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| 3GPP TR 23.700-61 V18.0.0 (2022-06) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on Seamless UE context recovery  (Release 18) | |
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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

This study will focus on the mechanism to determine the "unavailability period" in the 5G system for the UE.

# 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 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

# 3 Definitions of terms and abbreviations

## 3.1 Terms

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

## 3.2 Abbreviations

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

# 4 Architectural Assumptions and Requirements

1) The "unavailability period" may be made available on the user interface. Whether and how "unavailability period" is used on the user interface (if any) of the UE is outside the scope of this study.

2) The "unavailability period" for the UE is expected to be sufficiently long for the UE to execute required events such as:

a) Silent reset at Modem;

b) Security patch updates;

c) OS upgrade;

d) Modem SW updates; and

e) Device reboot upon Modem setting changes via OMA-DM.

# 5 Key Issues

## 5.1 Key Issue #1: Determination of unavailability period in 5GS for a specific UE

### 5.1.1 Description

To execute certain events, for example OS upgrade, silent reset at modem or modem software updates (also commonly called as binary updates) there are 3 parties involved: the device, the operator and the application function. Once the UE has downloaded the binary, the time when the UE performs the upgrade is left for the UE implementation, with possibly UE implementations seeking user input. If UEs cannot execute the event (e.g. the storage capacity or the battery level are insufficient), they may delay execution of the event. These UEs become unavailable (i.e. cannot interact with the 5G System) in the order of minutes whenever such operations are performed. As UEs become unavailable without prior knowledge from the core network and/or application function, it can impact critical operations of an application server if it depends on availability of the UE during the unavailability period (i.e. a period of time during which the UE is not available).

The present key issue shall study:

a) Whether and how an unavailability period is determined in 5GS for a specific UE.

b) Study the expected UE and/or network actions (if any) based on determined unavailability period.

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Key Issues | | | |
| Solutions | 1 |  |  |  |
| 1 | X |  |  |  |
| 2 | X |  |  |  |
| 3 | X |  |  |  |
| 4 | X |  |  |  |
| 5 | X |  |  |  |
| 6 | X |  |  |  |

## 6.1 Solution #1: Usage of MICO mode for UE unavailability period management

### 6.1.1 Introduction

This solution addresses Key Issue #1 on Determination of unavailability period in 5GS for a specific UE.

### 6.1.2 Functional Description

The solution relies on usage of Mobile Initiated Connection Only (MICO) mode as specified already in TS 23.501 [2] and TS 23.502 [3], with some enhancements.

Once the user or the application in the UE has decided to turn down the UE, the UE:

- triggers Mobility Registration Update procedure indicating preference for MICO mode.

- provides the network with an estimated time while the UE is going to be unavailable (or an estimated time for MICO mode).

- stores its MM context in USIM or in non-volatile memory to avoid a full re-registration and reauthentication after MICO mode is terminated.

- provides in the Registration Request message the PDU session status information indicating that all PDU sessions have been torn down, thus avoiding UE and 5G core to keep PDU sessions contexts while the UE is unavailable.

When receiving Registration Request with MICO indication, the AMF determines whether MICO mode is allowed for the UE, and if so, accepts the registration request and provides a periodic registration timer with a value that is at least equal to the estimated unavailability time from the UE. This then avoids that the network considers the UE de-registered while the UE is not in a situation where it could perform periodic registration update (because of the UE being unavailable).

After the unavailability period and when the UE comes back, the UE issues a new Registration Request without MICO mode indication, reusing the stored MM context, and re-establishes PDU sessions that are still required.

### 6.1.3 Procedures

The procedure is based on the general registration procedure specific in clause 4.2.2.2.2 of TS 23.502 [3]. Details are provided in figure 6.1.3-1 and steps below.



Figure 6.1.3-1: Registration with indication of UE unavailability

0. UE decides to turn down, e.g. for OS upgrade or device reboot. The UE stores its MM context in USIM or non-volatile memory to be able to reuse it after its unavailability period.

