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**Title: Update Solution#22 for addressing the Editor's note**

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*Abstract: Updating Solution#22 in 3GPP TR 23.700-29 to support multiple satellites and Data Transmission.*

# 1. Introduction/Discussion

This proposal is the revised version of unhandled contribution (S2-2401922) in SA2#161. This contribution updates to Solution#22 in 3GPP TR 23.700-29 to address the Editor's note and support Data Transmission including:

- procedure for provision of available communication information;

- MO/MT data transmission procedures and MO SMS delivery procedure for scenario of single satellites serving a UE;

- UE context synchronization among multiple satellites, MO/MT SMS delivery and MO/MT data transmission procedures for scenario of multiple satellites serving a UE.

# 2. Text Proposal

It is proposed to update the following revisions of clause 6.22.1, 6.22.2, 6.22.3.1, 6.22.3.2, 6.22.3.3 and 6.22.4, and add new clause 6.22.3.3A, 6.22.3.4 and 6.22.3.5 in 3GPP TR 23.700-29.

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

## 6.22 Solution#22 for Key Issue #2: Support of Store and Forward Satellite operation for SMS and Data Transmission

### 6.22.1 Introduction

This solution corresponds to KI#2 to enable SMS and data transmission services with store and forward satellite operation. It supports one satellite serving a UE (Scenario1) and Multiple satellites serving a UE (Scenario 2).

### 6.22.2 Description

This solution is applicable for the satellite architecture for SMS in MME and data transmission in Control Plane CIoT EPS Optimisation, as shown in figure below, based on the architectures in Annex C of TS 23.272 and TS 23.401.

The core network elements deployed on satellite include:

* MME: An on-board MME can be used to store MO/MT SMS and MO/MT data in Control Plane CIoT EPS Optimisation. The MME forwards MO SMS/MO data to S-GW/SMS-IWMSC when the feeder link is detected as available based on e.g. the ephemeris information and connectivity information of feeder link. The MME forwards MT SMS/MT data to UE when the service link to UE is available based on e.g. the ephemeris information and UE location.

NOTE: The mechanism proposed in this contribution can also apply for SMS over SGs, for example, MSC is deployed with MME on the satellite.



Figure 6.22.2-1: Satellite Architecture for SMS and data transmission

There could be two scenarios to offer UE services over satellite access.

* Scenario 1: Only one satellite serves a UE and different satellites serve different UEs. Only the satellite serving the UE needs to retain UE context, rather than requiring multiple satellites to retain UE context. Each satellite does not need a large capacity since different UEs contexts are distributed within different satellites. However, the UE must wait coverage from the serving satellite for MO/MT signaling or data.
* Scenario 2: Multiple satellites serve a UE. The multiple satellites could provide services to UE therefore reducing service delivery delay. However, synchronization of UE context among multiple satellites is necessary before serving a UE, and typically, one satellite maintaining contexts for all UEs needs large capacity of satellite, e.g. storage for all UEs context and processing for synchronization.

For the procedures outlined in this solution, clause 6.22.3.1 applies to both Scenario 1 and Scenario 2. Clause 6.22.3.2, 6.22.3.3, 6.22.3.3A and 6.22.3.4 apply to Scenario 1. Clause 6.22.3.5 applies to the Scenario 2, by specifying enhancement on the mechanisms of 6.22.3.2, 6.22.3.3, 6.22.3.3A and 6.22.3.4 to support multiple satellites.

It is assumed that the UE attaches to the EPS network in S&F operation mode by using other solutions, e.g. Solution#11, 12, 13 and 15 described in other chapters.

The following general mechanisms are used by this solution to support store and forward satellite operation for both Scenario 1 and Scenario 2.

* Since the NFs on-board satellite do not always have continuous feeder link connected to ground, if ground NFs do not know the availability communication information, including when NFs on-board satellite can communicate with and the corresponding connection information, DL signalling or data destinated to on-board NFs may fail and/or be retransmitted multiple times. In order to eliminate the impact on DL data and DL signalling including SMS, the on-board NF should provide the availability communication information to the ground NF. Specifically, the on-board NF (e.g. MME) can determine the availability communication information based on the ephemeris information and connectivity information of feeder link. When the satellite is connected to the ground via feeder link, the on-board NF can send the availability communication information to the ground NF (e.g. HSS and S-GW). Detailed procedure is described in clause 6.22.3.1.

