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**Title: Update the Solution#29 for KI#3: Enabling S&F operation with C-SGN onboard**

**Document for: Approval**

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**Work Item / Release:** **FS\_5GSAT\_ARCH\_Ph3 / Rel-19**

*Abstract of the contribution: This contribution proposes to update solution#29 for KI#3 considering especially to resolve ENs.*

# 1 Discussion

In TR23.700-29 v0.3.0, Solution#16 faces 5 ENs, the purpose of this paper is to resolve the ENs. Below are the ways to resolve the ENs:

Editor's note: It is FFS how the solution works in the presence of multiple satellites.

This solution assumes the serving SAT is not changed (i.e., MME is not changed), which means the UE is served by the registered SAT(MME) all the time. This assumption doesn’t mean that only one SAT is deployed..

Editor's note: regarding how the MME handles NAS pause/recovery for initial UE is FFS.

As introduced, NAS pause/recovery procedure in this solution can support any NAS interactions between UE and MME (as defined in TS24.301). Regarding the UE identifier, only when MME gets the authentication/authorization from HSS, the MME will assign GUTI to the UE. Otherwise, it is proposed to utilize IMSI as UE identifier for the initial UE context management.

Therefore, the corresponding procedure clause 6.12.2.1 regarding how to handle initial UE is updated.

Editor's note: SMS data transmission regarding S&F is FFS.

The corresponding procedures are added in clause 6.16.2.2. As the path of SMS is:

UE🡪RAN🡪MME🡪S-GW🡪SMS-GMSC

It is proposed that MME will be the point for store and forward SMS.

Editor's note: UL data transmission when UE is in the ECM-IDLE state is FFS.

The corresponding procedure clause 6.16.2.3.1 regarding how to enable restore from ECM-IDLE to ECM-CONNECTED is updated.

Editor's note: DL data transmission when UE is in the ECM-IDLE state is FFS.

The corresponding procedure clause 6.16.2.3.2 regarding how to enable restore from ECM-IDLE to ECM-CONNECTED is updated

Rev1:

1. Clarify the single UE serving UE with EN remove
	1. A UE is served by the same satellite all the time (i.e., the UE context is kept in one SAT(MME) without changing).
2. Add more clarification about NAS recovery clarification
	1. In this solution, it is proposed to use a mechanism about NAS suspend and resume to adapt the S&F operations for NAS message handling. When the feeder link is not available, the MME onboard will pause UE NAS message and notify the UE that its related NAS procedure is suspended (e.g., the attach request), the UE will correspondingly keep the NAS related context and waits for the network NAS resume notification to recover the NAS procedure. When the MME finished the interactions with other functions(e.g, the HSS) and the service link is available(or receies notification from RAN that UE has entered RRC connecrion), the MME will notify the UE to recover the NAS procedure and receive the DL NAS message
3. Remove the MME runging the pause timer description, the MME can consider the NAS recovery based on service link avialble infroamtion or RAN notification.
4. Add one more step about SMS for delivery report, and add a note to say: this solution is not applied to legacy UE.
5. Rewording the SGW stoping receving data in the MO/MT procedure for clarification.
6. Change the CIOT center to CIOT server.
7. Add a NOTE for clarification about access service for UE:
	1. NOTE: which acess service (e.g. CP CIoT, UP CIoT, SMS, non-IP etc) to be adopted for UE for S&F operation is determined during interaction with network and sent to the UE (e.g., during the attach procedure or PDN connectivity procedure).

Updates are highlighted with green.

# 2 Proposal

It is proposed to update solution#16 for KI#2 of TR 23.700-29.

\* \* \* \* First change \* \* \* \*

## 6.16 Solution #16: Enabling S&F operation with C-SGN onboard

### 6.16.1 Description

This is a candidate solution for Key Issue 2 - "Support of Store and Forward Satellite operation".

To facilitate Store-and-Forward (S&F) operations for delay-tolerant services, the assumption is made to activate the entire C-SGN on board. The architecture is derived from Annex L, specifically the "Optimised EPS Architecture option for CIoT" outlined in TS 23.401 [5]. In this architecture, the C-SGN incorporates the functionalities of MME, S-GW, and P-GW. Furthermore, it supports all the requisite interfaces to accommodate various types of delay-tolerant services.



Figure 6.16.1-1: The architecture and interfaces of C-SGN onboard

As shown in Figure 6.16.1-1, the C-SGN onboard architecture is assumed that:

- A UE is served by the same satellite all the time (i.e., the UE context is kept in one SAT(MME) without changing).