1. The UE sends Registration Request to the AMF (via (R)AN). This step is the same as step 1 from clause 4.2.2.2.2 of TS 23.502 [3]. The UE includes MICO mode preference and an estimated time while the UE is going to be unavailable. The UE indicates, via PDU session status, that all PDU sessions are inactive.

2-20. Same steps as steps 2 to 20 from clause 4.2.2.2.2 of TS 23.502 [3].

21. AMF sends Registration Accept to the UE. This step is similar to step 21 from clause 4.2.2.2.2 of TS 23.502 [3]. The AMF indicates accepted MICO mode. The AMF provides Periodic Registration Update timer greater than the estimated time when the UE is going to be unavailable, as provided by the UE in step 1.

21b-25. Same steps as steps 21b to 25 from clause 4.2.2.2.2 of TS 23.502 [3].

26. When the UE is available again, the UE sends a Registration Request to the AMF without MICO mode indication.

27. The UE re-establishes the PDU sessions that are required.

### 6.1.4 Impacts on services, entities and interfaces

UE:

- Determination of unavailability period;

- Registration with MICO mode when unavailability starts, together with an indication of duration for unavailability (equivalent to a duration for MICO mode);

- Storage of MM context in USIM or in non-volatile memory;

- Tearing down of PDU sessions.

AMF:

- Handling of MICO mode requests from the UE, and configuration of appropriate periodic registration timer taking UE indicated duration for unavailability into account.

## 6.2 Solution #2: UE provided Unavailability Period

### 6.2.1 Introduction

This solution addresses Key issue #1.

### 6.2.2 Functional Description

When the UE is about to become unavailable due to the events as described in Key issue #1, the UE initiates registration procedure indicating unavailability period.

The AMF, may set the periodic registration timer to a value equal or slightly larger than the unavailability period provided by the UE.

During this unavailability period the 5GC maintains the UE context in CM-IDLE, and considers the UE unreachable, in similar approach as MICO mode.

When the UE concludes the event that kept it unavailable, the UE triggers registration procedure and does not provide indication of unavailability period. During that registration procedure, if the AMF had assigned a periodic registration timer based on unavailability period, the AMF provides the UE with a regular value for the periodic registration timer (i.e. not considering unavailability period).

The use of periodic registration timer of similar value of the unavailability period is to make sure the UE resumes normal activity after the unavailability period is concluded.

### 6.2.3 Procedures

Figure 6.2.3-1 shows the call flow for this solution.



Figure 6.2.3-1: UE triggered Unavailability Period

1. During initial Registration procedure, the UE provides indication of support of "Unavailability Period" in Registration Request, and the AMF provides support of "Unavailability Period" in Registration Accept message.

2. When an event as described in Key issue #1 is to be triggered in the UE, if "Unavailability period" support was indicated by AMF, a supporting UE proceeds with step 3 before executing the event and becoming unavailable.

3. The UE sends Registration Request message indicating an Unavailability period. The Unavailability period is determined internally in the UE, and implementation dependent, (e.g. may be determined based on type of event and expected event duration).

4. The AMF responds with Registration Accept. The AMF may set the periodic registration timer to a value equal or slightly larger than the unavailability period provided by the UE. The AMF stores the information that the UE is in unavailability period in UE context, and considers the UE unreachable until the UE performs registration procedure again. In this state, all HLCom solutions apply if supported, e.g. extended data buffering, downlink data buffering status report, etc.

5. Once the event is executed, the UE triggers registration procedure to resume regular service. The UE does not include Unavailability period in the registration request. Depending of the state the UE ends up after the event, the registration type may be initial registration, "mobility" or "periodic" registration.

6. The AMF responds with registration accept. If the AMF has stored that the previously assigned periodic registration timer was assigned based on unavailability period, the AMF assigns a new periodic registration timer not considering unavailability period.

