**3GPP TSG-SA WG2 Meeting #162S2-2404063r01**

**Changsha, China, 15th Apr – 19th Apr 2024**

**Source: Nokia**

**Title: KI#2: Updates to Solution 11.**

**Document for: Approval**

**Agenda Item: 19.1**

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

*Abstract of the contribution: This contribution proposes to resolve EN of solution 11 and explains the suspend and resume procedure as RRC inactive state is not supported in IoT.*

# 1 Discussion

For:

Editor's note: It is FFS on what information the MME-NT is required to store for control plane procedure.

The MME-NT needs to store the interim GUTI information and the identifier of the serving MME-T. The MME-NT can additionally store RAN S1-AP ID and RAN control plane IP address and similarly MME S1-AP ID vs MME-T address.

For:

Editor's note: How to avoid/minimize DoS attack on MME-NT while handling integrity protected messages from UE (as it lacks the NAS keys for decoding) is FFS.

The approach that can be adopted should be similar to terrestrial networks. In addition, SA3 has agreed on relevant key issue to study this type of DoS attack in FS\_5GSAT\_Ph3\_SEC.

For:

Editor's note: How to avoid/minimize fake base station attack when delivering plain text RRC message (message 3) is FFS.

This fake base station attack exists in terrestrial network as well. If SA3 wants to close this security issue, the same approach can be applied for both terrestrial and non-terrestrial network.

For:

Editor's note: How to handle NAS timers due to extended delay in serving NAS transactions in S&F.

According to the TS 23.401(clause 4.13) and TS 24.301 (clause 10), for the introduction of satellite support for Cellular IoT, whenever the UE is accessing the network using a satellite RAT, the MME and the UE shall set the NAS timers long enough according to this satellite RAT. However, for the Store and Forward scenarios it is expected that the NAS timers need to have much longer duration, depending on the deployment of the satellites. A more detailed analysis about the estimation of NAS timers can be considered during the normative phase, in collaboration with CT1 and RAN WGs.For:

Editor's note: In step 1, how the MME-NT creates the temporary UE context for the ciphered NAS message is FFS.

The MME-NT doesn’t need to create any UE context, rather it will transparently pass the information to MME-T. The MME-NT can optionally store RAN-S1AP ID for future transactions throughout the procedure completion.

For:

Editor's note: In step 12, how the MME-T finds the suitable MME-NT is FFS.

The MME-T will need the information on next suitable satellite which can serve the UE e.g., in shortest possible time. This information can be provided within the PLMN, by a UE reachability Estimator (URE) (as presented in Solution #25) or based on satellites’ ephemeris data stored at the MME-T. Alternatively, this information can be received from an external source. A note has been added to step 12 to clarify the same.

For:

Editor's note: How to handle T3417 timeout due to expected larger delay for S&F based CIoT operation is FFS.

According to the TS 23.401(clause 4.13) and TS 24.301 (clause 10), for the introduction of satellite support for Cellular IoT, whenever the UE is accessing the network using a satellite RAT, the MME and the UE shall set the NAS timers long enough according to this satellite RAT. However, for the Store and Forward scenarios it is expected that the NAS timers will have much longer duration, depending on the deployment of the satellites. A more detailed analysis about the estimation of NAS timers could take place during the normative phase, in collaboration with CT1 and RAN WGs.

Following parts are merged from S2-2404144:

**Updates to Attach Procedure:**

**In step 1:**

- Current descriptions just say that UE camping a cell reads the SIB, it is not clear how the UE determine the camping cell supporting S&F.

- MME-NT onboard may need explicit indication that UE is attach for S&F. it is to avoid that the MME-NT reject the UE attach request not for S&F.

Thus, there is 2 proposals as below:

**Proposal 1:** Specify that the SIB includes whether supports S&F operation.

**Proposal 2:** UE add an S&F indication in the registration request to explicitly sate that the registration is for S&F.