- the onboarding C-SGN functionalities are only used for S&F operation, i.e. any UE that connects to the satellite without S&F operation cannot be served by the onboarding C-SGN.

- S-GW is responsible for storing/forwarding the data (or non-IP data) for CP CIoT EPS optimizations, UP CIoT EPS optimizations.

- MME is responsible for storing/forwarding the data for SMS services.

- ISL is not used to transfer the contexts among satellites.

Therefore, to finalize the registration of a UE that supports S&F operations within the network, multiple orbital cycles are required. The number of cycles is determined by the involvement of various procedures, encompassing the UE, onboarding functionalities (i.e. RAN, MME, S-GW, P-GW), and other CN NFs on the ground such as HSS, PCRF, AF, etc. This is due to the service link serves:

- AS layer management between UE and RAN.

- NAS layer management between UE and MME.

And feeder link serves:

- CN internal functionalities management between C-SGN onboard and CN NFs on the ground, i.e. MME/P-GW and HSS, P-GW and HSS/PCRF, P-GW and DN.

 This architecture needs enhancements on:

- Availability detection of service link/feeder link.

- S&F operation triggered condition detection.

- Signalling procedure development on pause/recover mechanisms regarding service link's availability, NAS suspend/resume.

- New procedure development on store/forward mechanism regarding UL/DL data transmission.

In this solution, it is proposed to use a mechanism about NAS suspend and resume to adapt the S&F operations for NAS message handling. When the feeder link is not available, the MME onboard will pause UE NAS message and notify the UE that its related NAS procedure is suspended (e.g., the attach request), the UE will correspondingly keep the NAS related context and waits for the network NAS resume notification to recover the NAS procedure. When the MME finished the interactions with other functions (e.g, the HSS) and the service is available, the MME will notify the UE to recover the NAS procedure and receive the DL NAS message.

### 6.16.2 Procedures

#### 6.16.2.1 Procedures of NAS Pause/Recovery of S&F Operation

This procedure can be applied to any NAS interactions between UE and MME as listed in TS 23.401 [5]. An example of how to utilize NAS Pause/Recovery to complete the initial attach procedure is given in clause 6.16.2.4, and how to utilize NAS pause/recovery to complete the MO/MT data transmission is given in clause 6.16.2.3.



Figure 6.16.2.1-1

0. Pre-condition: UE has established RRC connection with RAN, and RAN has established S1 interface with MME

1. MME decides to pause NAS.

 The trigger condition is when MME receives S1 messages from RAN/NAS message from UE and the procedure is to detect the necessaries to interact with CN NFs on the ground. For example, when UE sends an Attach Request, MME will interact with HSS to initiate the authentication and authorization procedures, as HSS is on the ground, the procedure can proceed only when the feeder link is available.

2. MME sends NAS Pause request to the UE including the following parameters:

- UE identifier, e.g. GUTI if it is assigned by MME, or IMSI that is reported by the UE;

NOTE: The scenario when IMSI is as UE identifier can be used for the initial UE, i.e. when UE sends attach request and MME has not yet received authentication/authorization information from HSS.

- a NAS pause timer/availability window that is calculated by the MME to let UE be aware of when the same satellite will come back to the coverage for the UE.The NAS pause timer/availability window is used when the UE detects a necessity to send a message to the network, e.g. when UE wants to sends a service request to be back the ECM-CONNECTED state, or when UE wants to send a MO data (e.g. CP CIoT, UP CIoT, SMS, non-IP etc).

NOTE: Which service type (e.g. CP CIoT, UP CIoT, SMS, non-IP etc) to be adopted for UE for S&F operation is determined during interaction with network and sent to the UE(e.g., during the attach procedure or PDN connectivity procedure).

3. RAN may Pause AS if an indication is provided by MME in step 2 to save UE energy consumption. The AS pause can be established with the current RAN mechanism, e.g. RAN sends RRCRelease message to UE and moves UE to RRC\_IDLE mode.

NOTE: whether the AS pause/recovery procedure can be proceeded via new RAN mechanism or not depends on RAN.

4. UE starts to pause NAS during the procedure even though the service link is still available based on the request as received in step 2. UE will start a NAS pause timer accordingly.

 Pause NAS means any concurrent NAS messages should be stopped until receive a Recover Request from MME.

5. UE sends a Pause NAS complete message to MME.

6. When the RAN orbits back to serve the UE, the RAN and UE recover the AS connection, the resumption can be triggered by UE (more power saving), or by RAN. When the AS connection is back, the RAN notifies AMF that the UE is back. The AS recovery can be established with the current RAN mechanism, e.g. RAN sends RRCSetup message.