### 6.2.4 Impacts on services, entities and interfaces

UE:

- Support of unavailability period indication in registration procedure.

AMF:

- Support of unavailability period indication in registration procedure.

- Storing unavailability period in UE context.

- Handling of MT data and control plane procedures for UE unreachable (no new procedures compared to CM-IDLE with MICO).

## 6.3 Solution #3: Determination of unavailability period in 5GS

### 6.3.1 Introduction

This solution addresses Key issue #1.

### 6.3.2 Functional Description

This is a solution to Key Issue #1, "Determination of unavailability period in 5GS for a specific UE".

In this solution, the unavailability period is requested by the UE from 5GC. Once requested, the UE-requested unavailability period can be delayed by the 5GC with a backoff timer, if necessary.

The UE and network undergo capability negotiation wherein the UE indicates its capability to support Unavailability period and the network indicates its capability to support and use the Unavailability period in 5GS as part of the initial registration procedure.

The UE may download software, patches and other updates from AF. When the UE determines the appropriate time to become unavailable, UE initiates the Registration procedure for mobility and periodic registration update. The UE indicates the duration for which it may become unavailable, and the network may accept the unavailability duration indicated by the UE or indicate a different value.

The AMF may also reject the UE request to become unavailable if it is currently not appropriate for the UE to become unavailable. The AMF may optionally provide a backoff timer to the UE, if it is appropriate for the UE to become unavailable after a certain duration. If the UE receives a backoff timer, the UE starts the backoff timer and delays becoming unavailable for doing internal updates. While the backoff timer is running the UE is available and normal operation continues.

Once the backoff timer expires, the UE initiates De-registration procedure and becomes unavailable. The AMF stores the UE context and starts an internal timer for the duration that the UE is unavailable. Once the internal updates are completed, the UE restarts and initiates the initial Registration procedure. The AMF seamlessly restores the UE context and registers the UE.

#### 6.3.2.1 Alternate solution with re-use of MUSIM features

Alternatively, UE may re-use some of the MUSIM features defined in Rel-17 for the purpose of this solution and indicate capabilities for Connection Release (clause 5.38.2 of TS 23.501 [2]) and Paging Restriction (clause 5.38.5 of TS 23.501 [2]). In addition, UE also indicates capability for "Expected Leaving Duration" that was discussed in the context of MUSIM in Rel-17 but eventually not adopted for MUSIM.

When the UE determines the appropriate time to become unavailable, the UE can initiate either a Service Request procedure or a registration procedure and include the Release Request indication and the Paging Restriction Information as specified for MUSIM. As part of the Connection Release, the UE can request Expected Leaving Duration, that specifies the length of the unavailability period. Expected Leaving Duration can only be used in combination of the Connection Release feature. The backoff timer mechanism remains the same as described above, but with the use of the MUSIM Connection Release feature, the UE does not need to de-register from the network.

### 6.3.3 Procedures



Figure 6.3.3-1: Procedure for determining Unavailability Period

Figure 6.3.3-1 represents the high-level procedure for determining the Unavailability period.

1) The UE indicates its capability to support Unavailability period in 5GMM Core Network Capability in Registration Request message as part of initial registration procedure.

2) The AMF indicates its capability to support and use the Unavailability period in 5GMM network feature support in Registration Accept message as part of registration procedure.

3) The UE may download software, patches and other updates from the AF. Once the updates are locally available the UE may determine a suitable time to install these updates and indicate the duration for which it may become unavailable to 5GC.

4) The UE requests the network to become unavailable for a duration of Unavailable time requested by sending the Registration Request message (for mobility and periodic registration update).

