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| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;Study on 5G AM Policy(Release 18) |
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| ***3GPP***Postal address3GPP support office address650 Route des Lucioles - Sophia AntipolisValbonne - FRANCETel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16Internethttp://www.3gpp.org |
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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:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The aim of this Technical Report is to study and evaluation of potential enhancements for Access and Mobility Policy Management with the following objective(s):

- To study the mechanisms to provide AM policy control on RFSP Index consistency when UE moves from 5GC to EPC, and define enhancements in R17 mechanism if needed.

# 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 23.501: "System Architecture for the 5G System; Stage 2".

[3] 3GPP TS 23.502: "Procedures for the 5G system, Stage 2".

[4] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System".

[5] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (EUTRAN) access".

[6] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[7] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[8] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[9] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".

[10] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[11] 3GPP TS 29.563: "Home Subscriber Server (HSS) services for interworking with Unified Data Management (UDM); Stage 3".

# 3 Definitions of terms and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1], in TS 23.501 [2] 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] or in TS 23.501 [2].

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1], in TS 23.501 [2] 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] or in TS 23.501 [2].

# 4 Architectural Assumptions and Principles

The architecture and framework as specified in TS 23.501 [2], TS 23.502 [3], TS 23.503 [4], and TS 23.401 [5] are regarded as the baseline for the present study.

Solutions shall build on the 5G interworking with EPC as in clause 4.3 and clause 5.17 of TS 23.501 [2], System interworking procedures for 5GS to EPS as in clause 4.11 of TS 23.502 [3], and AM policy control function description as defined in TS 23.503 [4].

# 5 Key Issues

## 5.1 Key Issue #1: RFSP Index consistency when UE moves from 5GC to EPC

### 5.1.1 Description

Currently, most operators run 4G and 5G merged network. To promote 5G service, the subscription data of UE may be set to 5G access first, i.e. the subscribed RFSP Index is of the value of "5G has higher priority than 4G". In some scenarios, the PCF may adjust the RFSP index to direct the UE from 5G to 4G according to dynamic network situations, for example:

- When network congestion prediction received from NWDAF, the PCF may move some of the "5G prioritized" UEs which consuming low value applications to 4G access.

- According to the request from AF, the PCF may move the requested UE(s) from 5G to 4G.

When UE registers to EPC, the MME chooses the RFSP Index in use based on the subscribed RFSP Index, the locally configured operator's policies and the UE related context information available at the MME. If the EPC decides the UE needs to go back to 5G, the MME provides "5G prioritized" RFSP Index to eNB.

To avoid network issue, e.g. the ping-pong issue, where the 5GC keeps sending the UE to EPC based on authorized RFSP Index from PCF, while the MME only has the subscribed RFSP Index and kick the UE in the above scenarios back to 5G immediately, this key issue will study AM policy control on RFSP Index consistency when UE moves from 5GC to EPC:

- Whether the current interworking procedure supports MME received the RFSP Index in use from 5GC? If no, what enhancements is needed.

- If the MME get the RFSP Index in used in handover procedure or idle mode mobility procedure, how and when it resumes to the subscription RFSP Index.

- When UE is under EPC, should MME receive any update of RFSP Index from 5GC and how.

NOTE: The KI covers EPC and 5GC interworking for both with N26-based and without N26 interface architecture.

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |
| --- | --- | --- |
| Solution # | Solution Title | Key Issue # |
| 1 | Use N26 to provide PCF-updated RFSP Index from 5GC to MME | 1 |
| 2 | Provide Authorized RFSP in EPC via UDM/HSS, during 5GS to EPS mobility | 1 |
| 3 | Enforcing RFSP index authorized by PCF in EPC via N26 | 1 |
| 4 | Enforcing RFSP index authorized by PCF in EPC without N26 interface | 1 |
| 5 | Authorized RFSP index provisioning from 5GC to MME without N26 interface | 1 |
| 6 | Provide updated RFSP when UE is already moved to EPS with N26 interface | 1 |
| 7 | Provide updated RFSP when UE is already moved to EPS without N26 interface | 1 |
| 8 | MME-enhancement solution on KI#1 for 5GS to EPS mobility without N26 interface | 1 |
| 9 | PCF-updated RFSP Index to MME via HSS | 1 |
| 10 | Provide RFSP Index via N26 interface when the UE moves from 5GC to EPC | 1 |

## 6.1 Solution #1: Use N26 to provide PCF-updated RFSP Index from 5GC to MME

### 6.1.1 Description

This solution is to allow MME to receive RFSP Index update from PCF when UE moves from 5G to 4G in N26-based interworking architecture. When MME is able to receive updated RFSP index from PCF as AMF, the RFSP index in use will be consistent when UE moves between 5G and 4G. This is a solution for N26-based interworking.

When N26-based interworking architecture applies, AMF and MME use N26 interface to transfer mobility management message. The parameters, subscribed RFSP index and RFSP index in use, are transferred in:

- Forward Relocation Request as in 5GS to EPS handover procedures using N26 interface, or

- Context Response as in 5GS to EPS Idle mode mobility using N26 interface.

Therefore, this solution proposes that, when UE moves from 5G to 4G, the old AMF should keep or defer to terminate the AM association of the UE within a reasonable period, i.e. AM Policy Association maintenance timer. When the PCF is triggered to update the RFSP Index, the updated RFSP index is delivered to the old AMF in the existing AM Policy association, and the AMF will transfer it to new MME use the N26 interface in a GTPv2 message.

For example, a UE may have subscribed RFSP Index of 5G prioritization in subscription data stored in HSS/UDM.

If a UE initially attaches to 5GC with AM Policy association established:

1. If something triggers the PCF to change the RFSP Index as of 4G prioritization, the UE will moves from 5GC to EPC. In handover or idle mode mobility procedure, the old AMF sends the PCF-updated RFSP Index, i.e. the RFSP Index in use, to the new MME using N26 interface.

2. With the received RFSP Index in use, the new MME may, as local logic, ignore the subscribed RFSP Index and keep the RFSP index in use as 4G prioritization. The UE will stay in 4G and will not be send right back to 5G as the subscribed RFSP Index as 5G prioritization. The old AMF may keep the established AM association or defer the AM policy association termination for the UE to receive further update on RFSP Index update from PCF, just as the old AMF will keep UE context for some time after the UE deregister. The duration value of this timer should be pre-configured at the AMF. And the AMF should subscribe to HSS/UDM for UE's serving MME update notification in case the UE moves further to another MME.

3. Later but before the AM Policy Association maintenance timer runs out, based on some trigger, the PCF may update UE's RFSP index in order to direct the UE back from EPC to 5GC. The update RFSP index is deliver to the old AMF. Then the old AMF transfers it to the serving MME the UE register to through N26 interface. Then the serving MME updates the RFSP index in use and triggers the UE move back to 5G using current mechanism.

4. When the AM Policy Association maintenance timer runs out, the old AMF initiates the AM Policy Association termination and unsubscribe to the HSS/UDM for further change on serving MME. This should be no later than the old AMF to release the UE context.

5. As AM Policy Association maintenance timer running in the old AMF, an equal timer should runs in the serving MME. The initial value of the timer may be pre-configured at the MME and no less than the value of the AM policy Association maintenance timer at the AMF. When the MME aware that the timer runs out, the MME will be free to select the RFSP Index in use, e.g. the subscription value, as in current specification. Also, when handover happens between MMEs, the remaining value of the timer should also be transfer as UE context.

If a UE initially attaches to EPC, or the AM policy association is invalid, that is, no exist AM policy association in PCF for that UE, the MME may update UE's RFSP Index according to current mechanism. The MME may decide to direct UE to 5GC by changing the RFSP Index. In some cases, when the EPS to 5GS procedure is complete and soon after a new AM association is established, the PCF may decides the UE should be in 4G. Then the EPS to 5GS procedure as described above may take place. With the proposed mechanism, the PCF selected RFSP Index will take over and the UE will not ping-pong between 4G and 5G.

### 6.1.2 Procedures

Figure 6.1.2 depicts the procedure of propose solution of providing PCF-updated RFSP Index update from 5GC to MME with N26 interface.