**In step 3:**

- Since in step 7, the original text mentions that UE can also reach out to RAN when seeing the new cell and reattempt the attach procedure using the interim GUTI, however the problem is that UE is not aware of which MME-NT is holding this suspended DL signalling, thus it doesn’t work. So it is proposed a Subsequently Accessing window is provided to UE that is used by UE when to recovery the Attach procedure by UE itself. The Subsequently Accessing window can be determined/calculated by MME-NT-1 based on the pre-configuration or the parameters queried from URE before that which MME-NTs are capable of serving a given UE next time as described in Sol#25. The Subsequently Accessing window can be e.g., UTC 10:00-10:30.

**Proposal 3:** A Subsequently Accessing window is provided to UE in step3 which is used by UE itself to recover the attach procedure correctly in step 7 and 10.

In 4G, the network can directly use the IMSI for paging, therefore alternative method is that the the network side just stores the association between IMSI and DL NAS message, and uses the IMSI for paging. It means there is no need to allocate an interim GUTI for the subsequent NAS message association.

**Proposal 7:** network can directly use the IMSI for the suspend NAS message association and paging instead of allocating a interim GUTI.

**Add MT Data Transport with following attributes:**

* + For the S&F MT transport, the MME-T establishes S11-U with SGW before paging compared with legacy MT Data transport.
  + When the suitable MME-NT is found, the MME-T establishes S11-U with SGW and receives the DL data.
  + MME-T forwards the DL data to MME-NT with GUTI in the S10 message. MME-NT stores the DL data associated with GUTI.
  + MME NT generates paging during pass over the UE location (TA).
  + When the UE is triggered by paging to enter the CM-connected, the MME-NT forwards the DL data to UE.

# 2 Proposal

It is proposed to agree below proposed changes to 23.700-29.

\*\*\* Next Change \*\*\*

## 6.11 Solution #11: MME Split Architecture to support Control plane procedure for S&F

### 6.11.1 Key Issue mapping

This solution aims to resolve Key Issue #2, "Support of Store and Forward Satellite operation".

### 6.11.2 Description

In this proposal, the MME, which is the mobility anchor for the UE, is split into 2 network elements, MME-NT (MME on board satellite) and MME-T (MME terrestrial). The MME-NT shall act as a mobility anchor point to UE and does only subset of MME functionality such as assist in Store and Forward operations i.e. combination of two steps not concurrent in time. The MME-T on the ground is responsible for maintaining UE context, including security context. MME-T is also responsible for NAS ciphering/deciphering and integrity protection. MME-NT is responsible for maintain S1 connection towards RAN node and maintain associated connection ID per UE towards MME-T. MME-NT is responsible for encoding NAS message received from MME-T into S1AP payload towards RAN and decode NAS payload from messages received from RAN and send it to MME-T.



Figure 6.11.2-2: Example of split MME architecture based on UE coverage or ground station connectivity at different time

The Store and Forward Satellite (S&F) operation in a EPC system with satellite access is intended to provide some level of communication service for UEs under satellite coverage with intermittent/temporary satellite connectivity (e.g. when the satellite is not connected via a feeder link or via ISL to the ground network) for delay-tolerant communication service.



Figure 6.11.2-1: Example of MME split architecture for Store and Forward operation

In regenerative architecture, the RAN will be placed in a satellite. In the Store & Forward (S&F) scheme, the MME is at satellite will be responsible for providing Store and forward feature. MME in satellites are represented as MME-NT (non-terrestrial) in the above diagram. Let's assume the time T1 is between 10:00 and 10:20 and T2 is between 10:40 and 11:00. The satellites will have ground station coverage when hovering over Rennes and Orleans but not when crossing Le Mans.

At time T1, the black satellite covers Le Mans, and the white satellite provides coverage to Rennes. At T2, the black satellite will be at Orleans and the white satellite will be covering Le Mans.

At time T3, the white satellite will sync up with the MME-T at Orleans.