5) The AMF evaluates the UE request to become unavailable for a duration of Unavailable time requested. The AMF indicates if the network accepts the UE becoming unavailable or the network rejects the UE request to become unavailable if it is currently not appropriate for the UE to become unavailable in the Registration Accept message. The AMF may accept the unavailability duration indicated by the UE or indicate a different value in Unavailable time accepted. The AMF may optionally provide a backoff timer to the UE, if it is appropriate for the UE to become unavailable after a certain duration. If the UE receives a backoff timer, the UE starts the backoff timer and delays becoming unavailable for doing internal updates equivalent to the value of backoff timer. While the backoff timer is running the UE is available and normal operation continues.

6) If the UE has received the backoff timer, the UE waits until the backoff timer expires. The UE initiates De-registration procedure to become unavailable. The UE shall indicate the type of de-registration. The UE may optionally indicate that de-registration is for software update.

7) The AMF accepts the de-registration request and sends a De-registration Accept message. If the UE has indicated that de-registration is for software update, the AMF may store the UE context and start an internal timer for duration of Unavailable time accepted.

8) Once the internal updates are completed and the UE has re-started, the UE registers with the network by sending the Registration Request message for initial registration.

9) If the UE restarts and initiates registration within the Unavailable time accepted time duration, by initiating the registration procedure, the AMF seamlessly restores the UE context and registers the UE.

#### 6.3.3.1 Alternate solution with re-use of MUSIM features

The UE follows similar steps as above in this case as well. The key differences in the alternative approach are as follows:

1) The UE indicates its capability to support the Connection Release and Paging Restriction features as per existing registration procedure defined in clause 4.2.2.2.2 of TS 23.502 [3] with the exception that support for these features is not restricted to Multi-USIM UEs. The UE also indicates support for Expected Leaving Duration.

2) The AMF indicates its capability to support the Connection Release and Paging Restriction features as per existing registration procedure defined in clause 4.2.2.2.2 of TS 23.502 [3] based on network capability and preference by the network (i.e. based on local network policy). The AMF only indicates Expected Leaving Duration Supported together with Connection Release Supported.

3) The UE initiates either a Service Request procedure or a Registration procedure as defined for MUSIM. The UE includes the Release Request indication, the Paging Restriction Information and the Expected Leaving Duration in the Service Request message, if the UE intends to leave CM-CONNECTED state, as defined in clause 4.2.3.2 of TS 23.502 [3]. The UE includes the Release Request indication, the Paging Restriction Information and the Expected Leaving Duration in the Registration Request message over 3GPP access, if the UE intends to leave CM-IDLE state (or CM-CONNECTED state and the UE needs to perform Registration Update at the same time), as defined in clause 4.2.2.2.2 of TS 23.502 [3]. In addition, the UE sets the Paging Restriction Information to "all paging is restricted" (according to clause 5.38.5 of TS 23.501 [2]). The Expected Leaving Duration indicates the requested unavailability period in seconds.

4) When using the MUSIM Connection Release feature, the UE does not need to de-register from the network.

### 6.3.4 Impacts on services, entities and interfaces

UE:

- Indicates its capability to support Unavailability time in 5GS in 5GMM Core Network Capability as part of registration procedure.

- Connects with the AF and downloads patches, software updates and other upgrades.

- Determines unavailability duration time interval and an appropriate time to become unavailable and requests the network to become unavailable by sending Registration Request (MRU) message.

- If the network has provided a backoff timer value, starts the backoff timer and delays becoming unavailable for duration of backoff timer.

- Initiates de-registration procedure by sending the De-registration request message and indicating that de-registration is for software update.

- Once the UE performs software updates and the operation is complete, initiates registration procedure.

In alternate solution with re-use of MUSIM features:

- The UE indicates its capability to support the Connection Release, the Paging Restriction and Expected Leaving Duration as part of registration procedure.

- The UE initiates either a Service Request procedure or a registration procedure and includes the Release Request indication, the Paging Restriction Information and the Expected Leaving Duration.

- When using the MUSIM Connection Release feature, the UE does not need to de-register from the network.

AMF:

- Indicates its capability to support and use Unavailability time in 5GS in 5GMM network feature support as part of registration procedure.