Figure 6.1.2: PCF-updated RFSP Index update from 5GC to MME in N26-base architecture

Step 1 and Step 2 follow the procedure already defined in TS 23.502 [3]. The change is: the AMF, where the UE originally register to, will not initiate the AM Policy Association termination procedure with the PCF when it received the Nudm\_UECM\_DeregistrationNotification from HSS/UDM as in clause 4.11.1.5.3 of TS 23.502 [3] (TAU of handover) nor clause 4.11.1.3.2 of TS 23.502 [3] (Idle mode mobility). But the AM Policy Association maintenance timer starts to run in AMF when the Nudm\_UECM\_DeregistrationNotification receives. A timer also start to runs in target MME1 to indicate it should wait for further input from AMF on RFSP Index update.

Step 3, the old AMF subscribes to HSS/UDM for the notification in case of UE S1-handover happens to insure the old AMF always know the serving MME of the UE.

Step 4 and Step 5, the PCF is trigger to update the RFSP Index and notify to the old AMF according to current description in TS 23.503 [4].

Step 6 and Step 7 are the proposed new mobility management messages using N26 interface, in which the AMF transfer the updated RFSP index to MME1 and MME1 reply with an acknowledgement.

If before the AM policy association maintenance timer runs out, S1-handover or TAU happens in EPC:

Step 8, the UE deregisters from MME1 and register to MME2 in EPC and the remaining of the timer is transfer from MM1 to MM2 as part of UE context.

Step 9, HSS/UDM notifies the old AMF with MME2. The RFSP index in use will be sent from MME1 to MME2 as in current specification.

For further RFSP Index update from PCF as in step 4, the old AMF transfer the updated RFSP index to MM2 as in step 5, 6 and 7.

When the AM Policy Association maintenance timer runs out, the AMF initiates the AM Policy Association termination as in TS 23.502 [3] and unsubscribe to HSS/UDM for further serving MME change notification. When the timer at the MME runs out, the MME could reselect an RFSP Index value as defined in current specification.

Or, if the AMF receives from HSS/UDM that the UE is not registered to any MME, i.e. deregistered from EPC, the AMF should initiates the AM Policy Association termination before the timer runs out.

### 6.1.3 Impacts on services, entities and interfaces

The solution has the following impacts:

AMF:

- When a UE is moving from 5GS to EPS, and HSS/UDM invokes Nudm\_UECM\_DeregistrationNotification to notify the AMF associated with 3GPP access with reason as 5GS to EPS Mobility, the AMF should not initiate the AM Policy Association termination.

- The AMF should maintain a timer for AM Policy Association maintenance in case of 5GS to EPS Mobility. And within that timer, the AMF subscribes to HSS/UDM for UE's serving MME update notification and transfer the updated RFSP Index to UE's serving MME when it is receive from PCF. When the timer runs out, the AMF initiate the AM Policy Association termination and unsubscribe to the HSS/UDM for further notification.

- New procedure is needed for AMF to inform the MME of the updated RFSP after UE moves to EPS.

MME:

- The MME should maintain a timer after the 5GS to EPS handover procedure or idle mode mobility complete within which it is able to receive and apply the updated RFSP Index from AMF.

- When S1-handover or TAU happens at EPC, the remaining value of the timer should be transfer from the source MME to the target MME as part of UE context.

- New procedure is needed for the MME to receive AMF provided RFSP index updated if the MME does not know the AMF.

HSS/UDM:

- New service needs to be defined to allow AMF to get UE's serving MME information.

- When HSS and UDM are deploy separately, new services are needed to allow HSS to provide serving MME information to UDM, then UDM to provide serving MME information to AMF. In a combined UDM+HSS deployment, service between HSS and UDM is not needed or handled in implementation specific way.

N26:

- New mobility management message are defined to support the RFSP Index transfer from AMF to MME.

N8 (& UDICOM interface if used)

- New event exposed to repost the change of MME to AMF.

## 6.2 Solution #2: Provide Authorized RFSP in EPC via UDM/HSS, during 5GS to EPS mobility

### 6.2.1 Description

The solution address KI#1 and applies to 5GC to EPC interworking when:

- 5GS to EPS handover using N26 interface.

- 5GS to EPS Idle mode mobility using N26 interface.

- 5GS to EPS Mobility without N26 interface.

The PCF, in 5GC, may adjust the RFSP index to request RAN to direct the UE from 5G to 4G according to dynamic network situations, for example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G) the PCF may request to move some of the "5G prioritized" UEs to 4G access.

- According to a request from AF, the PCF may request RAN to move the requested UE(s) from 5G to 4G.

When the AMF receives "Authorized RFSP" in AM Policy Establishment or modification from the PCF, the AMF notifies the HSS (via UDM) about the PCF decision to change the RFSP value and provides the new "Authorized RFSP". The notification can be sent by AMF based on implicit subscription to notify the UDM (based on operator policies and local configuration) or alternatively, the UDM could provide the notification endpoints to the AMF during the UE registration procedure. Sending "Authorized RFSP" to UDM is only required when N26 mobility does not apply in the local (serving) 5GS network. Otherwise, the AMF can send the "Authorized RFSP" over N26.

When the UE moves from 5GS to EPS, if the HSS has received the "Authorized RFSP", it shall provide both "Authorized RFSP" and "Subscribed RFSP" values to the MME. The MME sends the "Authorized RFSP" as the RFSP to use to the eNB, to avoid any possible ping-pong issue of continuously moving the UE between the 4G and 5G access.

The MME may continue to use the "Authorized RFSP" over the "Subscribed RFSP" for a certain duration of time based on locally configured or operator determined validity conditions (e.g. a configured duration of time or for the current registration time etc.). During inter MME handover, the source MME may provide the additional information on "Authorized RFSP" and its validity condition to the target MME. When the validity condition expires, the MME may then send the "Subscribed RFSP" as the RFSP to use to the eNB.

### 6.2.2 Procedures



Figure 6.2.2-1: Procedure to Provide Authorized RFSP in EPC via UDM/HSS, during 5GS to EPS mobility

The detailed procedure is described in Figure 6.2.2-1.

1. The UE registers to 5GC via NG-RAN. AMF establishes AM Policy association with PCF as in clause 4.16.1.2 of TS 23.502 [3].

2. The PCF decides to adjust the RFSP index to direct the UE from 5G to 4G. The PCF decision could be based on various inputs. For example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G).

- According to the request from AF.

3. The PCF provides the new "Authorized RFSP" for the UE by initiating AM Policy Modification procedure as in clause 4.16.2.2 of TS 23.502 [3].

4. The AMF provides the Authorized RFSP as the RFSP to use to the gNB by initiating a UE CONEXT MODIFICATION procedure as in clause 8.3.4 of TS 38.413 [7].

5. If N26 does not apply and the AMF identifies that the "Authorized RFSP" is different than the "Subscribed RFSP", then the AMF notifies the UDM on the "Authorized RFSP" received from PCF. If the UDM and HSS are deployed separately then the UDM further notifies the "Authorized RFSP" to the HSS. In a combined UDM+HSS deployment this step (5b in Figure 6.2.2-1) is not needed or handled in implementation specific way.

6-7.When the UE was guided to 4G access, the UE performs TAU or Attach procedure, during which the HSS provides "Authorized RFSP" to the MME serving the UE, along with the "Subscribed RFSP".

8. The MME stores the "Subscribed RFSP", the "Authorized RFSP" and a validity condition for the "Authorized RFSP" in the UE context in MME. The validity condition may be locally configured at the MME based on operator policy and may contain a duration for which the "Authorized RFSP" is applicable (e.g. timer or current registration etc.). During inter MME handover, the source MME also provides the "Authorized RFSP" and the validity condition to the target MME.

9. The MME may choose to continue using the "Authorized RFSP" instead of deriving the RFSP Index based on the subscribed RFSP Index. The MME provides the "Authorized RFSP" as the RFSP to use to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

10. When the validity condition is expired the MME may review the RFSP index and may choose the RFSP Index to use based on the subscribed RFSP Index, the locally configured operator's policies and the UE related context information available at the MME.