### 6.11.3 Procedures

#### 6.11.3.1 Architecture enhancement to support S&F

In regenerative architecture, the RAN will be placed in Satellite. In the Store & Forward (S&F) scheme, the MME is at Satellite will be responsible for providing Store and Forward feature. MME in the satellite is represented as MME-NT-1 (non-terrestrial) in the above diagram. E.g. in above figure 6.11.2-2 for the time T1 is between 10:00-10:20 and T2 is 10:30-10:50 and the satellite at T1 is providing coverage towards UE but not connected to the ground station, it shall store UL messages and forward DL messages towards UE; When the satellite at T2 is not providing coverage for UE but connected to ground station shall store any DL messages for the UE and forward any UL messages it had received at T1. At T3, the MME-T can select the appropriate MME-NT-2 in satellite for storing DL messages meant for the UE.



Figure 6.11.2-1: Architecture enhancement for control plane in Store and Forward operation

- MME-T manages all the existing functionality of existing MME. Instead of maintaining S1AP ID per UE context, it will maintain a context identifier for the S10` messages towards MME-NT

- MME-T is responsible for NAS ciphering/integrity protection function.

- MME-T needs to forward the RAN S1AP ID towards MME-NT to help MME-NT to maintain UE context per S1AP instance.

NOTE 1: The MME-NT needs to store the interim GUTI information and the identifier of the serving MME-T. The MME-NT can additionally store RAN S1-AP ID and RAN control plane IP address and similarly MME S1-AP ID vs MME-T address.

#### 6.11.3.2 Attach Procedure in EPC in S&F scenario



Figure 6.11.3-2: Attach procedure in S&F

1. A UE, camping on an E-UTRAN cell reads the related System Information Broadcast including whether supports S&F operation. If the UE is able to perform the S&F operation, it initiates the Attach procedure by the transmission, to the eNodeB, of an Attach Request (IMSI or old GUTI, Old GUTI type, last visited TAI (if available) and the S&F indication). The S&F indication in the Attach Request may be used to indicate MME-NT that the UE is trying to attach for S&F communication.

2. The eNodeB(RAN-1) forwards the Attach Request message in a S1-MME control message (Initial UE message) towards MME-NT-1. In the case of satellite access for Cellular IoT, the MME-NT-1 may verify the UE location and determine whether the PLMN is allowed to operate at the UE location.

3. If the MME-NT-1 is not in contact with the ground station when receiving a message in step2, MME-NT-1 shall store the attach request message and, generate a interim GUTI and send an new NAS clear text message towards UE asking to save the interim GUTI for future NAS transactions. MME shall also provide the validity time for this interim GUTI. (UE may send an ack for the same, not shown in the diagram). Alternatively, MME-NT-1 provides UE a Subsequently Accessing window(e.g., UTC 10:00-10:30) to make UE reattempt the attach procedure with the MME-NT containing the DL suspended message as described in step7. The Subsequently Accessing window can be determined/calculated by MME-NT-1 based on the pre-configuration or the parameters queried from URE before that which MME-NTs are capable of serving a given UE next time as described in Sol#25.

4. When MME-NT-1 regains ground connectivity, it shall forward the attach request, IMSI along with the interim GUTI created for this request in step3 towards MME-T. A UE having valid interim GUTI shall not reset the MM context.

5 If no UE context for the UE exists at the MME-T, and if the Attach Request (sent in step 1) was not integrity protected, or if the check of the integrity failed, then authentication and NAS security setup to activate integrity protection and NAS ciphering are carried out. The MME-T borrows the AV from HSS.

6. MME-T, after getting the authentication key from HSS, shall try to ascertain the next available satellite which can reach the UE next. When found, it shall create the Authentication NAS payload and forward it to MME-NT-2 (the next available satellite to reach UE). MME-T shall also provide the last known location of UE.

NOTE 1: The MME-T will need the information on next suitable satellite which can serve the UE in shortest possible time. This information can be provided within the PLMN, by a UE reachability Estimator (URE) (as presented in Solution #25), or from an external source.

