**3GPP TSG-SA3 Meeting #101-e *S3-203251-r1***

**e-meeting, 9th - 20th November 2020**

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| *CR-Form-v12.0* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **33.501** | **CR** | **1012** | **rev** | **-** | **Current version:** | **16.4.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network | **X** |

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| ***Title:*** | Handling of KAUSF upon successful primary authentication | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Samsung, Nokia, Nokia Shanghai Bell, Intel, Ericsson?, NEC | | | | | | | | | |
| ***Source to TSG:*** | S3 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | TEI16 | | | | |  | ***Date:*** | | | 2020-10-23 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | F |  | | | | | ***Release:*** | | | Rel-16 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
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| ***Reason for change:*** | | SA3 clarified in its LS to CT4 (S3-201350):  - Only one KAUSF (latest one) is maintained in the AUSF and in the UE, as KAUSF is security association between the UE and the HPLMN.  - The AUSF in home PLMN never maintains two KAUSF, when a user is simultaneously registered in two Serving Networks via different access-types (3gpp and non-3gpp).  - SA3 does not see the need for maintaining multiple KAUSF in the UE and in the HPLMN. Further keeping the old keys laying around in the network is not a good security practice.  The above clarifications needs to be captured in the TS 33.501. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | * UDM stores the authEvents for both serving networks in multiple registrations. UDM selects the AUSF reporting the most recent successful authentication result. * When the UE having multiple registrations, while de-registers from the new serving network:   + AUSF and UE stores the newest KAUSF after UE deregistration;   + UDM, when deleting the authentication results for the new serving network, keeps the AUSF info in the authEvent. * UDM selects the latest AUSF which served the UE and maintains the latest KAUSF, for SoRProtection or UPUProtection services. * AUSF stores only the latest KAUSF upon successful authentication procedure and deletes any stored old KAUSF. * UE stores only the latest KAUSF upon successful authentication procedure and deletes any stored old KAUSF.   During the execution of e.g. SoR/UPU procedures, the UDM selects the AUSF that stores the latest KAUSF. | | | | | | | | |
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| ***Consequences if not approved:*** | | UE and HN may store and use different versions of KAUSF leading to failure of SoRProtection, UPUProtection and AKMA services. | | | | | | | | |
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| ***Clauses affected:*** | | 6.1.1.1, 6.1.4.1, 6.2.2.1, 6.2.2.2, 6.3.2.1, 6.14.2.1, 6.14.2.2, 6.14.2.3, 6.15.2.1, 6.15.2.2, 10.2.2.2, 14.1.Y | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | | r1: merger of S3-202986, S3-203251 and S3-203227  r2: to have unified handling in the UE for both EAP-AKA’ and 5G AKA | | | | | | | | |

**\*\*\*\* Start of Changes \*\*\*\***

#### 6.1.1.1 General

The purpose of the primary authentication and key agreement procedures is to enable mutual authentication between the UE and the network and provide keying material that can be used between the UE and the serving network in subsequent security procedures. The keying material generated by the primary authentication and key agreement procedure results in an anchor key called the KSEAF provided by the AUSF of the home network to the SEAF of the serving network.

Keys for more than one security context can be derived from the KSEAF without the need of a new authentication run. A concrete example of this is that an authentication run over a 3GPP access network can also provide keys to establish security between the UE and a N3IWF used in untrusted non-3GPP access.

The anchor key KSEAF is derived from an intermediate key called the KAUSF. The KAUSF is an additional key established between the UE and HN resulting from the primary authentication procedure. The KAUSF may be securely stored in the AUSF based on the home operator's policy on using such key e.g. if the control plane solution for Steering of Roaming or UE Parameter Update procedures are supported by the HPLMN (see sections 6.14 and 6.15).

NOTE A: For standalone non-public networks when an authentication method other than 5G AKA or EAP-AKA' is used, Annex I.2 applies.

NOTE 1: This feature is an optimization that might be useful, for example, when a UE registers to different serving networks for 3GPP-defined access and untrusted non-3GPP access (this is possible according to TS 23.501 [2]). The details of this feature are operator-specific and not in scope of this document.

NOTE 2: A subsequent authentication based on the KAUSF stored in the AUSF gives somewhat weaker guarantees than an authentication directly involving the ARPF and the USIM. It is rather comparable to fast re-authentication in EAP-AKA'.

NOTE 2a: Void.

UE and serving network shall support EAP-AKA' and 5G AKA authentication methods.

NOTE 2b: It is the home operator's decision which authentication method is selected.

The USIM shall reside on a UICC. The UICC may be removable or non-removable.

NOTE 3: For non-3GPP access networks USIM applies in case of terminal with 3GPP access capabilities.

If the terminal supports 3GPP access capabilities, the credentials used with EAP-AKA' and 5G AKA for non-3GPP access networks shall reside on the UICC.