For Scenario 1 with different satellites serving different UEs, the following mechanisms apply:

* Before the UE decides to establishes connection to the current E-UTRAN onboard satellite for UL services, e.g. UL signalling/SMS or Data, the UE determines whether the current E-UTRAN onboard satellite can provide services for UE, based on comparation of the information provided before by MME and the broadcast information of the E-UTRAN. If not then the UE waits another applicable E-UTRAN onboard satellite.
* The E-UTRAN onboard satellite broadcasts the information according to the information provided by the connected MME. MME can provide this information to E-UTRAN during S-1 setup procedure. This information can be e.g. GUMMEI.
* During the completion of the Attachment, UE obtains this information from the MME. It can be e.g. GUMMEI derived from GUTI. When the UE needs to start Initial Attach the UE does not care the the broadcast information of the E-UTRAN. It means the UE can access any E-UTRAN onboard satellite for Initial Attachment.

The following general mechanisms are used by this solution to support Scenario 2.

* UE context synchronization among multiple satellites (MMEs) can be achieved through a synchronization system e.g. OAM, which is out of scope of 3GPP. The synchronization system only control the entities onboarding the Satellite, not the network entities on the ground.
* The HSS stores information of multiple MMEs toward UE, i.e. the HSS is aware of the list of MMEs which can serve the UE, along with MME availability communication information.
* The S-GW stores information of multiple MMEs toward UE, i.e. the S-GW is aware of the list of MMEs which can serve the UE, along with MME availability communication information.
* In order to ensure that multiple on-board network elements retain the context of the UE, upon receiving the Update Location Request message from the new MME, the HSS does not trigger the Cancel Location procedure to the old MME if it is multiple satellites serving a UE.

The following mechanisms are used by this solution to support SMS with store and forward satellite operation. If not specified, it applies to both Scenario 1 and Scenario 2.

When the ground NF (e.g. HSS) knows that there is a DL signalling to be sent, it determines whether the DL signalling/SMS can be sent to on-board NF (e.g. MME) based on the stored available communication information of the on-board NF. For MT SMS, the HSS can return a failure report or the address of MME to the SMS-GMSC and the detailed description is described in clause 6.22.3.2.

After the MME receives MT SMS from SMS-GMSC, MME decides two options, as further detailed in clause 6.22.3.3:

- Option A: The MME stores the MT SMS received from SMS-GMSC and forwards it to UE later when the UE can be reached.

- Option B: The MME rejects the MT SMS received from SMS-GMSC. The MME can receive the MT SMS again from SMS-GMSC at a future given time when the MME approaches the UE, then the MME performs Option A. This policy aims to economically utilize the costful storage resource on satellite. For Scenario 2, a more appropriate MME may be identified to handle the MT SMS. Then the MT SMS is sent to the new MME and subsequently Option A is performed.

The following mechanisms are used by this solution to support data transmission with store and forward satellite operation. If not specified, it applies to both Scenario 1 and Scenario 2.

* When S-GW receives the MT data from P-GW, it determines whether the MT data can be sent to on-board MME or be buffered locally based on the stored availability communication information of the MME.
* When receiving Downlink Data Notification message from S-GW, the MME responds to S-GW either indicating its readiness to receive MT data, or requesting the S-GW to buffer MT data if the MME determines to handle it at a future given time, or a more appropriate MME is identified to handle the MT data for Scenario 2.

### 6.22.3 Procedures

#### 6.22.3.1 Provision of available communication information

This procedure is used to inform the ground NFs about the availability communication information.

The availability communication information can be transmitted by on-board NFs to ground NFs at the node level once the feeder link is available. The per-node messages are transmitted through interfaces e.g. S6a between the MME and HSS, and S11-C between the MME and S-GW. The detailed procedure is assumed to be defined by CT.

This available communication information indicates the period of time when the on-board NFs can be communicated with the ground NFs and the corresponding connection information. It may have the following forms:

* the available communication time at present, which can be represented by the end time (UTC) or duration of the current communication period, and the corresponding connection information, e.g. MME Number for MT SMS and MME IP address for S11-C.
* all the available communication time intervals and all the connection information, e.g. MME Number for MT SMS and MME IP address for S11-C, within a certain long period of time (24 hours).

#### 6.22.3.2 MT SMS Delivery procedure related to HSS

This procedure is used when the HSS knows there is an MT SMS to be sent from SMS-GMSC to UE.



Figure 6.22.3.2-1: MT SMS Delivery procedure related to HSS

1. The UE attaches or performs Tracking Area Update to EPS network via Regenerative-based satellite access, which supports store and forward operation. The on-board MME may provide available communication information to ground HSS through the procedure defined in clause 6.22.3.1.
2. The SC initiates transfer of MT SMS.
3. The HSS is requested to retrieve the routing information for routing the MT SMS to the MME.
4. When receiving Send Routing Info for SM Request message, the HSS is aware that an MT SMS needs to be delivered to the UE. The HSS determines whether the MT SMS can be sent to on-board MME, based on the stored available communication information.