7. MME decides to recover NAS, i.e. continue the paused NAS procedure as specified in step 2 based on e.g.the notification from RAN, or the NAS pause timer is expired, or a request sent by the UE, or MME receives enough message via the interactions with the NFs on-ground.

 For example, e.g. in initial attach procedure, when MME receives the authentication request from HSS and the service link is available again, the MME will send a notification to the UE to indicate UE the concurrent NAS signaling can be continued.

Or when MME receives a service request from UE that the UE has a necessary to be ECM-CONNECTED to sends a message.

8. MME sends NAS Recovery request to UE with at least the following parameter to inform MME:

- UE identifier, e.g. GUTI if it is assigned by the MME, or IMSI.

NOTE: The scenario when IMSI is as UE identifier can be used for the initial UE, i.e. when UE sends attach request and MME has not yet received authentication/authorization information from HSS.9. UE sends back a Recovery NAS complete message to MME. To make full use of the service link available period, the MME/UE may include NAS messages within the recovery messages.

 Afterward, normal NAS messages can be exchanged between UE and MME.

#### 6.16.2.2 Procedures of Store/Forward of SMS transmission

The procedures are used for SMS service.

NOTE: this procedure can also be used for CP CIoT optimizations.

##### 6.16.2.2.1 Procedure of MO SMS transmission



Pre-condition: UE is registered to the S&F network. A NAS pause timer was assigned by the MME when the service link was about to be unavailable as defined in clause 6.16.2.1. UE has a NAS pause timer running.

1. UE has a SMS message to be sent. When the service link is available, and the UE’s NAS pause timer is expired, UE will initiate the NAS recovery procedure by establishing step 6-9 as defined in clause 6.16.2.1. Briefly, UE firstly restore the RRC connection with the RAN, RAN restores the S1 connection with the MME (both onboard), UE subsequently sends Service request message to the MME. When MME receives the SR message, MME will send the NAS recovery request to the UE. Afterwords, UE is back to be in ECM-CONNECTED state, and can send the MO SMS message to the MME.
2. MME stores the MO SMS message.
3. MME stops receiving the MO SMS message. The trigger condition could be when service link is about to be unavailable and/or the storage quota for the UE is exceeded.
4. MME sends NAS resume procedure to the UE, as defined instep 1-5 in clause 6.16.2.1.

No service period.

1. When the feeder link is available, the MME sends the stored MO SMS to the SMS-GMSC on-ground.
2. The SMS-GMSC replies with a delivery report to the MME.
3. When the service link is available, the MME performs paging procedure to get UE connection and then sends the delivery report to UE.

NOTE: This solution is not applied to legacy UE (i.e., not support S&F operation).

##### 6.16.2.2.2 Procedure of MT SMS transmission



Pre-condition: SMS-GMSC is assumed to be informed the S&F operation and is aware of the availability information of onboard P-GW/S-GW/MME.

1. SMS-GMSC receives a SMS message for a UE, SMS-GMSC checks the availability of MME onboard based on the fetched the routing information from HSS. When the availability information indicates the feeder link to the P-GW/S-GW/MME is available, SMS-GMSC sends the MT SMS to the MME.
2. MME stores the MT SMS
3. MME stops receiving the MT SMS. The trigger condition would be when the feeder link is about to be unavailable and/or the storage quota for the UE is exceeded.

No service period.

1. When feeder link is available, MME will initiate the NAS recovery procedure by establishing step 6-9 as defined in clause 6.16.2.1. Briefly, UE firstly restore the RRC connection with the RAN, RAN restores the S1 connection with the MME (both onboard), MME is notified and subsequently sends NAS recovery request to the UE. Afterwords, UE is back to be in ECM-CONNECTED state, and MME can send the MT SMS message to the MME. MT SMS message can also be integrated in the NAS recovery request message.
2. When the feeder link is available, the MME sends the delivery report to the SC / SMS-GMSC.

#### 6.16.2.3 Procedure of Store/Forward of Data transmission

This procedure applies to CP CIoT EPS Optimizations, UP CIoT EPS Optimizations, non-IP data transmissions.

##### 6.16.2.3.1 Procedure of MO Data transmission



Figure 6.16.2.2.1-1

Pre-condition: same precondition as defined in clause 6.15.2.2.1.

1. UE sends UL data via RAN and S-GW with NAS recovery firstly, similar procedure as defined in clause 6.16.2.2.1 step 1.