11. The MME provides the RFSP to use to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

### 6.2.3 Impacts on services, entities and interfaces

This solution may have the following impacts to existing entities and interfaces:

- AMF: AMF creates subscription for notification of "Authorized RFSP" to UDM/HSS. AMF notifies the "Authorized RFSP" received from PCF to the UDM/HSS

- UDM: When UDM and HSS are deployed separately, the UDM shall create an implicit subscription to send "Authorized RFSP" to HSS. When the USM receives "Authorized RFSP" for a UE from the AMF, it shall send a notification to the HSS.

- HSS: Provides the "Authorized RFSP" along with "Subscribed RFSP" for a UE to the MME. The "Authorized RFSP" may be provided during Update Location or as a Standalone Insert Subscriber Data operation.

- MME: MME stores the "Authorized RFSP" along with its validity conditions in the UE context in MME. As long as the validity condition is satisfied the MME uses "Authorized RFSP" over "Subscribed RFSP". The MME provides the "Authorized RFSP" and its validity conditions to target MME during inter MME mobility. When the validity condition is expired the MME decides to use "Subscribed RFSP".

## 6.3 Solution #3: Enforcing RFSP index authorized by PCF in EPC via N26

### 6.3.1 Description

The solution address KI#1 for deployment scenario with N26.

In this solution,

- The assumption is that PCF is aware of the mapping from RFSP index to cell selection and the RAT/Frequency Priorities which is typically known by RAN (see Annex I of TS 36.300 [8] and Annex D in TS 38.300 [9]). Note that RFSP index is also known as "SPID" (Subscriber Profile ID) for RAT/Frequency Priority.

- When the PCF provides authorized RFSP Index, if the PCF determines that the change of authorized RFSP index value indicates a change from prioritizing 5G access to prioritizing 4G access for the UE, the PCF includes a validity time (working name "RFSPinUseExpiryTime") indicating a time by which this RFSP index will take effect if the UE moves to EPS. As specified in clause 6.1.1.3 of TS 23.503 [4], PCF may use the network analytics on "Service Experience" for an Application Identifier, "any RAT type" and/or "any Frequency value" to determine the "authorized RFSP index" value for the UE when running this application. Furthermore, as specified in clause 6.4.3 of TS 23.288 [10], the "Service Experience" analytics including a Validity period for the Application service experience analytics. So, it is possible for the PCF to determine the "authorized RFSP index" together with a validity time i.e. RFSPinUseExpiryTime.

- When the AMF receives the authorized RFSP Index from the PCF with the validity time, the AMF stores also the validity time.

- If the NG-RAN triggers handover before "RFSPinUseExpiryTime", the AMF will include the new parameter "RFSPinUseExpiryTime" in Forward Relocation Request to the MME. If the NG-RAN triggers release with redirect, the UE will perform Tracking Area Request procedure, and the AMF will include new parameter "RFSPinUseExpiryTime" in Context Response if time is before "RFSPinUseExpiryTime".

- When the MME receives RFSPinUseExpiryTime, the MME will use "RFSP index in use". When the time indicated in RFSPinUseExpiryTime is due, the MME will do RFSP index re-evaluation as specified in clause 4.3.6 of TS 23.401 [5].

NOTE 1: If the UE is not directed to EPS by NG-RAN before the time indicated in RFSPinUseExpiryTime is due, no action is needed in AMF.

NOTE 2: When the 5GS to EPS mobility procedure is completed, the MME does not interact with the old AMF as in legacy.6.3.2 Procedures

Clause 4.11.1.2.1 of TS 23.502 [3] (5GS to EPS handover using N26 interface) is reused with the following addition:

- In step 3 when AMF sends Forward Relocation Request to the MME, the AMF additionally includes a timestamp indicating to the MME that "RFSP index in use" should be used before the indicated time is due. When the indicated time is due, the MME re-evaluates the RFSP index as specified in clause 4.3.6 of TS 23.401 [5].

Clause 4.11.1.3.2 of TS 23.502 [3] (5GS to EPS Idle mode mobility using N26 interface) is reused with the following addition:

- In step 6 when AMF sends Context Response to the MME, the AMF additionally includes a timestamp indicating to the MME that "RFSP index in use" should be used before indicated time is due. When the indicated time is due, the MME re-evaluates the RFSP index as specified in clause 4.3.6 of TS 23.401 [5].

If the UE moves further from one MME to another MME before the time indicated in RFSPinUseExpiryTime is due, the old MME includes the RFSPinUseExpiryTime in Forward Relocation Request or Context Response from the old MME to the new MME.

### 6.3.3 Impacts on services, entities and interfaces

Impact on interface:

N15: Introduce additional IE for validity time indicating the due time of "RFSP index in use" if the UE moves to EPS.

N26 and S10: Introduce additional IE for validity time (working name "RFSPinUseExpiryTime") indicating the due time of "RFSP index in use" in Forward Relocation Request and Context Response.

Impact on PCF:

- Include additional validity time when PCF determines that the change of RFSP index value indicates a change from prioritizing 5G access to prioritizing 4G access for the UE

Impact on AMF:

- When the AMF receives the additional validity time (in the form of due time), the AMF stores it in the UE Context. When mobility to EPS happens, the AMF also includes the validity time in the following GTP-C v2 messages informing the MME that "RFSP index in use" should be used before the indicated time is due:

- Forward Relocation Request

- Context Response

Impact on MME:

- When receiving the new timer in Forward Relocation Request, or Context Response, the MME will store it in the UE Context and use "RFSP index in use" received from the AMF or an old MME. When the indicated time is due, the MME will re-evaluate the RFSP index as specified in clause 4.3.6 of TS 23.401 [5].

## 6.4 Solution 4: Enforcing RFSP index authorized by PCF in EPC without N26 interface

### 6.4.1 Description

The solution addresses KI#1 is intended for the following interworking scenario (but could be applied to interworking scenario with N26 deployment):

- 5GS to EPS Mobility without N26 interface.

The PCF, in 5GC, may adjust the RFSP index to request RAN to direct the UE from 5G to 4G according to dynamic network situations, for example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G), the PCF may request to move some of the "5G prioritized" UEs to 4G access.

- According to a request from AF, the PCF may request RAN to move the requested UE(s) from 5G to 4G.

The PCF provides additional validity time if the PCF determines that the change of authorized RFSP index value indicates a change from prioritizing 5G access to prioritizing 4G access for the UE.

When the AMF receives "Authorized RFSP" and validity time in AM Policy Establishment or modification from the PCF, the AMF, the AMF may provision the new parameter" RFSP index in use" (which is applicable when UE in EPS and is set to the authorized RFSP index from PCF) to the UDM using existing Nudm\_ParameterProvision\_Update service operation. The AMF also includes new parameter of validity time, indicating the time by which the RFSP index in use will take effect when the UE moves to EPS. If interfaces for user data interworking, coexistence and migration are deployed is deployed, then the UDM provisions new " RFSP index in use" and the validity time to the HSS using new service operation Nhss\_ParameterProvision\_Update.

When the UE moves from 5GS to EPS, if the HSS has received the "RFSP index in use" and validity time is not due, the HSS provides both " RFSP index in use" (together with validity time) and "Subscribed RFSP" values to the MME. The MME sets the "RFSP index in use" as the RFSP index to use to the eNB, to avoid any possible ping-pong issue of the UE moving between the 4G and 5G.

The MME continues to use the "RFSP index in use" over the "Subscribed RFSP" until the validity time is due. When the validity time is due, the MME re-evaluates the RFSP index as specified in clause 4.3.6 of TS 23.401 [5].

If the UE moves further to another MME, the source/old MME provides "RFSP index in use" as in existing procedure and includes additionally the validity time if its indicated time is not due. When the validity time for the received RFSP in Useis due, the new MME re-evaluates RFSP index as specified in clause 4.3.6 of TS 23.401 [5] and provides the updated RFSP index to the eNB.

If the MME does not support the new parameters for "RFSP index in use" and related validity time, the HSS modifies sends to MME the Subscribed RFSP index set to the value of RFSP index in use. When the validity time is due, the HSS modifies the Subscribed RFSP index back to the originally subscribed value and sends it to MME.

### 6.4.2 Procedures

The detailed procedure is described in Figure 6.4.2-1.



Figure 6.4.2-1: Procedure to Enforcing RFSP index authorized by PCF in EPC without N26 interface

1. The UE registers to 5GC via NG-RAN. AMF establishes AM Policy association with PCF as in clause 4.16.1.2 of TS 23.502 [3].