Case 1: Forward the MT SMS.

5a. The HSS responds to the SMS-GMSC with the addresses of the serving nodes that are registered for MT SMS.

6a. The SMS-GMSC forwards the MT SMS message to the MME.

7a. Perform MT SMS Delivery procedure related to MME as specified in clause 6.22.3.3.

Case 2: Forward the MT SMS at a correct time.

5b. The HSS returns the failure information within the Send Routing Info for SM Answer message.

6b. The SMS-GMSC sends a failure report to SC.

7b. The HSS determines the correct time when the MT SMS can be sent based on the available communication information of the MME.

8. The HSS sends an Alert-SC message to the SMS-GMSC. Then a SC-Alert message is sent by SMS-GMSC to the SC.

9-10. The messages are same as steps 2-3.

11. Perform step 4 and steps 5a-7a as defined in Case 1.

#### 6.22.3.3 MT SMS Delivery procedure related to MME

This procedure is used after the MME receives a MT SMS from SMS-GMSC when the satellite is connected to the ground via feeder link.



Figure 6.22.3.3-1: MT SMS Delivery procedure related to MME

1. The MME receives the MT SMS and determines which option to perform. The MME can store the MT SMS received from SMS-GMSC and forwards it to UE later as described in Option A. The MME can reject the MT SMS received from SMS-GMSC. The MME receives the MT SMS again from SMS-GMSC at a future given time when the MME approaches the UE, as described in Option B. This policy aims to economically utilize the costful storage resource on satellite.

Option A: The MME performs S&F for SMS.

2a. The MME stores the MT SMS.

3a. The MME determines to send the MT SMS to the UE at the time when the satellite can cover the UE, e.g. based on the locations of the UE.

4a. The MME pages the UE. If the UE is in the ECM-IDLE state, upon reception of paging message from MME, the UE triggers Service Request procedure.

5a. The MME encapsulates the MT SMS in a NAS message and sends the message to the UE.

6a. The UE acknowledges receipt of the MT SMS to the MME.

7a. The UE sends the delivery report to the MME via the UL NAS Transport message.

If the UE has an MO SMS, it can encapsulate the MO SMS in a UL NAS message.

8a. The MME stores the MO SMS or the delivery report.

9a-10a. The delivery report or MO SMS message is transmitted to the destination SC, e.g. via SMS-GMSC or SMS-IWMSC when the satellite is connected to the ground via feeder link.

Option B: The MME performs S&F for SMS at a future given time.

3b. The MME sends a failure report.

4b. Upon reception of the failure report, the SMS-GMSC requests the HSS to add an SC address to the MWD by sending SM-DeliveryReportStatus message.

5b. The SMS-GMSC, in parallel with step 4b, sends a failure report to the SC.

6b. The MME determines when the MT SMS can be received again, e.g. when MME is approaching to UE, in order to economically utilize the costful storage resource on satellite.

7b. The MME sends a Notify Request message to HSS notifying that the MME is reachable. Then an Alert-SC message is sent by HSS to the SMS-IWMSC indicating that the MME (not the UE) is now available for MT SMS delivery. The SMS-GMSC forwards an SC-Alert message to SC.

8b. The MT SMS is sent from SC/SMS-GMSC to MME following existing procedures.

9b. After receiving MT SMS, then the MME performs Option A.

#### 6.22.3.3A MO SMS Delivery procedure



Figure 6.22.3.3A MO SMS Delivery procedure

1. The UE is ECM-IDLE.
2. When the UE needs to send MO SMS and there is an available service link to serve the UE, the UE establishes connection to E-UTRAN and MME and the MO SMS is received by MME.

For Scenario 1 with different satellites serving different UEs, the UE determines whether the current E-UTRAN onboard satellite can provide services for UE, based on comparation of the information provided before by MME and the broadcast information of the E-UTRAN, as described in 6.22.2.

1. The MME stores MO SMS until the feeder link is available.

3-4. When the feeder link is available, the MO SMS is forwarded to SC and a Delivery Report message is received by MME. The MME stores the Delivery Report until the service link is available.