NOTE 4: EAP-AKA' and 5G AKA are the only authentication methods that are supported in UE and serving network, hence only they are described in sub-clause 6.1.3 of the present document. For a private network using the 5G system as specified in [7] an example of how additional authentication methods can be used with the EAP framework is given in the informative Annex B.

NOTE 5: For non-public network (NPN) security the Annex I of the present document provides details.

**\*\*\*\* 2nd Change \*\*\*\***

#### 6.1.4.1 Introduction

The 5G authentication and key agreement protocols provide increased home control. Compared to EPS AKA in EPS, this provides better security useful in preventing certain types of fraud as explained in more detail below.

This increased home control comes in the following forms in 5GS:

- In the case of EAP-AKA', the AUSF in the home network obtains confirmation that the UE has been successfully authenticated when the EAP-Response/AKA'-Challenge received by the AUSF has been successfully verified, cf. sub-clause 6.1.3.1 of the present document.

- In the case of 5G AKA, the AUSF in the home network obtains confirmation that the UE has been successfully authenticated when the authentication confirmation received by the AUSF in Nausf\_UEAuthentication\_Authenticate Request message has been successfully verified, cf. sub-clause 6.1.3.2 of the present document.

When 3GPP credentials are used in above cases, the result is reported to the UDM. Details are described in clause 6.1.4.1a.

The feature of increased home control is useful in preventing certain types of fraud, e.g. fraudulent Nudm\_UECM\_Registration Request for registering the subscriber's serving AMF in UDM that are not actually present in the visited network. But an authentication protocol by itself cannot provide protection against such fraud. The authentication result needs to be linked to subsequent procedures, e.g. the Nudm\_UECM\_Registration procedure from the AMF in some way to achieve the desired protection.

The actions taken by the home network to link authentication confirmation (or the lack thereof) to subsequent procedures are subject to operator policy and are not standardized.

But informative guidance is given in sub-clause 6.1.4.2 as to what measures an operator could usefully take. Such guidance may help avoiding a proliferation of different solutions.

The feature of increased home control is also used to allow the UDM to keep track of the AUSF that stores the KAUSF to be used during e.g. the control plane solution for Steering of Roaming or UE Parameter Update procedures; i.e. the AUSF that stores the latest KAUSF generated after successful completion of the latest primary authentication reported to UDM.

**\*\*\*\* 3rd Change \*\*\*\***

#### 6.2.2.1 Keys in network entities

***Keys in the ARPF***

The ARPF shall process the long-term key K and any other sensitive data only in its secure environment. The key K shall be 128 bits or 256 bits long.

During an authentication and key agreement procedure, the ARPF shall derive CK' and IK' from K in case EAP-AKA' is used and derive KAUSF from K in case 5G AKA is used. The ARPF shall forward the derived keys to the AUSF.

The ARPF holds the Home Network Private Key that is used by the SIDF to deconceal the SUCI and reconstruct the SUPI. The generation and storage of this key material is out of scope of the present document.

***Keys in the AUSF***

In case EAP-AKA' is used as authentication method, the AUSF shall derive a key KAUSF from CK' and IK' for EAP-AKA' as specified in clause 6.1.3.1. In case that 5G AKA is used as authentication method, the UDM/ARPF shall generate the KAUSF as specified in clause 6.1.3.2.

The KAUSF may be stored in the AUSF between two subsequent authentication and key agreement procedures.

When the AUSF stores the KAUSF, the AUSF shall store the latest KAUSF generated after successful completion of the latest primary authentication. The authentication is considered as successful and the AUSF shall stores the latest KAUSF or replace the old KAUSF with the new KAUSF (if the AMF(s) end up selecting the same AUSF instance for (re)authentication of the UE) when:

- in case 5G AKA is used as authentication method, only if the RES\* and the XRES\* are equal (see clause 6.1.3.2.0).

- in case EAP-AKA' is used as authentication method, only if the AUSF sends an EAP-Success message to the SEAF (see clause 6.1.3.1).

The AUSF shall generate the anchor key, also called KSEAF, from the authentication key material received from the ARPF during an authentication and key agreement procedure.

***Keys in the SEAF***

The SEAF receives the anchor key, KSEAF, from the AUSF upon a successful primary authentication procedure in each serving network.

The SEAF shall never transfer KSEAF to an entity outside the SEAF. Once KAMF is derived KSEAF shall be deleted.

The SEAF shall generate KAMF from KSEAF immediately following the authentication and key agreement procedure and hands it to the AMF.

NOTE 1: This implies that a new KAMF, along with a new KSEAF, is generated for each run of the authentication and key agreement procedure.

NOTE 2: The SEAF is co-located with the AMF.

***Keys in the AMF***

The AMF receives KAMF from the SEAF or from another AMF.