6. When MME-NT-2 reaches the UE area, it will page the UE using either the IMSI or interim GUTI or both or UE can also reach out to RAN when seeing the new cell and reattempt the attach procedure if enters the Subsequently Accessing window. In both cases, when the UE gets RRC connected, the MME-NT shall forward the stored (in step 6) Authentication Request message to UE.

7. UE responds back with an authentication response towards MME-NT-2, which MME-NT-2 shall store it till it regains ground connection.

8. When MME-NT-2 regains connectivity with the ground station, it shall forward the stored Authentication response from UE to MME-T. MME-T validates the response.

9. If the UE is authenticated by MME-T successfully, MME-T initiates Security mode by selecting the next available satellite (as per NOTE 1) that can serve the UE next. When found, it shall relay the Security mode command to MME-NT-3 (shown as MME-NT-1 in the diagram). MME-NT-3 shall store the security mode command until it reaches the UE serving area. MME-T shall also provide the last known location of UE.

10. When the MME-NT-3 reaches the UE serving area, it shall page the UE using the interim GUTI or IMSI or both. or UE can also reach out to RAN when seeing the new cell and reattempt the attach procedure if enters the Subsequently Accessing window. When the UE becomes connected, the MME-NT-3 will forward the stored security mode command message to UE.

11. Once the UE applies the security mode, it shall acknowledge the security mode command towards MME-NT-3. MME-NT-3 shall store it till it regains the ground connection again.

12. When the MME-NT-3 regains ground connectivity, it relays the stored security mode ack message to MME-T.

13. After receiving the security mode ack from MME-NT-3, the MME-T selects a Serving GW and allocates an EPS Bearer Identity for the Default Bearer associated with the UE. Then it sends a Create Session Request (IMSI, MSISDN, MME-T TEID for control plane, PDN GW address, PDN Address, APN) message to the selected Serving GW.

14. The Serving GW creates a new entry in its EPS Bearer table and sends a Create Session Request (IMSI, MSISDN, APN, Serving GW Address for the user plane, Serving GW TEID of the user plane, Serving GW TEID of the control plane) message to the PDN GW indicated by the PDN GW address received in the previous step. (not shown in this diagram and SGW+PGW are represented as SAE GW).

15. When the create session is received from SAE-GW, the MME-T shall store till it finds the next available satellite to serve the UE next. Once found, the MME-T shall send Attach accept along with Create session response information such as user plane address and TEID to MME-NT-4. MME-T shall also provide the last known location of UE.

16. The MME-NT-4 shall store the message until it reaches the UE serving area again. When it reaches the UE serving area, it shall page the UE using the interim GUTI, IMSI or both. UE can also connect on its own if enters the Subsequently Accessing window. In either case, when the UE comes to connected state, the MME-NT-4 shall forward the message to RAN and UE. The RAN will create its PDN resources based the user plane IP and TEID information. The UE shall receive the Attach Accept, new GUTI, along with the PDN information.

17. UE shall acknowledge by sending the Attach complete message to MME-NT-4. MME-NT-4 shall store it till it regains the ground connectivity.

18. When the MME-NT-4 regains the ground connectivity, it shall forward the stored Attach complete message and uplink data if any to the MME-T.

19. After receiving Attach Complete, MME-T shall configure the PDN connection by sending a Modify bearer Request to SAE-GW by including RAN's tunnel ID and IP information. (not shown in the diagram).

NOTE 2: The UE shall support storing interim GUTI and use it to respond to Paging or while sending any initial NAS request until UE is attached to the network.

NOTE 3: MME-NT should be able to create distinct interim GUTI (one assumption is to have a distinct MME ID for each MME in satellite).

NOTE 4: MME-NTs are not keeping any security material (both AS and NAS). Integrity and ciphering are to be done at MME-T for every NAS message. This is to keep MME-NT as lightweight as possible to save precious Satellite energy resources.

NOTE 5: How to create trust between MME-T and MME-NT is up to SA WG3.

NOTE 6: Due to the dependency on paging procedures (steps 6, 10 and 16) to bring the UE into connected mode for DL signalling messages, the failure in paging will prolong the attach procedure.

