**SA WG2 Meeting #162 S2-2405017**

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**Title: KI#2, Sol#18 update to resolve the ENs**

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*Abstract of the contribution: This paper proposes to update the Solution#18 to resolve the ENs.*

# 1 Discussion

This paper proposed to update Solution#18 to address the following ENs:

Editor's note: how the onboard HSS is synchronized with the HSS on the ground is FFS.

Editor's note: how to address the multiple satellites deployment use case is FFS.

In order to distinguish the onboard HSS and the HSS on the ground, the Local Subscriber Server (LSS) is used to represent the HSS on the ground in this paper. The LSS is an HSS on the ground with following enhancements:

* The UE state (e.g. EMM state) and UE context are stored in the LSS.
* The LSS interacts with the onboard MME to synchronize the UE states and UE context when feeder link is available.

It is assumed that a subset of UEs have their subscriptions and credentials in the onboard HSS. Different satellite stores distinct subscriptions and credentials for different subsets of UEs. If the UE accesses a satellite which has its subscription and credentials, the UE can proceed to attach, otherwise the attach request is rejected due to the lack of UE subscription and credentials. Besides, the satellite can record the IMSI for the UEs whose attach request is rejected, and retrieve the subscriptions and credentials for the rejected UEs when the feeder link is available, and then the UE can access the satellite and tries to attach again when the service link become available.

The onboard MME can synchronize the UE states and UE context with LSS when feeder link is available. For instance, After the attach procedure without PDN Connectivity is complete, the UE shall enter EMM-REGISTERED state in the MME onboard satellite-1, and then when the feeder link become available, the UE state (e.g. EMM-REGISTERED) and UE context for UE-1 is stored in the LSS. After that, based on the UE-1’s location and the Ephemeris information of satellite-2, the LSS can send the UE-1’s state (e.g. EMM-REGISTERED) and UE context to the MME onboard satellite-2 when the feeder link is available.

# 2 Proposal

It is proposed to include the following changes in TR 23.700-29.

**\* \* \* \* Start of Changes (All text new) \* \* \* \***

6.18 Solution #18: Attach Procedure with MME and HSS on board the satellite

6.18.1 Description

This solution address key issue#2.

In order to support the attach under the S&F Satellite operation, the proposed solution follows the assumptions and principles as below:

* The eNB, MME and HSS are placed on board the same satellite.
* The eNB on board satellite broadcasts that it is in S&F satellite operation mode;
* The UE has a subscription and credentials in the onboard HSS, the onboard HSS is synchronized with the HSS on the ground when feeder link is available.

NOTE: For the UE in roaming case, i.e. there is no subscription and credentials for the H-PLMN stored in the onboard HSS, the MME onboard will reject the attach request and fetch the subscription and credential for the rejected UE from the HSS in HPLMN when the feeder link become available, as described in clause 6.18.2.2 or other methods captured in Sol#14,15.

Given the above assumption, the following procedures involved eNB, MME and HSS can be completed when the service link is available, no matter what the status of feeder link is:

* the negotiation between UE and MME regarding the capability to support S&F satellite operation;
* the authentication and NAS security can be accomplished when service link is available.

Therefore, if a UE has set "Attach without PDN Connectivity is supported" in the Preferred Network behaviour during attach procedure and the network has acknowledged its support to the UE, the initial attach procedure without PDN Connectivity can be completed when the service link is available.

If the UE also wants to establish a PDN connectivity during the attach procedure, this solution proposed to attach the UE to the MME and complete the NAS procedure without setting up GTP-C tunnels between the MME and SGW/PGW when service link is available. After the feeder link become available, the GTP-C tunnels can be established. In this case, only Control Plane CIoT EPS Optimisation is considered, and PDN connection only use the Control Plane CIoT EPS Optimisation, i.e. the MME includes a Control Plane Only PDN Connection Indicator in Create Session Request.

A new network function, the Local Subscriber Server (LSS), is introduced to integrate an HSS on the ground with following enhancements:

* The UE state (e.g. EMM state) and UE context are stored in the LSS.
* The LSS interacts with the onboard MME to synchronize the UE states and UE context when feeder link is available.

It is assumed that a subset of UEs have their subscriptions and credentials in the onboard HSS. Different satellite stores distinct subscriptions and credentials for different subsets of UEs. If the UE accesses a satellite which has its subscription and credential, the UE can proceed to attach, otherwise the attach request is rejected due to the lack of UE subscription and credential. Besides, the satellite can record the IMSI and current TAI for the UE whose attach request is rejected, and retrieve the subscription and credentials for the rejected UE c, and then the UE can access the satellite and tries to attach again when the service link become available. Besides, based on the ephemeris and current TAI of the rejected UE, LSS may also synchronize the rejected UE’s subscription and credentials with other satellites that may cover the rejected UE.

The onboard MME can synchronize the UE states and UE context with LSS when feeder link is available. For instance, After the attach procedure without PDN Connectivity is complete, the UE shall enter EMM-REGISTERED state in the MME onboard satellite-1, and then when the feeder link become available, the UE state (e.g. EMM-REGISTERED) and UE context for UE-1 is stored in the LSS. After that, based on the UE-1’s location and the Ephemeris information of satellite-2, the LSS can synchronize with MME onboard satellite-2 the UE-1’s state (e.g. EMM-REGISTERED) and UE context when the feeder link is available.

6.18.2 Procedures

#### 6.18.2.1 Procedures for E-UTRAN Attach in case the onboard HSS holds subscription and credentials for the UE

The procedure for E-UTRAN Attach under the S&F Satellite operation in case the onboard HSS holds subscription and credentials for the UE is shown in the Figure 6.18.2-1.