The AMF shall, based on policy, derive a key K'AMF from KAMF for transfer to another AMF in inter-AMF mobility. The receiving AMF shall use K'AMF as its key KAMF.

NOTE 3: The precise rules for key handling in inter-AMF mobility can be found in clause 6.9.3.

The AMF shall generate keys KNASint and KNASenc dedicated to protecting the NAS layer.

The AMF shall generate access network specific keys from KAMF. In particular,

- the AMF shall generate KgNB and transfer it to the gNB.

- the AMF shall generate NH and transfer it to the gNB, together with the corresponding NCC value.   
The AMF may also transfer an NH key, together with the corresponding NCC value, to another AMF, cf. clause 6.9.

- the AMF shall generate KN3IWF and transfer it to the N3IWF when KAMF is received from SEAF, or when K’AMF is received from another AMF.

***Keys in the NG-RAN***

The NG-RAN (i.e., gNB or ng-eNB) receives KgNB and NH from the AMF. The ng-eNB uses KgNB as KeNB.

The NG-RAN (i.e., gNB or ng-eNB) shall generate all further access stratum (AS) keys from KgNB and /or NH.

***Keys in the N3IWF***

The N3IWF receives KN3IWF from the AMF.

The N3IWF shall use KN3IWF as the key MSK for IKEv2 between UE and N3IWF in the procedures for untrusted non-3GPP access, cf. clause 11.

Figure 6.2.2-1 shows the dependencies between the different keys, and how they are derived from the network nodes point of view.



Figure 6.2.2-1: Key distribution and key derivation scheme for 5G for network nodes

NOTE 4: The key derivation and distribution scheme for standalone non-public networks, when an authentication method other than 5G AKA or EAP-AKA' is used, is given in Annex I.2.3.

**\*\*\*\* 4th Change \*\*\*\***

#### 6.2.2.2 Keys in the UE

For every key in a network entity, there is a corresponding key in the UE.

Figure 6.2.2-2 shows the corresponding relations and derivations as performed in the UE.



Figure 6.2.2-2: Key distribution and key derivation scheme for 5G for the UE

***Keys in the USIM***

The USIM shall store the same long-term key K that is stored in the ARPF.

During an authentication and key agreement procedure, the USIM shall generate key material from K that it forwards to the ME.

If provisioned by the home operator, the USIM shall store the Home Network Public Key used for concealing the SUPI.

***Keys in the ME***

The ME shall generate the KAUSF from the CK, IK received from the USIM. The generation of this key material is specific to the authentication method and is specified in clause 6.1.3.

When 5G AKA is used, the generation of RES\* from RES shall be performed by the ME.

The UE shall store the latest KAUSF or replace the old KAUSF with the latest KAUSF after successful completion of the latest primary authentication. If the USIM supports 5G parameters storage, KAUSF shall be stored in the USIM. Otherwise, KAUSF shall be stored in the non-volatile memory of the ME.

In case 5G AKA or EAP-AKA' is used as authentication method for initial registration then, upon receiving the valid NAS Security Mode Command message from the AMF, the performed primary authentication shall be considered as successful and the UE shall store the newly generated KAUSF as the latest KAUSF or replace the old KAUSF with the latest KAUSF. Instead, if an Authentication Reject message is received or NAS SMC is not received, then the performed primary authentication shall be considered as unsuccessful and the newly generated KAUSF is not taken as latest KAUSF.

NOTE x: When 5G AKA or EAP-AKA' is used as authentication method for re-authentication then, it is left to UE implementation to consider when to store the latest KAUSF or replace the old KAUSF with the latest KAUSF. An implementation option is, upon receiving a valid integrity protected NAS message (other than Authentication Reject message) from the network which stops the timer T3516 (specified in TS 24.501 [35]) or on expiry of the timer T3516, the primary authentication is considered as successful and the UE stores the newly generated KAUSF. If the timer T3516 is stopped by the Authentication Reject message, then the primary authentication to be considered as unsuccessful and the newly generated KAUSF is not taken as latest KAUSF.

The ME shall perform the generation of KSEAF from the KAUSF. If the USIM supports 5G parameters storage, KSEAF shall be stored in the USIM. Otherwise, KSEAF shall be stored in the non-volatile memory of the ME.

The ME shall perform the generation of KAMF. If the USIM supports 5G parameters storage, KAMF shall be stored in the USIM. Otherwise, KAMF shall be stored in the non-volatile memory of the ME.

The ME shall perform the generation of all other subsequent keys that are derived from the KAMF.

Any 5G security context, KAUSF and KSEAF that are stored at the ME shall be deleted from the ME if:

a) the USIM is removed from the ME when the ME is in power on state;

b) the ME is powered up and the ME discovers that the USIM is different from the one which was used to create the 5G security context;

c) the ME is powered up and the ME discovers that there is no USIM is present at the ME.