2. The PCF decides to adjust the RFSP index to direct the UE from 5G to 4G. The PCF decision could be based on various inputs. For example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G).

- According to the request from AF.

3. The PCF provides the new "Authorized RFSP" for the UE by initiating AM Policy Modification procedure as in clause 4.16.2.2 of TS 23.502 [3]. The PCF provides additional validity time as the PCF determines that the change of authorized RFSP index value indicates a change from prioritizing 5G access to prioritizing 4G access for the UE.

4. The AMF set the Authorized RFSP as the RFSP index in use which is provided to the gNB in *Subscriber Profile ID* *for RAT/Frequency priority* IE in a UE CONEXT MODIFICATION procedure as in clause 8.3.4 of TS 38.413 [7].

5. If N26 does not apply, and the AMF, then the AMF provisions "RFSP index in use" (set to the "Authorized RFSP" received from PCF) (which is applicable when UE is in EPS) and validity time to the UDM using existing Nudm\_ParameterProvision\_Update service operation. If the UDM and HSS are deployed separately then the UDM further provisions the "RFSP index in use" to the HSS using new service operation Nhss\_ParameterProvision\_Update. In a combined UDM+HSS deployment this step (step 5b in Figure 6.4.2-1) is not needed or handled in implementation specific way. In Nudm\_ParameterProvision\_Update service operation, the AMF includes additionally a validity time indicating that the "RFSP index in use" will take effect in EPS until the indicated time is due. The validity time will be included in Nhss\_ParameterProvision\_Update as well.

6. The UE is guided to 4G access,

**Case-1:** If MME is upgraded and supports new parameters "RFSP index in use" and "validity time", steps 7-8 are performed

7. The UE performs TAU or Attach procedure, during which the HSS provides "RFSP index in use" together with the validity time to the MME serving the UE, along with the "Subscribed RFSP".

NOTE: For the MME not upgraded, it is assumed that the MME use the subscribed RFSP index towards the eNB.

8. The MME stores the "Subscribed RFSP index", the "RFSP index in use" and a validity time for the "RFSP index in use" in the UE context in MME. During inter MME handover, the source MME also provides the validity condition to the target MME.

 Continue at step 9.

**Case-2:** If MME is not upgraded thus does not supports new parameters "RFSP index in use" and "validity time", steps 7a-8a are performed

7a. The UE performs TAU or Attach procedure, the HSS sends the subscribed RFSP index set to the value of RFSP index in use.

8a. MME chooses RFSP index as specified in clause 4.3.6 of TS 23.401 [5] assuming that MME always chooses subscribed RFSP index.

9. The MME provides the "RFSP index" in Subscriber Profile ID for RAT/Frequency priority IE to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

**Case-1:** If MME is upgraded and supports new parameters "RFSP index in use" and "validity time", step 10 is performed:

10. When the validity time is due, the MME may re-evaluate the RFSP index as specified in clause 4.3.6 of TS 23.401 [5]. When the validity time is due, the "RFSP index in use" is locally removed from the UDM/HSS.

 Continue at step 11.

**Case-2:** If MME is not upgraded thus does not supports new parameters "RFSP index in use" and "validity time", steps 10a-10b are performed:

10a. When the validity time is due, the HSS restore the subscribed RFSP index and provides the restored subscribed RFSP index to MME.

10b. The MME re-evaluates the RFSP index in use as specified in clause 4.3.6 of TS 23.401 [5].

11. The MME provides the updated RFSP in use in Subscriber Profile ID for RAT/Frequency priority IE to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

### 6.4.3 Impacts on services, entities and interfaces

This solution may have the following impacts to existing entities and interfaces:

AMF:

- AMF invokes existing Nudm\_ParameterProvision\_Update service operation to UDM but with new parameter "RFSP index in use" (applicable only when UE is in EPS) and validity time by which the RFSP index in use is valid.

UDM:

- When UDM and HSS are deployed separately, the UDM invokes new service operation Nudm\_ParameterProvision\_Update with "RFSP index in use" and validity time.

HSS/UDR:

- Provides the "RFSP index in use", validity time along with "Subscribed RFSP" for a UE to the MME in Update Location or as a Standalone Insert Subscriber Data operation.

- The "RFSP index in use" and its validity time are stored in the UDR.

- Determine whether MME supports the new feature requiring "RFSP index in use" and validity time.

MME:

- MME stores the "RFSP index in use" along with its validity conditions in the UE context in MME. As long as the validity condition is satisfied the MME uses "RFSP index in use" over "Subscribed RFSP". The MME provides the "RFSP index in use" as today and additionally includes its validity conditions to target MME during inter MME mobility. When the validity condition is expired, the MME re-evaluates the RFSP index as specified in clause 4.3.6 of TS 23.401 [5].

## 6.5 Solution #5: Authorized RFSP index provisioning from 5GC to MME without N26 interface

### 6.5.1 Description

In the current interworking procedures from 5G to 4G, when the UE moves from 5G to 4G, the PCF should provide the "authorized RFSP index" to the MME.

However, after the UE moves from 5G to 4G, all the UE's context in the 5G side should be released (including the AM policy association for the UE between AMF and PCF), so the PCF cannot update the RFSP index for the UE when it finds that the "authorized RFSP index" is not valid, which resulted in that the MME does not know when it should in turn to use the "subscribed RFSP index" instead of the "authorized RFSP index".

As specified in clause 6.1.1.3 of TS 23.503 [4], PCF may use the network analytics on "Service Experience" for an Application Identifier, "any RAT type" and/or "any Frequency value" to determine the "authorized RFSP index" value for the UE when running this application. Furthermore, as specified in clause 6.4.3 of TS 23.288 [10], the "Service Experience" analytics including a Validity period for the Application service experience analytics. So, it is possible for the PCF to determine the "authorized RFSP index" together with a Validity period.

When N26 interface is not supported, the authorized RFSP index and the Validity period can be provided by the PCF to the UDM/HSS via AMF during the without N26-based interworking procedures, then MME obtains the the authorized RFSP index and the Validity period from the HSS.

The MME continues to use the "Authorized RFSP" over the "Subscribed RFSP" during the Validity period. When the Validity period expires, the MME may then send the "Subscribed RFSP" as the RFSP to use to the eNB.

### 6.5.2 Procedures

Figure 6.5.2-1depicts the procedure of propose solution of providing "authorized RFSP index" provisioning from 5GC to MME without N26 interface.



Figure 6.5.2-1: "authorized RFSP index" provisioning from 5GC to MME in without N26-base architecture

The overall procedure re-uses the 5GS to EPS mobility without N26 interface as defined in TS 23.502 [3]. The change is:

- Step 1 and Step 2. PCF determines the "authorized RFSP index" together with the Validity period e.g. based on the "Service Experience" analytics from NWDAF and provides these information to AMF.

- Step 3. If N26 does not apply and the AMF identifies that the "Authorized RFSP index" is different than the "Subscribed RFSP", then the AMF notifies the UDM on the "Authorized RFSP index" and the Validity period received from PCF. If the UDM and HSS are deployed separately then the UDM further notifies the "Authorized RFSP" and the Validity period to the HSS by triggering an Nhss\_UEContextManagement service operation as defined in TS 29.563 [11]. In a combined UDM+HSS deployment this step is not needed or handled in implementation specific way.

 The MME continues to use the "Authorized RFSP index" over the "Subscribed RFSP index" for the Validity period. When the Validity period expires, the MME may then send the "Subscribed RFSP" as the RFSP to use to the eNB.

### 6.5.3 Impacts on services, entities and interfaces

The solution has the following impacts:

PCF:

- PCF should determine the "authorized RFSP index" together with the Validity period e.g. based on the "Service Experience" analytics from NWDAF.

- PCF provides the "authorized RFSP index" together with the Validity period to AMF during 5GS to EPS mobility without N26 interface.

AMF:

- When N26 interface is not supported, AMF provides the "authorized RFSP index" together with the Validity period to UDM during the 5GS to EPS mobility without N26 interface.