NOTE 7: The DoS attack on MME-NT due to handling of integrity protected messages without owning the NAS security keys needs to be studied in SA3.

NOTE 8: According to the TS 23.401(clause 4.13) and TS 24.301 (clause 10), for the introduction of satellite support for Cellular IoT, whenever the UE is accessing the network using a satellite RAT, the MME and the UE shall set the NAS timers long enough according to this satellite RAT. However, for the Store and Forward scenarios it is expected that the NAS timers need to have much longer duration, depending on the deployment of the satellites. A more detailed analysis about the estimation of NAS timers can be considered during the normative phase, in collaboration with CT1 and RAN WGs.

Alternatively, the network can directly use the IMSI for the suspend NAS message association and paging instead of allocating a interim GUTI as above for attach procedure in the S&F operation as following Figure 6.11.3-3:



**Figure 6.11.3-3: Attach procedure in S&F using IMSI**

The basic procedure is performed similar to Figure 6.11.3-2 with following adaptations:

- In step 3: the MME-NT-1 just indicates the UE that the attach procedure is suspended due to Feeder Link being not available (i.e, doesn’t allocate interim GUTI)

- In the following step 4-16:

- the MME-NT and MME-T interacts with each other for the suspend NAS message using the IMSI and use the IMSI for the suspend NAS message association.

- the MME-NT pages the UE using the IMSI not the interim GUTI.

- after receiving the paging, the UE sends the attach recovery message using the IMSI not the interim GUTI to recover the attach, the MME-NT then sends the stored/suspend NAS message to UE (e. g, the Authentication request/ security command /attach accept).

#### 6.11.3.3 MO Data Transport in Control Plane CIoT EPS Optimisation in S&F

High level procedure of Control plane CIoT EPS optimization in Store and Forward scenario be shown as following.



Figure 6.11.3.1-1: High-level Procedure of S&F Operation for MO Data Transport in Control Plane CIoT EPS Optimisation

0. The UE is ECM-IDLE.

1. The UE establishes a RRC connection and sends as part of it an integrity protected NAS PDU. The NAS PDU carries the EPS Bearer ID and encrypted Uplink Data. The NAS PDU is relayed to the MME-NT-1 by the eNodeB using a S1-AP Initial UE message.

2. The MME-NT-1 shall store the NAS payload without integrity check or deciphering until the satellite regains ground connection.

NOTE 1: The MME-NT doesn’t need to create any UE context, rather it will transparently pass the information to MME-T. The MME-NT can optionally store RAN-S1AP ID for future transactions throughout the procedure completion.

3. The MME-NT-1 sends the NAS PDU received in step 1 to MME-T when the Satellite 1 regains ground connection.

4. The MME-T checks the integrity of the incoming NAS PDU and decrypts the data it contains.

5. If the S11-U connection is not established, the MME sends a Modify Bearer Request message for each PDN connection to the Serving GW.

6. If the Info IEs and/or UE Time Zone and Serving Network id are present in step 4, the Serving GW shall send the Modify Bearer Request message (RAT Type, MO Exception data counter) to the PDN GW.

7. The PDN GW sends the Modify Bearer Response to the Serving GW.

8. If a Modify Bearer Request message was sent at step 5 the Serving GW shall return a Modify Bearer Response (Serving GW address and TEID for uplink traffic) to the MME as a response to a Modify Bearer Request message. The Serving GW address for S11-U User Plane and Serving GW TEID are used by the MME to forward UL data to the SGW.

9. The MME sends Uplink data to the P-GW via the S-GW.

10. If the MME-T is not aware of pending MT traffic and S1-U bearers are not established, step 11 is skipped and step 13 applies.

11. If Downlink data are received in step 10, the MME-T ciphers and integrity protects the Downlink data.

12. MME-T stores the DL message until it find suitable MME-NT which can serve the UE area next.

NOTE 2: The MME-T will need the information on next suitable satellite which can serve the UE e.g., in shortest possible time. This information can be provided within the PLMN, by a UE reachability Estimator (URE) (as presented in Solution #25) or from an external source.