NOTE 1: The key derivation and distribution scheme for standalone non-public networks, when an authentication method other than 5G AKA or EAP-AKA' is used, is given in Annex I.2.3.

**\*\*\*\* 5th Change \*\*\*\***

#### 6.3.2.1 Multiple registrations in different PLMNs

The UE shall independently maintain and use two different 5G security contexts, one per PLMN's serving network. . Each security context shall be established separately via a successful primary authentication procedure with the Home PLMN.

The ME shall store the two different 5G security contexts on the USIM if the USIM supports the 5G parameters storage. If the USIM does not support the 5G parameters storage, then the ME shall store the two different 5G security contexts in the ME non-volatile memory. Both of the two different 5G security contexts are current 5G security context.

Editor's Note: It is FFS to define the event(s) that triggers the storage of the key in the ME or in the USIM. Also, the appropriate clause needs to be considered.

The latest KAUSF result of the successful completion of the latest primary authentication shall be used by the UE and the HN regardless over which access network type (3GPP or non-3GPP) it was generated.

The UDM shall not delete the latest KAUSF in the AUSF, even if the UE deregisters from a serving network (over which latest KAUSF was generated), while the UE is still connected to the network via another serving network.

The UDM may request the AUSF to clear the stale security context, after the UE has been successfully (re)authenticated in different AUSF instance. If the UDM determine to delete the context in the AUSF, then the UDM shall use the procedure Nausf\_UEAuthentication\_deregister service operation (see clause 14.1.Y) to send the indication to the AUSF to clear the old KAUSF.

**\*\*\*\* 6th Change \*\*\*\***

6.14.1 General

This clause describes the security functions necessary to support steering of the UE in the VPLMN during registration procedure and also after registration as described in TS 23.122 [53] Annex C. The security functions are described in the context of the functions supporting the control plane solution for steering of roaming in 5GS.

If the control plane solution for Steering of Roaming is supported by the HPLMN, the AUSF shall store the latest KAUSF after the completion of the latest primary authentication.

The content of the Steering List as well as the conditions for sending it to the UE are described in TS 23.122 [53] Annex C. The Steering List includes either a list of preferred PLMN/access technology combinations, a secured packet or the HPLMN indication that 'no change of the "Operator Controlled PLMN Selector with Access Technology" list stored in the UE is needed and thus no list of preferred PLMN/access technology combinations is provided'.

NOTE: The Steering of Roaming Information is defined in clause 1.2 of TS 23.122 [53]. It contains thus the ACK indication, the Steering List and the integrity protection information.

**\*\*\*\* 7th Change \*\*\*\***

6.14.2.1 Procedure for steering of UE in VPLMN during registration

The security procedure for the case where the UE registers with VPLMN AMF is described below in figure 6.14.2.1-1:



**Figure 6.14.2.1-1: Procedure for providing list of preferred PLMN/access technology combinations** **during registration in VPLMN**

1) The UE initiates registration by sending Registration Request message to the VPLMN AMF.

2-3) The VPLMN AMF executes the registration procedure as defined in sub-clause 4.2.2.2.2 of 3GPP TS 23.502 [8]. As part of the registration procedure, the VPLMN AMF executes primary authentication of the UE and then initiates the NAS SMC procedure, after the authentication is successful.

4-5) The VPLMN AMF invokes the Nudm\_UECM\_Registration message to the UDM and registers access with the UDM as per step 14a in sub-clause 4.2.2.2.2 of 3GPP TS 23.502[8].

6) The VPLMN AMF invokes Nudm\_SDM\_Get service operation message to the UDM to get amongst other information the Access and Mobility Subscription data for the UE (see step 14b in sub-clause 4.2.2.2.2 of 3GPP TS 23.502 [8]).

7) The UDM decides to send the Steering of Roaming Information, and obtains a list of preferred PLMN/access technology combinations or a secured packet list as described in TS 23.122 [53].

If the UDM determines that the UE is configured to not expect to receive Steering of Roaming Information at initial registration and if the UDM determines that no change of the "Operator Controlled PLMN Selector with Access Technology" list stored in the UE is needed, then the UDM may not piggyback Steering of Roaming Information at all in the Nudm\_SDM\_Get response and hence the following steps are omitted.

8-9) The UDM shall invoke Nausf\_SoRProtection service operation message to the AUSF to get SoR-MAC-IAUSF and CounterSoR as specified in sub-clause 14.1.3 of this document. The UDM shall select the AUSF that holds the latest KAUSF of the UE.

If the HPLMN decides that the UE is to acknowledge the successful security check of the received Steering of Roaming Information, then the UDM shall set accordingly the ACK Indication included in the Nausf\_SoRProtection service operation message to signal that it also needs the expected SoR-XMAC-IUE, as specified in sub-clause 14.1.3 of this document.

