution proposes operations Cx/Sh-like as part of the service based interface to support T-ADS information retrieval and P-CSCF restoration via UDM.

**EVALUATION:** the solution can be considered an option for deployments using EPS UDR and 5GS UDR separate repositories, accessed by an HSS containing several applications front end logic (i.e. IMS HSS, AuC, EPS HSS) via Ud and by UDM via Nudr respectively, and when converting HSS into an SBA entity is a suitable/feasible operator option.

**OPEN POINTS** if conclusion is to progress during normative work:

- The solution does not address cases in which the applications front end logic is split

- The solution does not address the case of IMS requests based on IMPU (e.g. T-ADS information retrieval) that need to be translated into SUPI in order to obtain the right information, either from the 5GS UDR or from the AMF.

- Solution #5 provides, similarly to solution #1, an implementation option for separating the front ends and accessing the back end repositories, with the difference that this solution is based on using notifications triggered by the repositories, at data modification related to a particular 5G enabled subscriber, in order to execute different network procedures in EPS or 5GS.

The solution assumes full separation of all front ends, i.e. UDM, IMS HSS, EPC HSS, and AuC/ARPF.

For IMS procedures, the solution proposes making use of the IMS SLF functionality and implementation of a lite Sh interface by UDM in order to support T-ADS information retrieval when UE is camped in the 5GS and, as an alternative for P-CSCF restoration via UDM, a lite Cx interface by UDM.

**EVALUATION:** the solution can be considered an implementation option for deployments with separate 5GS UDR and EPS UDR, accessed by UDM and HSS or IMS HSS respectively. It can be suitable for scenarios of interworking in which full separation of front ends and repositories exist; however, for IMS interaction, the introduction of SLF functionality and use of Diameter interfaces in the UDM may not be feasible/acceptable in some deployments and a different solution may be preferred. In order to reduce the number of options to address during normative phase, this solution is proposed to not be pursued during the normative stage 2 work in Rel-16.

### 7.1.2 Evaluation of solutions with separation of FEs with common repository

Solutions 2 and 4 address key issue #1 for common repository with separation of front ends.

- Solution #2 implies standardisation of a service based interface between HSS and UDM, for separation of front ends, that access the back end repository independently.

The access to the common repository is performed by both Nudr and Ud interfaces.

The solution addresses separation of UDM from HSS, where HSS contains as well IMS logic.

For IMS procedures, the solution proposes lite Cx/Sh operations as part of the service based interface to support T-ADS information retrieval and P-CSCF restoration via UDM.

**EVALUATION:** the solution can be considered an option for deployments reusing EPS UDR as common repository, accessed by an HSS containing all applications front end logic (i.e. IMS HSS, AuC, EPS HSS) via Ud, and by UDM via Nudr, and when converting HSS into an SBA entity is a suitable/feasible option for the operator.

**OPEN POINTS** if conclusion is to progress during normative work:

- The solution does not address cases in which the applications front end logic is split

- The solution does not address conversion of Nudr to Ud when the common repository is based on EPS UDR.

- The solution does not address the case of IMS requests based on IMPU (e.g. T-ADS retrieval) that need to be translated into SUPI in order to obtain the right information, either from the 5GS UDR or from the AMF.

- Solution #4 provides an implementation option for separating the front ends and accessing the common back end repository, i.e. the EPS UDR. The implementation is based of using notifications triggered by the repository in order to execute different network procedures in EPS or 5GS.

The solution assumes full separation of all front ends, i.e. UDM, IMS HSS, EPC HSS, and AuC/ARPF.

For IMS procedures, the solution proposes making use of the IMS SLF functionality and implementation of a lite Sh interface by UDM in order to support T-ADS information retrieval when UE is camped in the 5GS and, as an alternative for P-CSCF restoration via UDM, a lite Cx interface by UDM.

**EVALUATION:** the solution can be considered an implementation option for deployments reusing EPS UDR as common repository, accessed by UDM, HSS or IMS HSS independently. It can be suitable for scenarios of interworking in which full separation of front ends exist; however, for IMS interaction, the introduction of SLF functionality and use of Diameter interfaces in the UDM may not be feasible/acceptable in some deployments and a different solution may be preferred.

### 7.1.3 Evaluation of solutions with common FEs with separate repositories

Solutions 3 and 6 address key issue #2 for separate repositories, with no separation of front ends.