13a-b. Once a suitable satellite is found, the MME-T will forward the NAS DL message to MME-NT-2. If step 11 is executed then Downlink data are encapsulated in a NAS PDU and sent to the eNodeB in a S1-AP Downlink NAS Message.

14. The MME-NT-2 shall attempt to page the UE via its own RAN on-board the same satellite. The UE responds and get RRC connected.

15. The eNodeB sends a RRC Downlink data message including the Downlink data encapsulated in NAS PDU.

16. The eNodeB sends a NAS Delivery indication to the MME-NT-2 if requested, MME-NT-2 shall store the "S1-AP NAS Non Delivery Indication" till it regains ground connection.

17. When ground connectivity is available for MME-NT-2, it will deliver the stored delivery indication NAS message to MME-T.

NOTE 3: According to the TS 23.401(clause 4.13) and TS 24.301 (clause 10), for the introduction of satellite support for Cellular IoT, whenever the UE is accessing the network using a satellite RAT, the MME and the UE shall set the NAS timers long enough according to this satellite RAT. However, for the Store and Forward scenarios it is expected that the NAS timers will have much longer duration, depending on the deployment of the satellites. A more detailed analysis about the estimation of NAS timers could take place during the normative phase, in collaboration with CT1 and RAN WGs.

#### 6.11.3.4 Connection Suspend and Resume Procedure



Figure 6.11.3.4-1: Connection Suspend and Resume procedure

0. The UE is in RRC connected and ECM-Connected.

1. The eNodeB(RAN-1) in first satellite initiates the Connection Suspend procedure.

2. The eNodeB(RAN-1) indicates to the MME-NT-1 that the UE's RRC connection is to be suspended. Data related to the S1AP association, UE Context and bearer context, necessary to resume the connection is kept in the eNodeB(RAN-1), UE and the MME-NT-1.

3. eNodeB (RAN-1) sends RRC message to suspend the RRC Connection towards the UE, as described in TS 36.300.

4. The MME-NT-1 transmits the S10 “UE Context Suspend notification” message including UE context information (bearer context, AS security context and resume ID) to the ground MME (MME-T).

5. The MME-T stores the UE context information that can be retrieved once the MME-T finds a suitable satellite containing MME-NT which can reach the UE. MME-T marks the UE as ECM-idle, but the data related to the S1AP association, UE Context and bearer context are kept intact, which is necessary to resume the connection between the UE and a satellite (that will resume the connection with the UE)

6. The MME-T sends a Release Access Bearers Request message to the Serving GW that requests the release of all S1-U bearers for the UE.

7. The Serving GW releases all eNodeB related information (address and downlink TEIDs) for the UE and responds with a Release Access Bearers Response message to the MME. Other elements of the UE's Serving GW context are not affected. If downlink packets arrive for the UE, the Serving GW starts buffering downlink packets received for the UE and initiating the "Network Triggered Service Request" procedure, described in clause 5.3.4.3 in TS 23.401. The Serving GW informs the MME in the Release Access Bearer Response message about release of S1-U bearers.

8. The MME-T determines which non-terrestrial network element(s) (i.e., satellite(s)) could provide coverage to the UE. The MME-T, according to identified satellites (e.g. MME-NT-2), triggers the resume notification procedure for one or more satellites.

NOTE 1: The MME-T will need the information on next suitable satellite which can serve the UE in shortest possible time. This information can be provided within the PLMN, by a UE reachability Estimator (URE) (as presented in Solution #25), or from an external source.

9. The MME-T transmits an S10 “UE Context Resume notification” message to the MME-NT-2 including UE context information, resume ID to assist the resume of the connection of the UE, DL tunnel information of S-GW towards the selected satellites (e.g., Satellite 2) and E-RAB request to create tunnel resources in RAN.