UDM:

- When N26 interface is not supported, UDM receives the "authorized RFSP index" together with the Validity period from AMF during the 5GS to EPS mobility without N26 interface. Optionally, the UDM further provides the "authorized RFSP index" together with the Validity period to HSS when a combined UDM+HSS is not deployed.

MME:

- When N26 interface is not supported, MME receives the "authorized RFSP index" together with the Validity period from HSS.

- The MME continues to use the "Authorized RFSP" over the "Subscribed RFSP" for the Validity period. When the Validity period expires, the MME may then send the "Subscribed RFSP" as the RFSP to use to the eNB.

## 6.6 Solution #6: Provide updated RFSP when UE is already moved to EPS with N26 interface

### 6.6.1 Description

This paper reuse the concept of solution 1 to implement AM policy association maintenance timer to send any further updated RFSP and updated validity timer (as mentioned in solution 3) from AMF to MME when UE is already moved to EPS.

When UE moves to EPS, MME registers its address in UDM+HSS and then UDM+HSS shall maintain UE's 5G registration state temporarily for some duration i.e. AM Policy Association maintenance timer if the request from MME has some new indication (MME will provide this indication for only those UEs for which it has received validity condition along with RFSP Index In use from AMF). It provides this timer while sending deregistration notification to AMF so that both AMF and UDM+HSS will be in sync in holding this temporary registration state for the UE. AMF after receiving this deregistration notification shall behave as per the clause 4.2.2.2.2 step 14d of TS 23.501 [2] except for the termination of AM policy towards PCF for the duration mentioned by UDM. The AMF shall send the AM Policy Association maintenance timer to PCF while sending to delete the AM policy. PCF after receiving this AM Policy delete message shall defer the policy termination for the received time period and only send the updated policy related to UE’s RFSP Index. If the implementation specific (guard timer) is running at AMF then AMF shall stop this timer and start the AM Policy Association maintenance timer received in deregistration notification from UDM.

NOTE 1: The AM Policy Association maintenance timer should be maintained at only AMF or at both UDM and AMF is for evaluation.

NOTE 2: The exact indication from MME to UDM+HSS will be decided during normative phase.

During this time period based on some trigger (e.g. no more congestion in 5GC), the PCF may update UE's RFSP index or validity timer (to extend the timer if congestion still persist in 5G) in order to direct the UE back from EPC to 5GC. The update RFSP index is deliver to the AMF. AMF then will query the MME address from UDM+HSS and transfer the updated RFSP to the latest MME (e.g. If UE has been moved from one MME to another while in EPS) through N26 interface.

During this time period if UE moves back to 5G because of some reasons (e.g. mobility or radio conditions) and gets registered through a new AMF in 5G, then UDM+HSS will inform old AMF and remove old AMF address which was stored temporarily. When the AM Policy Association maintenance timer expires, the AMF clears the UE context, PCF terminates the AM Policy and UDM+HSS removes the AMF address which was stored temporarily.

If the AM policy Association maintenance timer expired while UE is in EPS then if there is a need for UE to bring back to 5GS, subscribed RFSP index can be modified in HSS and sent to MME so that MME redirect UE to 5GS.

### 6.6.2 Procedures



Figure 6.6.2-1: Updated RFSP from 5GS to EPS with N26 interface

The detailed procedure is described in Figure 6.6.2-1.

1. The UE registers to 5GC via NG-RAN. AMF establishes AM Policy association with PCF as in clause 4.16.1.2 of TS 23.502 [3].

2. The PCF decides to adjust the RFSP index to direct the UE from 5G to 4G. The PCF decision could be based on various inputs. For example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G).

- According to the request from AF.

 The PCF provides the new "Authorized RFSP" and validity timer for the UE by initiating AM Policy Modification procedure as in clause 4.16.2.2 of TS 23.502 [3].

3. UE moves to EPS via E-UTRAN

4. AMF sends the "RFSP Index in use" and validity timer to MME

5. The MME sends the ULR with single registration indication along with one new indication and register its address in UDM+HSS.

6. The UDM+HSS starts the "AM Policy Association maintenanceTimer" and maintain the UE's 5G registration state and provides this timer in the Nudm\_UECM\_DeregistrationNotification to AMF.

7. The MME stores and use the received "RFSP Index in use" and validity timer from AMF.

8. The AMF didn't clear the UE context for the time duration received from UDM+HSS. AMF provides "AM Policy Association maintenance timer” in the Npcf\_AMPolicyControl\_Delete to PCF. PCF shall defer the policy termination for the received time duration and update only policy related to UE’s RFSP Index during this time period and implicitly removes the AM policy after expiry of this timer.

9. UE moves to new MME.

10. The new MME sends the ULR with single registration indication and registers its address in UDM+HSS

11. Based on some trigger, PCF decides to update the RFSP Index or validity timer and notify to the AMF according to current description in TS 23.503 [4].

12. The AMF queries the new MME address from UDM+HSS and receive it.

13. The AMF queries the serving node address for the UE from UDM using existing Nudm\_UECM\_Get service operation and UDM provides serving MME (new MME) address. The AMF sends the "RFSP Index in use" or validity timer to new MME.

14. The new MME updates the received "RFSP Index in use" and validity timer and use it.

### 6.6.3 Impacts on services, entities and interfaces

This solution may have the following impacts to existing entities and interfaces:

AMF:

- When a UE is moving from 5GS to EPS, and HSS/UDM invokes Nudm\_UECM\_DeregistrationNotification to notify the AMF associated with 3GPP access with reason as 5GS to EPS Mobility, the AMF should maintain the UE's registration context for the received time period. AMF provides “AM Policy Association maintenance timer” in the Npcf\_AMPolicyControl\_Delete to PCF.

UDM+HSS:

- UDM+HSS should maintain the UE's 5G registration state temporarily for some duration based on the indication received from MME. Also it will provide this time period to AMF while sending deregistration notification.

MME:

- MME should be able to receive and apply the updated RFSP Index from AMF after the 5GS to EPS handover procedure or idle mode mobility complete. It will provide one indication for those UEs it has received validity condition along with RFSP Index In use from AMF.

PCF:

- PCF should defer the policy termination for the received time duration and update only policy related to UE’s RFSP Index during this time period and implicitly removes the AM policy after expiry of this timer.

## 6.7 Solution #7: Provide updated RFSP when UE is already moved to EPS without N26 interface

### 6.7.1 Description

This paper reuse the concept of solution 1 to implement AM policy association maintenance timer to send any further updated RFSP to MME when UE is already moved to EPS. It retains the concept of solution 2 to send the RFSP to MME via UDM+HSS.

When UE moves to EPS, MME registers its address in UDM+HSS and then UDM+HSS shall maintain UE's 5G registration state temporarily for some duration i.e. AM Policy Association maintenance timer if the UE is in single registration mode. It provides this timer while sending deregistration notification to AMF so that both AMF and UDM+HSS will be in sync in holding this temporary registration state for the UE.

During this time period based on some trigger, the PCF may update UE's RFSP index in order to direct the UE back from EPC to 5GC. The update RFSP index is deliver to the AMF. AMF then notifies to HSS+UDM and then UDM+HSS will notify to MME.

### 6.7.2 Procedures



Figure 6.7.2-1: Updated RFSP from 5GS to EPS without N26 interface

The detailed procedure is described in Figure 6.7.2-1.

1. The UE registers to 5GC via NG-RAN. AMF establishes AM Policy association with PCF as in clause 4.16.1.2 of TS 23.502 [3].

2. The PCF decides to adjust the RFSP index to direct the UE from 5G to 4G. The PCF decision could be based on various inputs. For example:

- Based on various analytics and prediction result from NWDAF (e.g. network congestion in 5G).

- According to the request from AF.

 The PCF provides the new "Authorized RFSP" for the UE by initiating AM Policy Modification procedure as in clause 4.16.2.2 of TS 23.502 [3].

3. AMF notifies the UDM on the "Authorized RFSP" received from PCF. If the UDM and HSS are deployed separately then the UDM further notifies the "Authorized RFSP" to the HSS. In a combined UDM+HSS deployment this step (step 5b in Figure 6.2.2-1) is not needed or handled in implementation specific way.

4. UE moves to EPS via E-UTRAN.

5. The MME sends the ULR with single registration or dual registration mode indication and register its address in UDM+HSS.