- Accepts or rejects the UE request to become unavailable. Indicates the duration for which the UE may become unavailable. Provides a backoff timer if it is appropriate for UE to delay becoming unavailable for a certain duration.

- When UE indicates de-registration is for software update, stores the UE context and starts an internal timer for duration of Unavailable time accepted.

- Restores the UE context, when UE performs registration within Unavailable time accepted duration and registers the UE.

In alternate solution with re-use of MUSIM features:

- The AMF indicates its capability to support the Connection Release, the Paging and the Expected Leaving Duration as part of registration procedure.

- The AMF suspends the NAS signalling connection per the Connection Release initiated by the UE and it does not page the UE per UE's request that "all paging is restricted" during the Unavailability time.

## 6.4 Solution #4: Exposing UE provided unavailability period via Loss of Connectivity event subscription

### 6.4.1 Introduction

This solution addresses key issue #1: Determination of unavailability period in 5GS for a specific UE.

### 6.4.2 Functional Description

This solution proposes to extend "Loss of Connectivity" event subscription to notify unavailability period of the UE if the UE provides unavailability period via NAS message. How the UE determines unavailability period is not defined by this solution and out of scope of 3GPP.

### 6.4.3 Procedures



Figure 6.4.3-1: Overall procedure for unavailability period report to the AF

1. The UE is registered with 5GC.

2-7. The AF subscribes "Loss of Connectivity" event to the NEF based on existing procedure.

8. The UE may send NAS message (e.g. Registration, Deregistration) with unavailability period information, which is determined by the UE.

9. If the AMF received unavailability period in the NAS message and there is "Loss of Connectivity" event subscription for the UE, the AMF includes unavailability period in the event notification report even though the UE is not deregistered.

10. If the NEF receives unavailability period in the event notification report from the AMF, the NEF provide the received unavailability period to the AF.

### 6.4.4 Impacts on services, entities and interfaces

UE:

- Provides unavailability period via NAS message.

AMF:

- If the UE provides unavailability period via NAS message and there is "Loss of Connectivity" event subscription for the UE, the AMF triggers "Loss of Connectivity" event report and includes unavailability period during the "Loss of Connectivity" event report.

NEF:

- Notifies unavailability period during the "Loss of Connectivity" event report to the AF if the AMF provided unavailability period in the "Loss of Connectivity" event report.

## 6.5 Solution #5: Determination of unavailability period in 5GS for a specific UE

### 6.5.1 Introduction

This solution aims to solve Key Issue #1 as described in clause 5.1.

### 6.5.2 Functional Description

Once the UE has downloaded the binary, the time when the UE performs the upgrade is left for the UE implementation, with possibly UE implementations seeking user input. In order to avoid impact to critical operations which would be executed during the UE unavailable period without prior knowledge from the core network and/or application function, this solution proposes that the UE reports its unavailable period to the network. The network takes the UE unavailable period into account when determining recommended time window for data transfer of the UE.

It is proposed that the NWDAF collects UE unavailable period from the UE via Data Collection AF. The application function negotiates recommended time window using background data transfer procedure. During this procedure, the PCF requests from the NWDAF the UE unavailable period. The PCF determines the recommended time for the application function to avoid the UE unavailable period.

### 6.5.3 Procedures

#### 6.5.3.1 Procedures for future background data transfer

This procedure is performed as per Figure 4.16.7.2-1 Negotiation for future background data transfer in TS 23.502 [3] with the following differences:



Figure 6.5.3.1-1: Negotiation for future background data transfer

In step 1, the AF invokes the Nnef\_BDTPNegotiation\_Create service and carries a "critical" indication. It indicates that this service is critical and the data transfer shall be performed avoid UE unavailable period.

In step 2, the NEF sends the "critical" indication within the Npcf\_BDTPolicyControl\_Create message to the H-PCF.