NOTE: At reception of Nausf\_SoRProtection\_Protect request from the UDM, the AUSF constructs the SOR header, as described in clause 9.11.3.51 of TS 24.501 [35], based on the information received from the UDM, i.e. ACK Indication and list of preferred PLMN/access technology combinations or secured packet (if provided).

The details of the CounterSoR are specified in sub-clause 6.14.2.3 of this document. The inclusion of the Steering List and the SoR header in the calculation of SoR-MAC-IAUSF allows the UE to verify that the received Steering of Roaming Information is not tampered with or removed by the VPLMN. The expected SoR-XMAC-IUE allows the UDM to verify that the UE received the Steering of Roaming Information.

10) The UDM responds to the Nudm\_SDM\_Get service operation to the VPLMN AMF, which shall include the ACK Indication, the list of preferred PLMN/access technology combinations or secured packet (if provided), SoR-MAC-IAUSF and CounterSoR within the Access and Mobility Subscription data. If the UDM requests an acknowledgement, it shall temporarily store the expected SoR-XMAC-IUE.

11) The VPLMN AMF shall construct the SOR header based on the ACK Indication and the list of preferred PLMN/access technology combinations or secured packet (if provided) received from the UDM and include it in the SOR transparent container as specified in clause 9.11.3.51 of TS 24.501 [35]. The resulting Steering of Roaming Information, also including SoR-MAC-IAUSFand CounterSoR(both also received from the UDM), is conveyed to the UE in the Registration Accept message;

12) On receiving the Registration Accept message with Steeringof Roaming Information the UE shall calculate the SoR-MAC-IAUSF in the same way as the AUSF (as specified in Annex A.17) on the received Steering of Roaming Information, including the CounterSoR and the SoR header, and verifies whether it matches the SoR-MAC-IAUSF value received in the Registration Accept message. Based on the SoR-MAC-IAUSF verification outcome, the behaviour of the UE is specified in TS 23.122 [53].

13) If the UDM has requested an acknowledgement from the UE and the UE verified that the Steering of Roaming Information received in step 11 has been provided by the HPLMN, then the UE shall send the Registration Complete message to the serving AMF. The UE shall generate the SoR-MAC-IUE as specified in Annex A.18 and includes the generated SoR-MAC-IUE in a SOR transparent container in the Registration Complete message.

14) The AMF sends a Nudm\_SDM\_Info request message to the UDM. If a transparent container with the SoR-MAC-IUE was received in the Registration Complete message, the AMF shall include the SoR-MAC-IUEin the Nudm\_SDM\_Info request message.

15) If the HPLMN indicated that the UE is to acknowledge the successful security check of the received Steering of Roaming Information in step 10, then the UDM shall compare the received SoR-MAC-IUE with the expected SoR-XMAC-IUE that the UDM stored temporarily in step 10.

**\*\*\*\* 8th Change \*\*\*\***

6.14.2.2 Procedure for steering of UE in VPLMN or HPLMN after registration

The security procedure for the steering of UE in VPLMN after registration is described below in figure 6.14.2.2-1:



**Figure 6.14.2.2-1: Procedure for providing list of preferred PLMN/access technology combinations** **after registration**

1) The UDM decides to notify the UE of the changes to the Steering of Roaming Information by the means of invoking Nudm\_SDM\_Notification service operation.

2-3) The UDM shall invoke Nausf\_SoRProtection service operation message by including the ACK Indication and optionally the list of preferred PLMN/access technology combinations or secured packet to the AUSF to get SoR-MAC-IAUSF and CounterSoR as specified in sub-clause 14.1.3 of this document. The UDM shall select the AUSF that holds the latest KAUSF of the UE.

If the HPLMN decided that the UE is to acknowledge the successful security check of the received Steering of Roaming Information, then the UDM shall set accordingly the ACK Indication included in the Nausf\_SoRProtection service operation message to signal that it also needs the expected SoR-XMAC-IUE, as specified in sub-clause 14.1.3 of this document.

NOTE: At reception of Nausf\_SoRProtection\_Protect request from the UDM, the AUSF constructs the SOR header, as described in clause 9.11.3.51 of TS 24.501 [35], based on the information received from the UDM, i.e. ACK Indication and optionally the list of preferred PLMN/access technology combinations or secured packet.

The details of the CounterSoR are specified in sub-clause 6.14.2.3 of this document. The inclusion of the Steering List and the SOR header in the calculation of SoR-MAC-IAUSF allows the UE to verify that the Steering of Roaming Information received is not tampered with or removed by the VPLMN. The inclusion of these information in the calculation of the expected SoR-XMAC-IUE allows the UDM to verify that the UE received the Steering of Roaming Information.