- Solution #3 implies no standardisation of interfaces between UDM and HSS FE, as UDM acts as a combo node that is the single point of contact for IMS, SMS, 5GC and EPC.

The solution assumes UDM incorporates HSS FE interfaces (i.e. S6a, Sh, Cx/Dx, C/S6c), with no impact on legacy HSS.

The EPC repository holds both 4G and IMS data, whilst 5GS UDR holds 5G data. The combo node UDM/HSS FE interfaces both 5GS UDR, via Nudr, and EPS UDR via legacy interface.

**EVALUATION:** This solution can be considered a suitable solution in order to introduce 5G subscription data without impacting or migrating legacy subscription data already provisioned, or impacting legacy HSS.

**OPEN POINTS** if conclusion is to progress during normative work:

- The solution does not address the case of IMS requests based on IMPU (e.g. T-ADS retrieval) that need to be translated into SUPI in order to obtain the right information, either from the 5GS UDR or from the AMF.

- Solution #6 implies another combo node UDM/HSS FE, interfacing separate 5GS UDR and EPS UDR holding 5G and 4G/IMS data, respectively.

The solution assumes coexistence of the combo UDM/HSS FE with legacy HSS/UDR (monolithic or layered) that keeps serving legacy 4G subscribers.

The solution assumes impacts for migration of 4G/IMS profiles when separate repositories are used and requires the introduction of a Routing Function based on subscriber IMSI.

**EVALUATION**: This solution can be considered as addressing the goals of the study as long as migration of legacy 4G data is acceptable for the 5G enabled subscribers. It does not require standardisation so normative work will not be pursued.

### 7.1.4 Evaluation of solutions with common FEs with common repository

Solutions 6 addresses the case of common repository and no separation of front ends. However, this solution does not address any of the goals of the study and thus it is not intended to be progressed as standardisation work.

# 8 Conclusions

## 8.1 For EPS and 5GS interworking required for mobility cases from EPS to 5GS and from 5GS to EPS, including the impacts on SMS handling

Solution #2 is considered to progress as normative optional feature, both stage 2 and stage 3 for deployments in which upgrading legacy systems to service based architectures is a feasible/acceptable option for the network operator. A number of open issues listed in clause 7 need to be addressed during normative phase.

CT WG4 is expected to take the responsibility of the normative specification work while SA WG2 will add relevant references in affected 5G specifications (TS 23.501 [6], TS 23.502 [2]).

Solutions #3 and #6 are feasible alternatives in different scenarios where migration of subscription data or upgrades of legacy systems are not possible/feasible, and conclusion is to document them as implementation/deployment options, addressing the open issues in the relevant evaluation clauses.

Editor's note: A 900 series TR will be created from this TR, to clearly document these solutions with reference to the CT WG4 TS for what relates to solution #2.

## 8.2 For IMS and 5GS interworking required for T-ADS, P-CSCF restoration and NPLI retrieval

Three different scenarios are addressed by the proposed solutions:

- HSS as single point of contact for IMS (diameter based).

- An UDM/HSS combo as single point of contact for IMS (diameter based).

- IMS HSS/SLF as single point of contact for IMS (diameter based).

To facilitate this, conclusion is to progress normative work for new service(s) with new service Request-Response operation(s) produced by UDM: for T-ADS (i.e. IMS over PS support) and NPLI (i.e. time stamp and RAT type), and for P-CSCF restoration. The decision about the number of operations is left for normative work.

The operations can be consumed by HSS (as in solution #2) for scenarios in which HSS is the single point of contact for IMS (diameter based) interactions and adapted to SBA.

The operations can be consumed by an IMS HSS when in stand-alone mode and acting as a single point of contact for a diameter-based IMS. This case would correspond to solution #2 when the HSS referred acts as IMS HSS and is adapted to SBA.

NOTE 1: These new operations require coordination with the normative work derived from FS\_eIMS5G (TS 23.794 [14]).

NOTE 2: Any Modification of TS 23.228 [7] to clarify the interactions between HSS, UDM and IMS will be coordinated with any normative work arising from FS\_eIMS5G (TS 23.794 [14]).

Solutions #3 and #6 are feasible alternatives and concluded to be documented as implementation/deployment options.

Editor's note: A 900 series TR will be created from this TR, to clearly document these solutions with reference to the CT WG4 TS for what relates to solution #2.

Annex A:  
Change history

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2018-12 | SP#82 | SP-181099 | - | - | - | MCC editorial update for presentation to TSG SA#82 | 1.0.0 |
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