Alternative 1) In step 5, the H-PCF interacts with the NWDAF using Nnwdaf\_AnalyticsSubscription\_Subscribe and requests for UE unavailable period for the corresponding UEs.

The NWDAF responds to the H-PCF with UE unavailable period using Nnwdaf\_AnalyticsSubscription\_Notify.

Alternative 2) In step 3, the PCF requests UE unavailable period from the UDR.

In step 4, the UDR response to the H-PCF with UE unavailable period.

The H-PCF determines Background Data Transfer policies by taking into account the UE unavailable period.

#### 6.5.3.2 Procedure for NWDAF collects UE unavailable period from the UE



Figure 6.5.3.2-1: NWDAF collects UE unavailable period

1. The UE determines its unavailable period. The UE can determine its unavailable period based on UE implementation. The UE sends the UE unavailable period to the Data collection AF. This step reuses the data collection procedure in clause 6.2.8.2.1 of TS 23.288 [4].

2. The Data Collection AF sends the UE unavailable period to the NWDAF, e.g. using Naf\_EventExposure\_Notify.

The NWDAF may subscribe the UE unavailable period from the AF using Naf\_EventExposure\_Subscribe.

Editor's note: Whether NWDAF needs to be involved is FFS.

#### 6.5.3.3 Procedure for UDR collects UE unavailable period



Figure 6.5.3.3-1: UDR collects UE unavailable period

1. The UE determines its unavailable period. The UE can determine its unavailable period based on UE implementation. The UE sends the UE unavailable period to the AF.

2. The AF sends the UE unavailable period to the NEF, e.g. using Nnef\_ParameterProvision\_Create.

3. The NEF sends the UE unavailable period to the UDR.

The UDR stores the UE unavailable period and is provided to the PCF as described in clause 6.5.3.1.

### 6.5.4 Impacts on services, entities and interfaces

For alternative 1):

UE:

- Be able to send UE unavailable period to the Data collection AF.

Data collection AF:

- Be able to send UE unavailable period to the NWDAF.

NWDAF:

- Be able to send UE unavailable period to the PCF.

PCF:

- Be able to request for UE unavailable period from the NWDAF and to take the UE unavailable period into account when determining recommended time window in Background Data Transfer policies.

AF:

- Be able to send "critical" indication to the NEF.

For alternative 2):

UE:

- Be able to send UE unavailable period to the AF.

AF:

- Be able to send UE unavailable period to the NEF.

NEF:

- Be able to send UE unavailable period to the UDR.

PCF:

- Be able to request for UE unavailable period from the UDR and to take the UE unavailable period into account when determining recommended time window in Background Data Transfer policies.

AF for critical application:

- Be able to send "critical" indication to the NEF.

## 6.6 Solution #6: Determination of unavailability period in 5GS for a specific UE

### 6.6.1 Introduction

This is a candidate solution to the key issue#1.

### 6.6.2 Functional Description

As described in key issue#1, UEs become unavailable (i.e. cannot interact with the 5G System) in the order of minutes whenever below events (hereafter called as events) are executed:

a) Silent reset at Modem;

b) Security patch updates;

c) OS upgrade;

d) Modem SW updates; and

e) Device reboot upon Modem setting changes via OMA-DM.

As UEs become unavailable without prior knowledge from the core network and/or application function while executing these events, it can impact critical operations of an application server if it depends on availability of the UE during the unavailability period (i.e. a period of time during which the UE is not available).

Thus this solution proposes a mechanism to co-ordinate the unavailability period between UE, 5GC and AF. So that UE can make informed decision on when to execute these events.

### 6.6.3 Procedures



Figure 6.6.2-1: Determination of unavailability period in 5GS for a specific UE

Option-A:

1a) By re-using the procedures described in clause 4.15.6.2 of TS 23.502 [3], the AF provisions the unavailability period parameter into the UDM/UDR, or the UDM/UDR can be configured with the unavailability period parameter based on operator policy.