5. When the service link is available, MME sends Delivery Report to UE following existing procedures.

#### 6.22.3.4 MT/MO data transmission



Figure 6.22.3.4-1: MT data transmission in S&F operation mode

1. The UE is EPS attached and in ECM-Idle mode.
   1. The P-GW sends the DL data to S-GW received from SGi, e.g. from Application Server. The S-GW determines whether the DL data can be sent to on-board MME, based on the stored availability communication information of MME. The S-GW buffers DL data, if the on-board MME is unavailable.
2. If the S-GW is buffering data in step 2, when the feeder link between satellite and the ground is available, the S-GW sends the Downlink Data Notification message to the MME serving UE when it is Control Plane CIoT EPS Optimisation, based on the stored connection information, e.g. MME IP address for S11-C. The TEID of an MME for a given UE remains unchanged across different feeder links.
3. If the MME determines not to handle the DL data this time, e.g. due to restricted and costful storage resource on satellite, the MME responds to the S-GW with a Downlink Data Notification ACK message, including the indication for Downlink Buffering Requested and the Downlink Buffering Duration time, in order to delay the DL data transmission.
4. The bearer modification procedure is performed.

6-7. Buffered Downlink data is sent by the S-GW to the MME and MME stores the Downlink data.

1. When the service link is available, the UE is paged by E-UTRAN/MME if the UE is in the ECM-IDLE state. The MME can determine the paging time, e.g. based on the locations of the UE.
2. Steps 12-21 in clause 5.3.4B.3 of TS 23.401, if it is Control Plane CIoT EPS Optimisation, are performed. Then the DL data stored in MME is sent to UE.



Figure 6.22.3.4-2: MO data transmission in S&F operation mode

1. The UE is ECM-IDLE.
2. When the UE needs to send UL data and there is an available service link to serve the UE, the UE establishes connection to E-UTRAN and MME for Control Plane CIoT EPS Optimisation and the UL data is received by MME, as specified in clause 5.3.4B.2 of TS 23.401, if it is Control Plane CIoT EPS Optimisation.

For Scenario 1 with different satellites serving different UEs, the UE determines whether the current E-UTRAN onboard satellite can provide services for UE, based on comparation of the information provided before by MME and the broadcast information of the E-UTRAN, as described in 6.22.2.

1. The MME stores the UL data until the feeder link is available.
2. When the feeder link is available, other steps defined in clause 5.3.4B.2 of TS 23.401 are performed. Then the stored UL data is sent to S-GW.

#### 6.22.3.5 Support for multiple satellites serving a UE

##### 6.22.3.5.1 UE context synchronization among multiple satellites



Figure 6.22.3.5.1-1: UE context synchronization among multiple satellites serving a UE

1. UE attaches to EPS network via MME on-board Satellite #1 by using other solutions, e.g. Solution#11, 12 and 15, described in other chapters.
2. During the attachment, when the feeder link is available, the MME on-board Satellite #1 performs location updating and session creation procedures with ground HSS and ground S-GW, respectively. The on-board MME can include a mutiple-MMEs support indication in e.g. Update Location Request message and Create Session Request message to the HSS and S-GW, respectively. The HSS and S-GW are aware that the MME on-board Satellite #1 serves the UE and store the list of MMEs serving the UE to support Multiple satellites serving a UE (Scenario 2).

If the UE moves from legacy network(e.g. TN network) to NTN network supporting S&F operation, then the HSS shall perform Cancel Location procedure towards the old MME in legacy network, since the old legacy MME did not include mutiple-MMEs support indication during the previous Update Location Request procedures.

1. After attach completion, multiple satellites synchronize information, including UE context, through a Synchronization System, e.g. OAM. The synchronization may also take place during the attach procedure.
2. If another satellite, e.g. Satellite #2, serving the UE connects to ground then MME on-board Satellite #2 may perform location updating and bearer modification procedures. The on-board MME can include a mutiple-MMEs support indication within e.g. Update Location Request message and Modify Bearer Request message to the HSS and S-GW, respectively. The HSS and S-GW are aware that the MME on-board Satellite #2 serves the UE and update the list of MMEs serving the UE to support Multiple satellites serving a UE (Scenario 2). The HSS does not trigger Cancel Location procedure to the old MME on-board Satellite #1, as described in clause 6.22.2.

If the UE moves to a new legacy network, e.g. TN network that does not supporting S&F operation, the MME in the legacy network shall send Update Location Request and Create Session Request following existing procedures. Then the HSS shall store the new MME information serving UE and perform Cancel Location procedure towards the old MMEs in S&F NTN network. If the SGW is not changed, then the SGW shall remove all the context of the old MMEs within the S&F supporting NTN network.