6. The UDM+HSS starts the "AM Policy Association Timer" and maintain the UE's 5G registration state for this duration if the UE is in single registration mode and provides this timer in the Nudm\_UECM\_DeregistrationNotification to AMF.

7. The UDM+HSS provides the Authorized RFSP to MME.

8. The MME stores and use the received "Authorized RFSP Index" from UDM+HSS.

9. The AMF didn't clear the UE context for the time duration received from UDM+HSS.

10. Based on some trigger, PCF decides to update the Authorized RFSP and notify to the AMF according to current description in TS 23.503 [4].

11. The AMF notifies the Authorized RFSP to UDM+HSS

12. The UDM+HSS provides the Authorized RFSP to MME.

13. The MME updates the received "Authorized RFSP" and use it.

### 6.7.3 Impacts on services, entities and interfaces

This solution may have the following impacts to existing entities and interfaces:

AMF:

- When a UE is moving from 5GS to EPS, and HSS/UDM invokes Nudm\_UECM\_DeregistrationNotification to notify the AMF associated with 3GPP access with reason as 5GS to EPS Mobility, the AMF should maintain the UE's registration context for the received time period.

UDM+HSS:

- UDM+HSS should maintain the UE's 5G registration state temporarily for some duration. Also it will provide this time period to AMF while sending deregistration notification.

NOTE: The impacts mentioned in solution 2 is applicable as well.

## 6.8 Solution #8: MME-enhancement solution on KI#1 for 5GS to EPS mobility without N26 interface

### 6.8.1 Description

For 5GS to EPS mobility procedure without N26 interface, i.e. no UE context on RFSP Index in use could be transferred from the source AMF to the target MME. If the MME immediately select the RFSP Index following the current specifications, it is likely that, it will select a value as "5G prioritized" that conflict with the one selected by PCF in 5GC as "4G prioritized" which drives the UE moving from 5GS to EPS. This may cause the ping-pong issue.

So it is propose that, when the MME realizes that the UE is moving from 5GC with the indication provided by the UE, and not receiving UE context containing RFSP Index in use information as no N26 interface applies, after successful attachment, the target MME should set the value of RFSP Index as "4G prioritized" for a pre-configured timer at the MME. When the timer runs out, the MME can re-select the RFSP Index value following the current specifications.

This can make sure that the UE won't be sent back to the 5GS immediately to trigger the ping-pong issue because of conflict on RFSP index between 5GC and EPC, and allow the MME to select the RFSP Index considering local configuration and subscribed RFSP Index from HSS.

### 6.8.2 Procedures

This solution has no impact on current procedures.

### 6.8.3 Impacts on services, entities and interfaces

The solution has the following impacts:

MME:

- When a MME aware that a UE is moved from 5GS and without UE context of RFSP Index in use as no N26 interface applies, the MME locally sets the RFSP Index in use as "4G prioritized" for a certain duration of time pre-configured in the MME. When the validity condition expires, the MME selects the RFSP Index value following the current specifications.

## 6.9 Solution #9: PCF-updated RFSP Index to MME via HSS

### 6.9.1 Description

This solution address KI#1 and applies to UE interworking between 5G and 4G, including:

- 5G to 4G mobility with N26 or without N26.

- 4G to 5G mobility with N26 or without N26.

NOTE: This solution is applicable to non-roaming scenario and how PCF updates RFSP Index to MME in roaming case will not be involved.

To direct the UE from 5G to 4G in some scenarios, the PCF may adjust the RFSP index for the UE and notify it to the AMF to update the RFSP index in use for the UE, for example:

- Based on some statistics and prediction result from NWDAF F (e.g. Observed Service Experience analytics, UE communication analytics, Network Performance analytics for 5G, etc.), the PCF may request to move some of UEs to 4G to reduce the 5G network congestion.

- Bases on application in use, e.g. if the application in use for the UE is suitable to be performed in 4G, then the PCF may request to move the UE to 4G for better service experience.

The PCF notifies the updated RFSP index to the UDM/HSS.

The UDM/HSS will send the updated RFSP index to the MME serving the UE in the Location Update Response message during the TAU or attach procedure, which is initiated by the UE after accessing to 4G.

Based on the updated RFSP index received from HSS, the MME sets RFSP index in use for the UE, which is consistent with AM policy in 5G and allows the UE to stay in 4G.

After the UE is directed from 5G to 4G, the PCF may adjust the RFSP index again to request 4G network to direct the UE back to 5G according to dynamic network situations, for example:

- Based on some statistics and prediction result from NWDAF F (e.g. Observed Service Experience analytics, UE communication analytics, Network Performance analytics for 5G, etc.), the PCF may request to move some of UEs to 5G when the 5G network congestion has eased

- Bases on application in use, e.g. if the application in use for the UE is suitable to be performed in 5G, then the PCF may request to move the UE to 5G for better service experience.

In a similar way, the PCF notifies the updated RFSP index to the UDM/HSS, and the UDM/HSS will notify the updated RFSP index to the MME by reusing the Insert Subscribe Data procedure. Then based on the updated RFSP index received from HSS, the MME sets RFSP index in use for the UE. The RFSP index in use will be sent to eNB, which will guide the UE to move from 4G to 5G.

### 6.9.2 Procedures

#### 6.9.2.1 Procedure for triggering UE to move from 5G to 4G



Figure 6.9.2.1-1: PCF-updated RFSP Index update from 5GC to MME in N26-base architecture

1. The UE registers to 5GC via NG-RAN. AMF establishes AM Policy association with PCF as in clause 4.16.1.2 of TS 23.502 [3].

2. The PCF decides to adjust the RFSP index to direct the UE from 5G to 4G. The PCF decision could be based on various inputs. For example:

- Based on various analytics result from NWDAF (e.g. Observed Service Experience analytics, UE communication analytics, Network Performance analytics for 5G, etc.).

- Bases on application in use, e.g. the application in use is suitable to be performed in 4G.

3. The PCF updates RFSP index for the UE to RFSP index value 1, and provides the RFSP index vaule1 to the AMF by initiating AM Policy Modification procedure as in clause 4.16.2.2 of TS 23.502 [3].

4. The AMF provides the RFSP index vaule1 as the RFSP index in use to the gNB by initiating a UE CONEXT MODIFICATION procedure as in clause 8.3.4 of TS 38.413.

5. Then the PCF notifies the UDM/HSS the RFSP index vaule1. If the UDM and HSS are deployed separately then the UDM further notifies the RFSP index vaule1 to the HSS. In a combined UDM+HSS deployment this step (5b in Figure 6.9.2.1-1) is not needed or handled in implementation specific way.

6-7. When the UE accesses to 4G, the UE performs TAU or Attach procedure, during which the HSS provides RFSP index vaule1 to the MME serving the UE.

8. The MME updates RFSP index in use for the UE from subscribed RFSP Index value to RFSP index vaule1.

9. The MME provides the RFSP index vaule1 as the RFSP in use to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

10. Based on RFSP index value 1, the ENB keeps the UE in 4G, and will not direct the UE to 5G bases on subscribed RFSP Index value.

#### 6.9.2.2 Procedure for triggering UE to move from 4G to 5G



Figure 6.9.2.2-1: Procedure for triggering UE to move from 4G to 5G

0. After procedure depicted in clause 6.9.2.1, the UE moves from 5G and registers to EPC via E-UTRAN. The PCF doesn't release AM Policy association for the UE.

1. The PCF decides to adjust the RFSP index to direct the UE from 4G to 5G. The PCF decision could be based on various inputs. For example:

- Based on various analytics result from NWDAF (e.g. Observed Service Experience analytics, UE communication analytics, Network Performance analytics for 5G, etc.).

- Bases on application in use, e.g. the application in use is suitable to be performed in 5G.

 The PCF updates RFSP index for the UE to RFSP index value 2.

2. Then the PCF notifies the UDM/HSS the RFSP index vaule2. If the UDM and HSS are deployed separately then the UDM further notifies the RFSP index vaule1 to the HSS. In a combined UDM+HSS deployment this step (step 2b in Figure 6.9.2.2-1) is not needed or handled in implementation specific way.

3. The HSS notifies RFSP index vaule2 to the MME serving the UE, e.g. by reusing the Insert Subscribe Data procedure as in clause 5.3.9.2 of TS 23.401 [5].