1b) The unavailability period parameter is provided to AMF by UDM using Nudm\_SDM\_Get response. Based on the unavailability period, AMF may choose to not initiate procedures which can force UE to enter deregistered state.

1c) UDM uses the UE Parameters Update via UDM Control Plane Procedure as described in clause 4.20 of TS 23.502 [3] to configure the unavailability period parameter into the UE.

Option-B:

2a) By re-using the procedures described in clause 4.15.6.7 of TS 23.502 [3], AF provisions the unavailability period parameter into the PCF, or the PCF can be configured with the unavailability period parameter based on operator policy.

2b) The unavailability period parameter is provided to AMF by PCF during AM policy association. Based on the unavailability period, AMF may choose to not initiate procedures which can force UE to enter deregistered state.

2c) PCF uses the UE Configuration Update procedure for transparent UE Policy delivery as described in clause 4.2.4.3 of TS 23.502 [3] to configure the unavailability period parameter into the UE.

NOTE: The AF configures the unavailability period parameter which is acceptable to 5GC .i.e. based on negotiation between 5GC and AF.

The unavailability period parameter is the time slot which indicates the time in which UE is allowed to perform deregistration procedure to execute events described in clause 6.6.2. The unavailability period parameter can have multiple time slots for example 10:00-12:00 UTC, 14:00 - 18:00 UTC, 22:00-23:59 UTC etc. If UE is not able to execute the events for example due to the less storage capacity or insufficient battery level in the first time slot then UE should wait for the next time slot to execute the events.

The network takes unavailability period parameter into account to execute Device reboot upon Modem setting changes via OMA-DM procedures.

If UE have a user interface, how UE indicates the unavailability period to the user and take his consent to execute the events during unavailability period is outside the scope of this study as agreed in clause 2.

The unavailability period is configured by the HPLMN, based on agreements with the AF and operator policy, into the UE.

### 6.6.4 Impacts on services, entities and interfaces

This solution impacts the following system entities.

UDM or PCF:

- To support provisioning of the unavailability period parameter from the application function which is acceptable to both 5GC and AF.

- To support provisioning of the unavailability period parameter provisioning into the UE.

AMF:

- To take unavailability period into account to decide whether it can initiate procedures which makes UE enter deregistration procedure.

UE:

- To take unavailability period into account to decide whether it can trigger deregistration procedure to execute the events described in clause 6.6.2.

## 6.X Solution #X: <Solution Title>

### 6.X.1 Introduction

Editor's note: This clause lists the key issue(s) addressed by this solution.

### 6.X.2 Functional Description

Editor's note: This clause outlines solution principles, assumptions and high-level architectures, etc.

### 6.X.3 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.X.4 Impacts on services, entities and interfaces

Editor's note: This clause describes impacts to existing services, entities and interfaces.