NOTE: If there maybe a NTN network supporting S&F operation where not all the satellites can serve a UE because of the specific satellite constallation. When UE moves to a new area within the NTN network, the UE performs Tracking Area Update due to TA change, then the new MME on the satellite serving the new area performs step 2 and MMEs list in the HSS is updated accordingly. The old MME serving the old area shall remove itself from the MMEs list in the HSS by sending purge message including mutiple-MMEs support indication to HSS, based on controll of the synchronization system.

##### 6.22.3.5.2 MT/MO SMS delivery procedure

MT SMS delivery procedure for Scenario 2 is performed by reusing the MT SMS delivery procedure for Scenario 1 in 6.22.3.2 and 6.22.3.3 with the following enhancements:

- In step 4 of clause 6.22.3.2, the HSS determines one MME within the list stored in HSS, to be responsible for sending MT SMS to the UE, based on the list of MMEs serving UE and the availability communication information. Then the HSS sends MME Number for MT SMS to SMS-GMSC.

- In step 1 of clause 6.22.3.3, the MME can determine whether to process the MT SMS. If not, a new MME, e.g. the one capable of providing service to the UE most quickly, is identified via e.g. synchronization system, to handle the MT SMS. Then the old MME performs steps 3b-5b and the new MME performs steps 6b-9b in clause 6.22.3.3.

MO SMS delivery procedure in S&F operation mode for Scenario 2 can reuse the procedure for Scenario 1 defined in clause 6.22.3.3A.

##### 6.22.3.5.3 MT/MO data transmission procedure

MT data transmission procedure for the Scenario 2 is performed by reusing the MT data transmission procedure for Scenario 1 defined in clause 6.22.3.4, with the following enhancements:

* In step 2 of Figure 6.22.3.4-1, the S-GW determines one MME within the list stored in S-GW, to be responsible for sending MT data to the UE, based on the list of MMEs serving UE and the availability communication information. Then the S-GW sends Downlink data Notification message to the MME.
* In step 4 of Figure 6.22.3.4-1, the MME can determine whether to process the MT data. If not, a new MME, e.g. the one capable of providing service to the UE most quickly, is identified via e.g. synchronization system, to handle the MT data. Then the new MME performs steps 5-9 in Figure 6.22.3.4-1.

MO data transmission procedure in S&F operation mode for Scenario 2 can reuse the MO data transmission procedure for Scenario 1 defined in clause 6.22.3.4.

### 6.22.4 Impacts on services, entities and interfaces

The following impacts are foreseen by this solution:

MME:

* The MME determines the available communication information and provides it to the ground NFs (e.g. HSS and/or S-GW) at the node level.
* Upon reception of an MT SMS from SMS-GMSC,the MME decides to store and forward it this time, or rejects it and then receives the MT SMS again at a future given time, based on policy. For Scenario 2, the MME responsible for delivering MT SMS to UE may be changed through e.g. synchronization system
* Upon reception of an DL data Notification message from S-GW, the MME decides to receive this time or at a future given time, based on policy. For Scenario 2, the MME responsible for delivering MT data to UE may be changed via e.g. synchronization system.
* The MME stores MT SMS/MO SMS, and forwards it to UE/SMS-IWMSC when the UE/SMS-IWMSC can be reached later.
* The MME stores MT data/MO data, and forwards it to UE/S-GW when the UE/S-GW can be reached later.
* The MME determines to page the UE at appropriate time and/or location if there are MT SMS or MT data.
* Synchronization of UEs EPS context information among multiple MMEs by synchronization system, e.g. OAM.

HSS:

* The HSS receives the available communication information from on-board NF (e.g. MME) at the node level.
* The HSS determines whether the DL singalling can be sent to on-board NF (e.g. MME) based on the available communication information of the on-board NF.
* For MT SMS, the HSS determines to forward MT SMS, or rejects it and forwards it at a correct time based on the avaiable communication information.
* The HSS stores the list of MMEs serving the UE along with the corresponding availability communication information for multiple MMEs. Upon receiving the Update Location Request message from the new MME, the HSS does not send a Cancel Location message to the old MME for Scenario 2.

S-GW:

* The S-GW receives the availability communication information from on-board NF (e.g. MME) at the node level.
* The S-GW determines whether the MT data can be sent to on-board NF (e.g. MME) or be buffered locally based on the availability communication information of the on-board NF.
* The S-GW stores the list of MMEs serving the UE along with the corresponding availability communication information for multiple MMEs.

UE:

* Determines whether the current E-UTRAN onboard satellite can provide UL services for UE, based on the broadcast information of the E-UTRAN, in case of Scenario 1 with different satellites serving different UEs.

E-UTRAN onboard satellite:

* Broadcasts the corresponding information provided by the connected MME, in case of Scenario 1 with different satellites serving different UEs.

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