10. The MME-NT-2 transmits to the eNodeB(RAN-2) UE Context Resume notification. The eNodeB(RAN-2) creates the access network bearers to receive the DL traffic from the S-GW and to store the UE Context information and resume ID for the UE resumption procedure once Satellite 2 can provide coverage/connection service to the UE. RAN-2 creates necessary UL U-plane resources.

11-12. The RAN-2 creates the UE context for resuming UE. RAN-2 shall send an acknowledgement to notify on the resumption of context towards MME-NT2

13. The MME-NT2 transmits to the MME-T confirmation that the access bearer has been established, providing access network tunnel information (S1 TEID(s) (DL)) for the provision of the DL traffic from the S-GW to the eNodeB (RAN-2).

14. The MME-T sends a Modify Bearer Request message to the Serving GW including the access network tunnel information of eNodeB (RAN-2) that requests to to establish the user plane with the eNodeB (RAN-2).

15. The Serving GW sends the Modify Bearer Response to the MME-T.

14. The S-GW transmits the buffered DL packets to the eNodeB(RAN-2). The RAN-2 shall store it against the UE context until the RRC resume operation is not complete. The MME can trigger paging via RAN-2 to indicate DL stored data.

15. The UE, once is under the coverage of the eNodeB(RAN-2) or on receipt of paging, triggers the RRC Connection Resume procedure including information needed by the eNodeB (RAN-2) to access UE's stored AS context, according to the Connection Resume procedure in TS 36.300

NOTE 2: In case of no paging from MME, how the UE determines the next available RAN for RRC context resume is up to the UE implementation and/or RAN.

6.11.3.X MT Data Transport in Control Plane CIoT EPS Optimisation in S&F

Figure 6.11.3.X-1 depicts a high-level Procedure of S&F Operation for MT Data Transport in Control Plane CIoT EPS Optimisation.



**Figure 6.11.3.4-1: High-level Procedure of S&F Operation for MT Data Transport in Control Plane CIoT EPS Optimisation**

0. The UE is ECM-IDLE.

1. PGW sends the downlink data to the SGW. SGW buffers the downlink data packet.

2. If the Serving GW is buffering data in step 1, SGW sends a Downlink Data Notification message to MME-T. The MME responds to the SGW with a Downlink Data Notification Ack message.

3. When there is available MME-NT (MME-NT-1), the MME-T establish the S11-U with SGW. The MME sends the Modify Bearer Request message (MME address, MME TEID DL) to SGW.

4. SGW responds to the MME-T the Modify Bearer response (Serving GW address and TEID for uplink traffic).

5. Buffered Downlink data is sent by the S-GW to the MME-T.

6. MME-T encrypts and integrity protects Downlink data

7. MME-T sends DL data to MME-NT-1 with UE context using the S10 message to the MME-NT-1.

8. The MME-NT-1 creates the temporary UE context for the ciphered DL data associated with the GUTI.

9. The MME-NT-1 attempts to page the UE via its own eNB on-board on the same satellite.

10. The UE responds and get connected.

11. The MME-NT-1 sends the DL data using the DL S1-AP msg to the eNB.

12. eNB forwards the DL data to the UE.

13. eNB responds to the MME-NT-1 of the NAS delivery notification.

14. When ground connectivity is available for MME-NT-1, it will deliver the stored NAS delivery notification message to MME-T.

#### 6.11.4 Impacts on services, entities and interfaces

**UE:**

- NAS impact to handle larger delay due to S&F mode of operation.

- NAS impact due to new interim GUTI allocation.

**MME-T:**

- Handling of new S10 messages to carry both ciphered and plain text NAS messages to/from MME-NTs.

- Transmits Resume notification messages to MME-NT, in case of connection Suspend and Resume procedure.

**MME-NT:**

- Handling of new S10 messages to carry both ciphered and plain text NAS messages to/from MME-T.

- Handling of plain text NAS and NGAP messages on behalf of MME-T.

- Transmits Suspend notification messages to MME-T, in case of connection Suspend and Resume procedure

\*\*\* End of Change \*\*\*