# 7 Overall Evaluation

Table 7-1: Evaluations

|  |  |  |  |
| --- | --- | --- | --- |
|  | Summary | System impacts | AF interaction |
| Solution #1: Usage of MICO mode for UE unavailability period management | UE provides unavailability period via Registration  UE requests MICO and release all PDU Sessions  UE stores MM context  AMF sets periodic registration timer considering unavailability period | UE provides unavailability period in Registration | No interaction |
| Solution #2: UE provided Unavailability Period | UE provides unavailability period via Registration  Capability negotiation between UE and AMF  AMF sets periodic registration timer considering unavailability period  HLCom for DL data | UE provides unavailability period in Registration  Capability negotiation | No interaction |
| Solution #3: Determination of unavailability period in 5GS | Capability negotiation between UE and AMF  AMF may reject UE request to become unavailable and optionally provide a back off timer  If AMF accepts unavailability period, UE triggers deregistration.  Alternatively, MUSIM connection release and paging restriction can be used instead of performing deregistration. | UE provides unavailability period in Registration  Capability negotiation  AMF may reject unavailability period and provide back off timer  UE needs to support unavailability back off timer | No interaction |
| Solution #4: Exposing UE provided unavailability period via Loss of Connectivity event subscription | UE provides unavailability period  If Loss Of Connectivity event exists, the AMF sends notification. | UE provides unavailability period in Registration or Deregistration  If Loss of Connectivity Event subscription is exist, the AMF reports notification when the UE provided unavailability period | Report unavailability period to the AF via Loss of Connectivity event subscription |
| Solution #5: Determination of unavailability period in 5GS for a specific UE | UE reports unavailability period to the AF via application layer signalling.  AF provides unavailability period to the UDR / NWDAF  For critical service, the AF negotiates BDT | AF provisions unavailability period provisioning via external parameter provisioning procedure  Critical indication in BDT negotiation | Negotiate BDT time window considering unavailability period |
| Solution #6: Determination of unavailability period in 5GS for a specific UE | AF provides unavailability period to the UDM/UDR.  UDM/UDR provides unavailability period to the AMF via subscription or AM Policy association  UDM/PCF provides unavailability period to the UE via UPU / Policy delivery  AMF / UE uses the unavailability period to determine whether deregistration can be executed | AF provisions unavailability period provisioning via external parameter provisioning procedure  AMF, UE use the unavailability period whether to trigger deregistration | AF determines unavailability period |

# 8 Conclusions

## 8.1 Conclusions for Key Issue #1

During Registration procedure, the UE provides indication of support of "Unavailability Period" in Registration Request message, and the AMF indicates the support of the "Unavailability Period" in Registration Accept message.

If UE and network support "Unavailability Period" and an event is triggered in the UE that would make the UE unavailable for a certain period of time (e.g. for OS upgrade or device reboot), the UE may store its MM context in USIM or Non Volatile memory to be able to reuse it after its unavailability period. When the UE is ready to execute the event, the UE triggers mobility registration or deregistration procedure including the unavailability period. The AMF may provide Periodic Registration Update timer based on unavailability period indicated by the UE, e.g. the AMF may provide a Periodic Registration Update time larger than unavailability period. If the UE is not deregistered, the AMF stores the information that the UE is unavailable in UE context, and considers the UE is unreachable until the unavailability period has passed or the UE enters CM-CONNECTED state. While the UE is unreachable, all high latency communication solutions (see clause 5.31.8 of TS 23.501 [2]) may apply if supported, e.g. extended data buffering, downlink data buffering status report, etc. If there is "Loss of Connectivity" event subscription for the UE by AF, the AMF triggers "Loss of Connectivity" event report and includes unavailability period towards the NEF and the unavailability period is reported to the respective subscribed AF.

When the UE is ready to execute the event (e.g. for OS upgrade or device reboot), the UE may choose to store the UE contexts (MM and SM context).

NOTE 1: How the UE stores the context depends upon the UE implementation. The UE may store some or all of the UE contexts in the USIM using existing USIM functionality.

Once the event which makes the UE unavailable is completed in the UE or the event is delayed to a future time or cancelled in the UE (e.g. due to insufficient storage capacity, insufficient battery level or the event which makes the UE unavailable is completed), the UE triggers registration procedure to resume regular service. The UE does not include the Unavailability Period in the Registration Request message. Depending on the state the UE ends up after the event, the registration procedure can be Initial Registration procedure or Mobility Registration Update procedure.

NOTE 2: The actual event execution in the UE, including user interaction, is out of the scope of this feature.

NOTE 3: Exact names for the parameters exchanged between UE and Network can be decided during normative work.

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-02 | SA2#149E | S2-2201195 | - | - | - | Proposed skeleton agreed at SA2#149E | 0.0.0 |
| 2022-05 | SP#96 | SP-220424 | - | - | - | MCC editorial update for presentation to TSG SA#96 for approval | 1.0.0 |
| 2022-06 | SP#96 | - | - | - | - | MCC editorial update for publication after TSG SA#96 approval | 18.0.0 |