4) The UDM shall invoke Nudm\_SDM\_Notification service operation, which contains optionally the list of preferred PLMN/access technology combinations or secured packet,the ACK Indication, SoR-MAC-IAUSF, and CounterSoR within the Access and Mobility Subscription data. If the UDM requests an acknowledgement, it shall temporarily store the expected SoR-XMAC-IUE.

5) Upon receiving the Nudm\_SDM\_Notification message, the AMF shall send a DL NAS Transport message to the served UE. The AMF shall include in the DL NAS Transport message the SOR transparent container (including the SOR header) constructed as specified in clause 9.11.3.51 of 3GPP TS 24.501 [35] based on the ACK Indication, the Steering List, SoR-MAC-IAUSF and CounterSoR received from the UDM.

6) On receiving the DL NAS Transport message, the UE shall calculate the SoR-MAC-IAUSF in the same way as the AUSF (as specified in Annex A.17) on the received Steering of Roaming Information, including the CounterSoR and the SoR header and verify whether it matches the SoR-MAC-IAUSF value received in the DL NAS Transport message.

7) If the UDM has requested an acknowledgement from the UE and the UE verified that the Steering Information has been provided by the HPLMN, then the UE shall send the UL NAS Transport message to the serving AMF. The UE shall generate the SoR-MAC-IUE as specified in Annex A.18 and includes the generated SoR-MAC-IUE in a SOR transparent container in the UL NAS Transport message.

8) The AMF shall send a Nudm\_SDM\_Info request message to the UDM. If a SOR transparent container with the SoR-MAC-IUE was received in the UL NAS Transport message, the AMF shall include the SoR-MAC-IUE in the Nudm\_SDM\_Info request message.

9) If the HPLMN indicated that the UE is to acknowledge the successful security check of the received Steering of Roaming Information, then the UDM shall compare the received SoR-MAC-IUE with the expected SoR-XMAC-IUE that the UDM stored temporarily in step 4.

**\*\*\*\* 9th Change \*\*\*\***

6.14.2.3 SoR Counter

The AUSF and the UE shall associate a 16-bit counter, CounterSoR, with the key KAUSF.

The UE shall initialize the CounterSoR to 0x00 0x00 when the KAUSF is made valid.

To generate the SoR-MAC-IAUSF, the AUSF shall use a counter, called a CounterSoR. The CounterSoR shall be incremented by the AUSF for every new computation of the SoR-MAC-IAUSF. The CounterSoR is used as freshness input into SoR-MAC-IAUSF and SoR-MAC-IUE derivations as described in the Annex A.17 and Annex A.18 respectively, to mitigate the replay attack. The AUSF shall send the value of the CounterSoR (used to generate the SoR-MAC-IAUSF) along with the SoR-MAC-IAUSF to the UE. The UE shall only accept CounterSoR value that is greater than stored CounterSoR value. The UE shall store the received CounterSoR, onlyif the verification of the received SoR-MAC-IAUSF is successful. The UE shall use the stored CounterSoR received from the HPLMN, when deriving the SoR-MAC-IUE for the SoR acknowledgement.

The AUSF and the UE shall maintain the CounterSoR for lifetime of the KAUSF.

The AUSF that supports the control plane solution for steering of roaming shall initialize the CounterSoR to 0x00 0x01 when the KAUSF is made valid. The AUSF shall set the CounterSoR to 0x00 0x02 after the first calculated SoR-MAC-IAUSF, and monotonically increment it for each additional calculated SoR-MAC-IAUSF. The SoR Counter value of 0x00 0x00 shall not be used to calculate the SoR-MAC-IAUSF and SoR-MAC-IUE.

The AUSF shall suspend the SoR protection service for the UE, if the CounterSoR associated with the KAUSF of the UE, is about to wrap around. When a fresh KAUSF is generated for the UE, the CounterSoR at the AUSF is reset to 0x00 0x01 as defined above and the AUSF shall resume the SoR protection service for the UE.

**\*\*\*\* 10th Change \*\*\*\***

### 6.15.1 General

This clause describes the security functions necessary to update the UE parameters using the UDM control plane procedure specified in TS 23.502 [8]. The security functions are described in the context of the functions supporting the delivery of UE Parameters Update Data from the UDM to the UE after the UE has successfully registered to the 5G network.

If the control plane procedure for UE parameters update is supported by the UDM, the AUSF shall store the latest KAUSF after the completion of the latest primary authentication.

The content of UE Parameters Update Data and the conditions for sending it to the UE as well as how it is handled at the UE are specified in TS 24.501 [35].

NOTE: The home network relies on the serving network to deliver the UE parameters update.