4. The MME updates RFSP index in use for the UE from RFSP index vaule1 to RFSP index vaule2.

5. The MME provides the RFSP index vaule2 as the RFSP in use to the eNB in UE CONTEXT MODIFICATION procedure as in clause 8.3.4 of TS 36.413 [6].

6. Based on RFSP index value 2, the eNB initiates RRC release procedure, which will trigger the UE access to 5G, then UE performs mobility registration procedure to 5GC.

### 6.9.3 Impacts on services, entities and interfaces

The solution has the following impacts:

PCF:

- Notifies the updated RFSP index to the UDM/HSS.

- Remains the AM policy association for the UE in the 5G&4G interworking scenario when the UE moves from 5G to 4G.

UDM/HSS:

- Receives the updated RFSP index from the PCF and notifies it to the MME serving the UE during Update Location or as a Standalone Insert Subscriber Data operation.

MME:

- Receives the updated RFSP index from the HSS and set the RFSP index in use for the UE based on it.

AMF:

- Remains the AM policy association for the UE in the 5G&4G interworking scenario when the UE moves from 5G to 4G.

## 6.10 Solution #10: Provide RFSP Index via N26 interface when the UE moves from 5GC to EPC

### 6.10.1 Description

This solution is applicable only when N26-based interworking is used.

When N26-based interworking architecture applies, AMF and MME use N26 interface to transfer mobility management message. The parameters, subscribed RFSP index and RFSP index in use, are transferred in:

- Forward Relocation Request as in 5GS to EPS handover procedures using N26 interface, or

- Context Response as in 5GS to EPS Idle mode mobility using N26 interface.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Subscribed RFSP Index | CO | This IE shall be included by the source MME/SGSN/AMF, if received from the HSS or UDM. | RFSP Index | 0 |
| RFSP Index in Use | CO | This IE shall be included by the source MME/SGSN/AMF, if it supports the feature. | RFSP Index | 1 |

During UE registration in 5GC, the AMF may report to the PCF the subscribed RFSP Index received from the UDM for further evaluation as described in clause 6.1.2.1 of TS 23.503 [45]. When receiving the "authorized RFSP Index" from the PCF, the AMF replaces the "subscribed RFSP Index" with the "authorized RFSP Index" as specified in clause 5.3.4.3.1 of TS 23.501. So the "subscribed RFSP Index" stored in the UE context in AMF may be different than the "subscribed RFSP Index" received from the UDM as the AMF may replace the "subscribed RFSP Index" with the "authorized RFSP Index" received from the PCF.

Therefore, this solution proposes that, when UE moves from 5G to 4G, the MME shall compare the "subscribed RFSP Index" received from the AMF (which could be the "Authorized RFSP Index" provided by the PCF) with the "RFSP Index" received from the HSS. If they are different, the MME shall store the "subscribed RFSP Index" received from AMF in a new IE "5GC Authorized RFSP Index" and store the RFSP Index received from the HSS in "subscribed RFSP Index".

The difference in "5GC Authorized RFSP Index" and "subscribed RFSP Index" is an indication to the MME that 5GC has dynamically assigned an RFSP Index to the UE and the MME shall, based on operator's policies, ignore the RFSP Index received from the HSS e.g. for a configured duration. This policy/duration could be operator determined e.g.:

- "5GC Authorized RFSP Index" is used only for the current registration in the MME and is not used when the UE moves to another MME due to mobility.

- "5GC Authorized RFSP Index" is used only for a configured duration (e.g. T). When the UE moves to another MME due to mobility (e.g. after a period "t"), the source MME then provides the remaining duration (i.e. T-t) for which "5GC Authorized RFSP Index" shall be used by the destination MME.

- Or it could be a combination of both of the above.

When the configured duration is reached, the MME may remove the "5GC Authorized RFSP Index" from its context for the UE and start using the "subscribed RFSP Index" that was received from the HSS.

### 6.10.2 Procedures

There is no additional procedure needed to update the RFSP Index when the UE is served by the EPC. MME uses the 5GC authorized RFSP Index for a configuration duration as explained in clause 6.10.1.

### 6.10.3 Impacts on services, entities and interfaces

The solution has the following impacts:

PCF:

- No impact.

AMF:

- No impact.

MME:

- MME shall compare the "subscribed RFSP Index" received from the AMF (which could be the "Authorized RFSP Index" provided by the PCF) with the "RFSP Index" received from the HSS.

- If they are different, the MME shall store the "subscribed RFSP Index" received from AMF in a new IE "5GC Authorized RFSP Index" and store the RFSP Index received from the HSS in "subscribed RFSP Index".

- MME shall ignore the RFSP Index received from the HSS for a configured duration.

- When the configured duration is reached, the MME may remove the "5GC Authorized RFSP Index" from its context for the UE and start using the "subscribed RFSP Index" that was received from the HSS.

N26:

- No impact.

# 7 Overall Evaluation

Editor's note: This clause will provide evaluation of different solutions.

## 7.1 Evaluation on Key Issue #1: RFSP Index consistency when UE moves from 5GC to EPC

### 7.1.1 For deployment without N26 interface interworking

NOTE: Below evaluation assumes that solution for deployment without N26 is needed.

Per TS 23.501 clause 5.3.4.3.1, when receiving the authorized RFSP Index from the PCF, for non-roaming subscribers, the AMF chooses the RFSP Index in use according to one of the following procedures, depending on operator's configuration:

- the RFSP Index in use is identical to the authorized RFSP Index, or

- the AMF chooses the RFSP Index in use based on the authorized RFSP Index, the locally configured operator's policies, the Allowed NSSAI and the UE related context information available at the AMF, including UE's usage setting, if received during Registration procedures.

The above would mean that the "RFSP Index in use" chosen by AMF may be different from the authorized RFSP Index from PCF, therefore it is the RFSP Index in use (but not the authorized RFSP Index) that should be sent to the EPC. Besides, when the PCF provides modified/authorized RFSP Index (e.g., based on network congestion analytics), PCF has the knowledge how long the congestion may last, therefore it should be the PCF (but not the EPC/MME) that determines the validity time, as the EPC/MME does not have the necessary information.

There are following solutions addressing the deployment scenario **without** N26 interface:

Sol#2, Sol#4, Sol#5, Sol#7, Sol#8, Sol#9.

Among the above solutions, except Sol#8, the other solutions propose to involve UDM+HSS either by modifying the existing Subscribed RFSP Index in HSS or add new parameter (either "Authorized RFSP Index" or "RFSP Index in use" for MME to use.

Table 7.1.1-1 below list the comparison in the following aspects:

#1 PCF or AMF notifies or provisions UDM of the RFSP Index chosen by the AMF?

#2 Which NF determines the validity time?

#3 Is a new parameter introduced in the subscription data provided by HSS? If yes, what parameter name?

Table 7.1.1-1: Evaluation on principles of KI#1 candidate solutions on without N26 interface scenario