When the delay-tolerant service is CP CIoT optimizations, the path is: UE🡪RAN🡪MME🡪S-GW;

When the delay-tolerant service is UP CIoT optimizaitions or non-IP data, the path is: UE🡪RAN🡪S-GW

2. S-GW stores the UL data

3. S-GW stops receiving the UL data when the service link is unavailable or .when the storage quota for the UE is exceeded.

. S-GW detects feeder link is available. The availability detection of feeder link can be based on pre-configured information, MME notifications, or gateway notifications (out of 3GPP scope). At the same time the connection between CN C-SGN onboard and CN NFs on the ground is recovered. 5S-GW forwards the stored data to P-GW, and P-GW forwards to the ground.

##### 6.16.2.3.2 Procedure of MT data transmission

 

Figure 6.16.2.2.2-1

Pre-condition: CIoT service server is assumed to be informed the S&F operation and is aware of the availability information of onboard P-GW/S-GW/MME

1. P-GW and S-GW receives DL data. CIoT service center receives MT data for a UE, CIoT service center checks the availability of P-GW/S-GW/MME onboard. When the availability information indicates the feeder link to the P-GW/S-GW/MME is available, CIoT service server sends the MT SMS to the P-GW.

When the delay-tolerant service is CP CIoT optimizations, the path is: CIoT service server 🡪P-GW🡪S-GW;

When the delay-tolerant service is UP CIoT optimizaitions or non-IP data, the path is: CIoT service server 🡪SCEF🡪P-GW🡪S-GW

2. S-GW stores the DL data

3. S-GW stops receiving the DL data when the feeder link is not available or when the storage quota for the UE is exceeded.4. S-GW detects service link is available. The availability detection of service link can be based on pre-configured information, MME notifications. . The NAS is recovered between UE and MME, similar to what has been defined in step 4b in clause 6.16.2.2.2.S-GW forwards the stored data to RAN, and RAN forwards to the UE.

#### 6.16.2.4 Example of initial attach procedure

This provides an example of how the UE can complete the attach procedure with C-SGN onboard. Generally, if the UE hasn't established any connection with the network before, it needs at least 3 rounds of satellite orbiting periods, each round of orbiting UE and network can complete some parts of the procedure.

##### 6.16.2.3.1 1st round orbiting



Figure 6.16.2.3.1-1

1. When service link is available, UE initiates the RRC connection with RAN and sends Attach Request to MME.

2. MME pause the NAS because MME needs to wait for the response from HSS. As MME has not completed the interactions with the HSS (on ground), MME cannot assign a GUTI to the UE yet. Therefore, when MME decides to pause the NAS, the MME will utilize IMSI as the UE identifier to inform UE the NAS pause decision, as specified in clause 6.12.2.1.

3. When feeder link is available, MME initiates the interactions with HSS for the authentication and authorization.

4. MME waits for the Auth response from UE and assigns a GUTI to the UE.

##### 6.16.2.3.2 2nd round orbiting



Figure 6.16.2.3.2-1

1. When service link is available, MME recovers the interactions with UE to complete the authentication and authorization procedure. The NAS recovery procedure will be executed as described in clause 6.16.2.1.

2. MME pause the NAS because MME needs to wait for the response from HSS, S-GW-P-GW and etc. . As MME has assigned a GUTI to the UE, the MME will utilize IMSI as the UE identifier to inform UE the NAS pause decision, as specified in clause 6.12.2.1.

3. When feeder link is available, MME recovers the interactions with CN NFs on the ground to complete e.g. UE context setup, PDN session establishment, optionally dynamic PCC rules retrieval, IP address registration in HSS.

4. MME waits for the attach response from UE.

##### 6.16.2.3.3 3rd round orbiting



Figure 6.16.2.3.3-1

1. When the service link is available, MME recovers the interactions with UE to complete the attach procedure. The NAS recovery procedure will be executed as described in clause 6.16.2.1. Afterwards, UE can send UL data.

### 6.16.3 Impacts to Services, Entities and Interfaces

**MME:**

- Detection of service link/feeder link availability.

- Initiate NAS pause/recover procedure when CN interactions with CN NFs on the ground is needed.

- Pause/recover NAS based on service link's availability.

- Store/Forward SMS data

**RAN:**

- Optionally, initiate AS pause procedure if NAS is paused, and initiate AS recovery procedure.

**UE:**

- Pause/recover NAS.

- Optionally, Pause/recover AS.

**S-GW:**

- Detection of service link/feeder link availability.

- Store/Forward UL/DL data for CP CIoT optimizations, UP CIoT optimization, and Non-IP services.

\* \* \* \* End of changes \* \* \* \*