**\*\*\*\* 11th Change \*\*\*\***

6.15.2.1 Procedure for UE Parameters Update

The UDM may decide to perform UE parameters update anytime after the UE has been successfully authenticated and registered to the 5G system. The security procedure for the UE parameters update is described below in figure 6.15.2.1-1:

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**Figure 6.15.2.1-1: Procedure for UE Parameters Update**

1) The UDM decides to perform the UE Parameters Update (UPU) using the control plane procedure while the UE is registered to the 5G system. If the final consumer of any of the UE parameters to be updated (e.g., the updated Routing ID Data) is the USIM, the UDM shall protect these parameters using a secured packet mechanism (see 3GPP TS 31.115 [65]) to update the parameters stored on the USIM. The UDM shall then prepare the UE Parameters Update Data (UPU Data) by including the parameters protected by the secured packet, if any, as well as any UE parameters for which final consumer is the ME (see TS 24.501 [35]).

2-3) The UDM shall invoke Nausf\_UPUProtection service operation message by including the UPU Data to the AUSF to get UPU-MAC-IAUSF and CounterUPU as specified in sub-clause 14.1.4 of this document. The UDM shall select the AUSF that holds the latest KAUSF of the UE.

If the UDM decided that the UE is to acknowledge the successful security check of the received UE Parameters Update Data, then the UDM shall set the corresponding indication in the UE Parameters Update Data (see TS 24.501 [35]) and include the ACK Indication in the Nausf\_UPUProtection service operation message to signal that it also needs the expected UPU-XMAC-IUE, as specified in sub-clause 14.1.4 of this document.

The details of the CounterUPU is specified in sub-clause 6.15.2.2 of this document. The inclusion of UE Parameters Update Data in the calculation of UPU-MAC-IAUSF allows the UE to verify that it has not been tampered by any intermediary. The expected UPU-XMAC-IUE allows the UDM to verify that the UE received the UE Parameters Update Data correctly.

4) The UDM shall invoke Nudm\_SDM\_Notification service operation, which contains UE Parameters Update Data, UPU-MAC-IAUSF, CounterUPU within the Access and Mobility Subscription data. If the UDM requests an acknowledgement, it shall temporarily store the expected UPU-XMAC-IUE.

5) Upon receiving the Nudm\_SDM\_Notification message, the AMF shall send a DL NAS Transport message to the served UE. The AMF shall include in the DL NAS Transport message the transparent container received from the UDM.

6) On receiving the DL NAS Transport message, the UE shall calculate the UPU-MAC-IAUSF in the same way as the AUSF (as specified in Annex A.19) on the received UE Parameters Update Data and the CounterUPU and verify whether it matches the UPU-MAC-IAUSF value received in the DL NAS Transport message. If the verification of UPU-MAC-IAUSF is successful and the UPU Data contains any parameters that is protected by secured packet (see 3GPP TS 31.115 [65]), the ME shall forward the secured packet to the USIM using procedures in 3GPP TS 31.111 [66]. If the verification of UPU-MAC-IAUSF is successful and the UPU Data contains any parameters that is not protected by secure packet, the ME shall update its stored parameters with the received parameters in UDM Updata Data.

7) If the UDM has requested an acknowledgement from the UE and the UE has successfully verified and updated the UE Parameters Update Data provided by the UDM, then the UE shall send the UL NAS Transport message to the serving AMF. The UE shall generate the UPU-MAC-IUE as specified in Annex A.20 and include the generated UPU-MAC-IUE in a transparent container in the UL NAS Transport message.

8) If a transparent container with the UPU-MAC-IUE was received in the UL NAS Transport message, the AMF shall send a Nudm\_SDM\_Info request message with the transparent container to the UDM.

9) If the UDM indicated that the UE is to acknowledge the successful security check of the received UE Parameters Update Data, then the UDM shall compare the received UPU-MAC-IUE with the expected UPU-XMAC-IUE that the UDM stored temporarily in step 4.

**\*\*\*\* 12th Change \*\*\*\***

6.15.2.2 UE Parameters Update Counter

The AUSF and the UE shall associate a 16-bit counter, CounterUPU, with the key KAUSF.

The UE shall initialize the CounterUPU to 0x00 0x00 when the KAUSF is made valid.

To generate the UPU-MAC-IAUSF, the AUSF shall use a counter, called a CounterUPU. The CounterUPU shall be incremented by the AUSF for every new computation of the UPU-MAC-IAUSF. The CounterUPU is used as freshness input into UPU-MAC-IAUSF and UPU-MAC-IUE derivations as described in the Annex A.19 and Annex A.20 respectively, to mitigate the replay attack. The AUSF shall send the value of the CounterUPU (used to generate the UPU-MAC-IAUSF) along with the UPU-MAC-IAUSF to the UE. The UE shall only accept CounterUPU value that is greater than stored CounterUPU value. The UE shall update the stored CounterUPU with the received CounterUPU, onlyif the verification of the received UPU-MAC-IAUSF is successful. The UE shall use the CounterUPU received from the UDM, when deriving the UPU-MAC-IUE for the UE Parameters Upadate Data acknowledgement.