| **Sol#** | **PCF or AMF notifies/provisions UDM?** | **Which NF determines validity time?** | **New parameter in subscription data in HSS** | **UDM+HSS maintaining UE's 5G registration as in legacy?**  | **Evaluation** |
| --- | --- | --- | --- | --- | --- |
| #2 | AMF notifies UDM of new parameter "Authorized RFSP Index" | MME (when receiving "Authorized RFSP Index" from HSS) | "Authorized RFSP Index" | Yes | - Conceptually incorrect as "Authorized RFSP Index" may be different from "RFSP Index in use"- Data entry to be managed by UDM, better to use PP instead of AMF Notify- unclear Service Operation |
| #5 | AMF notifies UDM, with validity time | PCF | "Authorized RFSP Index" + validity time | Yes |
| #4 | AMF use PP service, new para "RFSP Index in use" with validity time  | PCF | "RFSP Index in use" + "validity time | Yes |  |
| #7 | Similar as Sol#2 | Similar as Sol#2 | Similar as Sol#2 | No, UDM+HSS maintain UE’s 5G state temporarily for some duration. | UDM+HSS behavior not BW compatible, see **NOTE 1**.  |
| #8 | NA | NA | NA | Yes | Changes also the handling of 5GS to EPS mobility due to other reasons than KI#1, see **NOTE 2** |
| #9 | - PCF notifies UDM of "Authorized RFSP Index"- PCF does not release AM Policy association for the UE | No timer mentioned | Use "subscribed RFSP Index"**Prerequisite**: MME must use "Subscribed RFSP Index" | Yes | - Unclear how PCF not releasing AM policy association- Limitation that MME must use subscribed RFSP Index |
| **NOTE 1: Sol#7** proposes that at 5GS to EPS mobility without N26, the MME its address in UDM+HSS and then UDM+HSS shall maintain UE's 5G registration state temporarily for some duration. **Such proposal is not (backward) compatible with the existing system behaviour** that the MME indicates to the UDM+HSS not to cancel the AMF as specified in clause 4.11.2.4.1 of TS 23.502. Note that no addition address of MME needs to be sent to HSS+UDM. |
| **NOTE 2:** As RFSP Index change is not the only reason for UE mobility from 5GS to EPS, the MME will not be able to tell, therefore Sol#8 (see below) changes also the handling of 5GS to EPS mobility due to other reasons than KI#1 and implication needs further analysis and evaluation."…*when the MME realizes that the UE is moving from 5GC with the indication provided by the UE, and not receiving UE context containing RFSP Index in use information as no N26 interface applies, after successful attachment, the target MME should set the value of RFSP Index as "4G prioritized" for a pre-configured timer at the MME. When the timer runs out, the MME can re-select the RFSP Index value following the current specifications…*" If the operator can accept the implication that MME sets a timer for 5GS to EPS mobility regardless of the reason, this can be done without standardization. |

### 7.1.2 For deployment with N26-based interworking

There are 4 solutions proposed for Key Issue #1, targeting to provide RFSP Index consistency when UE moves from 5GC to EPC for N26-based interworking scenario.

Table 7.1.2-1 compares the principles between the proposed solutions.

Table 7.1.2-1: Evaluation on principles of KI#1 candidate solutions on N26-based interworking scenario

|  |  |  |  |
| --- | --- | --- | --- |
| **Sol#** | **Need to keep AM Policy Association after UE Moves from 5GC to EPC** | **Impacts to Existing Nodes and Proposed Enhancements** | **Use of Validity Condition(s)** |
| **AMF** | **MME** | **HSS+UDM** | **PCF for a UE** |
| 1 | X | X | X | X(AMF be aware of the change of serving MME from HSS/UDM) | - | New timer for AM association maintenance at AMF and equivalent new timer for MME to use RFSP Index from AMF |
| 3 | - | X | X | - | X(PCF for a UE generates a timer along with the authorized RFSP Index) | MME re-evaluates the RFSP Index when the timer expires. |
| 6 | X | X | X | X(maintain the UE's 5G registration state temporarily for some duration and provide the MME address to AMF) | - | HSS+UDM maintain UE's 5G registration state for AM Policy Association maintenance timer and provides it to AMF. During the validity timer, if PCF for a UE updates RFSP index, AMF queries the MME address from HSS+UDM and send the updated RFSP index to MME. |
| 10 | - | X(AMF replaces "subscribed RFSP Index" with "authorized RFSP Index" from PCF in UE context and send to MME.) | X | - | - | When the configured duration is reached, the MME may remove the "5GC Authorized RFSP Index" from its context for the UE and start using the "subscribed RFSP Index" that was received from the HSS. |

All these solutions are trying to answer the following 3 questions for N26-based interworking in KI#1:

*Q1: Whether the current interworking procedure supports MME received the RFSP Index in use from 5GC? If no, what enhancements is needed.*

For N26-based interworking: (Solution #1, #3, #6 and #10) the current specification already supports the RFSP Index in use transferred to MME in UE context during handover/TAU.

**If there is any enhanced information, it should also be transferred via N26.**

*Q2: If the MME get the RFSP Index in used in handover procedure or idle mode mobility procedure, how and when it resumes to the subscription RFSP Index.*

* (Solution #1 and #6) The PCF for a UE maintains the AM Policy Association when UE move from 5G to 4G and updates the authorized RFSP Index according to triggers and conditions defined in current specification. The MME re-selects the RFSP Index in use considering the dynamic input from PCF at the cost of network overhead and extra procedures.
* When MME realizes a UE is moving from 5GC, it starts a timer within which value of the RFSP Index in use will not be changed. When the timer expires, the MME will be free to re-select the RFSP Index in use according to current method. The value of this timer may be set to:
	+ (Solution #10) A local value preconfigured in MME, which is same to all UE and not adjustable.
	+ (Solution #3) A value selected by PCF when it generates an authorized RFSP Index value indicating the UE to move from 5G to 4G. So the timer is per UE from 5G and not adjustable after the UE in 4G. PCF can decide that timer based on information, e.g., from UDR or NWDAF. If the AMF modifies the authorized RFSP Index from PCF, i.e., the AMF selects a different value of RFSP Index in use, whether the timer value from PCF should still be sent to MME is clarified in S2-2205525 (ongoing discussion).

**Considering the trade-off of system impact and flexibility, the PCF-selected timer seems to solve the problem in a more agreeable way. Preconfigured timer in MME can implementation specific without standardization as such timer will apply to EPS to 5GS mobility scenario not targeted in the KI.**

*Q3: When UE is under EPC, should MME receive any update of RFSP Index from 5GC and how.*

* + (Solution #1 and #6) Yes. The PCF is able to update the RFSP Index In Use or the timer according to, e.g., AF's influence request. And MME is able to change the RFSP Index in use in a timely manner.
	+ (Solution #3 and #10) No. The MME is able to re-select the RFSP Index only after the validity time provided by the AMF (decided by PCF) expires.

**The evaluation of Q2 also applies to Q3.**

# 8 Conclusions

Editor's note: This clause will list conclusions that have been agreed during the course of the study item activities.

## 8.1 Conclusion on Key Issue #1: RFSP Index consistency when UE moves from 5GC to EPC

### 8.1.1 For deployment without N26 interface interworking

For deployment scenario without N26 interface it is concluded that no normative work is required at this point.

### 8.1.2 For deployment with N26-based interworking

The following conclusion are agreed:

- When a UE moves from 5GC to EPC, the MME sets the "RFSP Index in use" value the same as the value in the UE context received from AMF via N26 if the UE context in AMF also contains a validity period.

- When the validity period expires, the MME re-evaluates the RFSP Index value according to current specification (see clause 4.3.6 of TS 23.401 [5]).

- The validity period, i.e., "RFSPinUseExpiryTime" is selected by PCF for a UE. When the PCF for a UE provides the Authorized RFSP Index indicating the UE to move to 4G, it may also provide the value of "RFSPinUseExpiryTime". If the AMF selects the RFSP Index in use identical to the authorized RFSP Index, it should store the received "RFSPinUseExpiryTime" in UE context in AMF and further also send the received "RFSPinUseExpiryTime" to MME in UE context along with the "RFSP Index in use" when N26 interface applied.

- When mobility happens between MMEs before the "RFSPinUseExpiryTime" expires, the remaining value of the "RFSPinUseExpiryTime" should also be sent to the new MME. The new MME handles RFSP Index in the same way as for mobility from the AMF to the MME as described above.

- When a UE is served by the EPC, there is no use case or requirement to provide updated RFSP Index from 5GC to the EPC.

# Annex A:Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-02 | SA2#149E | S2-2200161 | - | - | - | Proposed skeleton approved at S2#149E | 0.0.0 |
| 2022-02 | SA2#149E |  |  |  |  | Documented approved p-CR at S2#149E, including S2-2200162, S2-2200163, S2-2200164, S2-2200833, S2-2201598 | 0.1.0 |
| 2022-04 | SA2#150E |  |  |  |  | Documented approved p-CR at S2#150E, including S2-2202070, S2-2202342, S2-2202456, S2-2203315, S2-2203316, S2-2203317, S2-2203318, S2-2203319, S2-2203320 | 0.2.0 |
| 2022-8 | SA2#152E |  |  |  |  | Documented approved p-CR at S2#152E, including solution update doc S2-2205525, S2-2205716, S2-2206337, S2-220A7098, evaluation and conclusion doc S2-2207099, S2-2207100, S2-2207101. | 0.3.0 |