The AUSF and the UE shall maintain the CounterUPU for lifetime of the KAUSF.

The AUSF that supports the UE parameters update using control plane procedure shall initialize the CounterUPU to 0x00 0x01 when the KAUSF is made valid. The AUSF shall set the CounterUPU to 0x00 0x02 after the first calculated UPU-MAC-IAUSF, and monotonically increment it for each additional calculated UPU-MAC-IAUSF. The UPU Counter value of 0x00 0x00 shall not be used to calculate the UPU-MAC-IAUSF and UPU-MAC-IUE.

The AUSF shall suspend the UE Parameters Update protection service for the UE, if the CounterUPU associated with the KAUSF of the UE, is about to wrap around. When a fresh KAUSF is generated for the UE, the CounterUPU at the AUSF is reset to 0x00 0x01 as defined above and the AUSF shall resume theUE Parameters Update protection service for the UE.

**\*\*\*\* 13th Change \*\*\*\***

10.2.2.2 UE sets up an IMS Emergency session with emergency registration

UEs that are in limited service state (LSM) request emergency services by initiating the Registration procedure with the indication that the registration is to receive emergency services, referred to as Emergency Registration.

UEs that had earlier registered for normal services but now cannot be authenticated by the serving network, shall initiate Emergency Registration procedure to request emergency services.

It shall be possible to configure whether the network allows or rejects an emergency registration request and whether it allows unauthenticated UEs to establish bearers for unauthenticated IMS emergency sessions or not.

The AMF may attempt to authenticate the UE after receiving the emergency registration request.

If authentication failed in the UE during an emergency registration request, the UE shall wait for a NAS SMC command to set up an unauthenticated emergency bearer.

If authentication failed in the serving network and if the serving network policy does not allow unauthenticated IMS Emergency Sessions, the UE and AMF shall proceed as with the normal initial registration requests. The AMF shall reject the unauthenticated emergency bearer setup request from the UE.

If authentication failed in the serving network and if the serving network policy allow unauthenticated IMS Emergency Sessions, then the AMF shall support unauthenticated emergency bearer setup and the behaviours of the UE and the AMF are as described below.

a) UE behaviour:

After sending Emergency Registration request to the serving network the UE shall know of its own intent to establish an unauthenticated IMS Emergency Session.

The UE shall proceed as specified for the non-emergency case in except that the UE shall accept a NAS SMC selecting NEA0 and NIA0 algorithms from the AMF. If the UE accepts a NAS SMC selecting NEA0 and NIA0 algorithms from the AMF as part of Emergency Registration request, then the primary authentication performed if any shall be considered as unsuccessful and the newly generated KAUSF is not taken as latest KAUSF.

NOTE: In case of authentication success the AMF will send a NAS SMC selecting algorithms with a non-NULL integrity algorithm, and the UE will accept it.

b) AMF behavior:

After receiving Emergency Registration request from the UE, the AMF knows of that UE's intent to establish an unauthenticated IMS Emergency Session.

- If the AMF cannot identify the subscriber, or cannot obtain authentication vector (when SUPI is provided), the AMF shall send NAS SMC with NULL algorithms to the UE regardless of the supported algorithms announced previously by the UE.

- After the unsuccessful verification of the UE, the AMF shall send NAS SMC with NULL algorithms to the UE regardless of the supported algorithms announced previously by the UE.

- If both, the Emergency Registration request and an AUTHENTICATION FAILURE message with error code as defined in 24.501 [35] clauses 5.4.1.2.4.5 (for EAP based authentication) or 5.4.1.3.7 (for 5G AKA based authentication) are received by the AMF from the UE, then the AMF shall send NAS SMC with NULL algorithms to the UE regardless of the supported algorithms announced previously by the UE.

If the UE has initiated a PDU session establishment procedure to establish bearers for unauthenticated IMS emergency sessions and the AMF has indicated to the SMF that this is an unauthenticated emergency call, then the SMF shall indicate 'Not Needed' in the UP security policy for both UP confidentiality and UP integrity protection to the ng-eNB/gNB.

**\*\*\*\* 14th Change \*\*\*\***

### 14.1.Y Nausf\_UEAuthentication\_deregister service operation

**Service operation name:** Nausf\_UEAuthentication\_deregister

**Description:** Deletion of stale security context in AUSF. UDM uses this service operation to request the AUSF to clear the stale security context, after the UE has been successfully (re)authenticated in same or different AUSF Instance or when the UE is no longer registered via any access-type or serving-network. The UDM determines to initiate this service only if, the UE is not connected via another serving network via other access and if the AUSF-instance which is a candidate for deletion does not holds the latest KAUSF.

**Input, Required:** SUPI

**Input, Optional:** None

**Output, Required:** None

**Output, Optional:** None

**\*\*\*\* End of Changes \*\*\*\***