**Figure 6.18.2-1: Attach Procedure under the S&F Satellite Operation in case the onboard HSS holds subscription and credentials for the UE**

0. When service link is available, the eNB broadcasts that it is in the S&F satellite operation mode.

1. If the UE has the capability to support the S&F satellite operation, it initiates the Attach procedure by the transmission, to the eNB, of an Attach Request Message. In addition to the required parameters as specified in clause 5.3.2.1 of TS 23.401 [5], the UE also indicates its capability to support the S&F satellite operation in the Attach Request message.

2. The eNB forwards the Attach Request message to MME as specified in clause 5.3.2.1 of TS 23.401 [5]. MME checks if the UE has the capability to support the S&F satellite operation, if not, rejects the Attach Request with an appropriate cause value.

3. If the UE has its subscriptions and credentials in the onboard HSS, Authentication and NAS security is performed as specified in clause 5.3.2.1 of TS 23.401 [5].

4. MME sends an Attach Accept message to the eNB in the S1-AP Initial Context Setup Request message or DL NAS Transport message. In addition to the required parameters as specified in clause 5.3.2.1 of TS 23.401 [5], MME indicates its capability to support the S&F satellite operation in the Attach Accept message. And then, the eNB forwards the Attach Accept message to the UE. If the UE has not included the ESM message container in the Attach Request in step 1, the following steps are skipped. If the UE has included the ESM message container in the Attach Request in step 1, the MME allocates an EPS Bearer Identity for the Default Bearer associated with the UE. The EPS QoS info can be set to the default value received from the HSS.

5. The UE sends the Attach Complete message to MME. The MME enters the EMM-REGISTERED for the UE.

6. When the feeder link is available, the MME synchronizes the UE states and UE context with LSS. The MME sends the UE states (e.g. EMM-REGISTERED) and UE context to the LSS.

6a. If there’s another satellite that doesn’t holds the UE context for the registered UE. Based on the ephemeris and UE location (e.g. the current Tracking Area List) , LSS may determine to synchronize the UE states (e.g. EMM-REGISTERED), UE context, and credentials with such satellite for the possible data transmission.

7. If the UE has included the ESM message container in the Attach Request in step 1, when feeder link is available, MME sends a Create Session Request message and a Modify Bearer Request message to the SGW as specified in clause 5.3.2.1 of TS 23.401 [5].

8. The SGW sends a Create Session Request message and a Modify Bearer Request message to the PGW as specified in clause 5.3.2.1 of TS 23.401 [5].

9. The PGW returns a Create Session Response message and a Modify Bearer Response message to the SGW as specified in clause 5.3.2.1 of TS 23.401 [5].

10. The SGW returns a Create Session Response message and a Modify Bearer Response message to the MME as specified in clause 5.3.2.1 of TS 23.401 [5].

11. The DL data can be sent from S/PGW to MME. The MME receives and stores the DL data for the UE.

12. When the service link is available, i.e. the satellite covers the tracking area(s) in which the UE is registered, the MME sends a paging message to the eNB. If eNB receive the paging message from the MME, the UE is paged by the eNB.

13. UE establishes a radio bearer for DL data transmission.

14. A S1-MME path is established for DL data transmission.

15. The MME sends the DL data to the UE.

16. The UL data can also be sent to the MME.

#### 6.18.2.2 Procedures for E-UTRAN Attach in case no subscription and credentials for the UE is stored in the onboard HSS

The procedure for E-UTRAN Attach under the S&F Satellite operation in case no subscription and credentials for the UE is stored in the onboard HSS is shown in the Figure 6.18.2-2.



**Figure 6.18.2-2: Attach Procedure under the S&F Satellite Operation in case no** **subscription and credentials for the UE is stored in the onboard HSS**

1. When service link is available, the eNB broadcasts that it is in the S&F satellite operation mode.
2. If the UE has the capability to support the S&F satellite operation, it initiates the Attach procedure by the transmission, to the eNB, of an Attach Request Message. In addition to the required parameters as specified in clause 5.3.2.1 of TS 23.401 [5], the UE also indicates its capability to support the S&F satellite operation in the Attach Request message.
3. The eNB forwards the Attach Request message to MME as specified in clause 5.3.2.1 of TS 23.401 [5]. MME checks if the UE has the capability to support the S&F satellite operation, if not, rejects the Attach Request with an appropriate cause value.
4. If there is no subscription and credentials stored in the HSS, the Authentication and NAS security cannot be performed, and the attach request is rejected.
5. MME stores the IMSI and current TAI for the rejected UE.
6. MME sends the Attach Reject message to UE with an appropriate cause.
7. When the feeder link is available, the MME sends the rejected UE’s IMSI and current TAI to LSS. LSS provides the rejected UE’s subscription and security credentials (e.g. subscriber Key) to the onboard HSS. The onboard HSS can use the subscriber Key to generate the Authentication Vectors (RAND, AUTN, XRES, KASME) and provides the AVs to MME for Authentication as described in clause 6.1 of TS 33.401[xx]. After that, based on the ephemeris and current TAI of rejected UE, LSS may decide to synchronize the rejected UE’s subscription and credentials with other satellites that will cover the rejected UE.

Editor's note: SA3 would need to verify the above.

1. When UE determines that it is in satellite coverage again, the UE re-initiates the Attach procedure as shown in Figure 6.18.2-1 if the onboard HSS holds its subscription and credentials. Otherwise, repeat steps 1-6.

#### 6.18.2.3 Procedure for MO Data Transport in Control Plane CIoT EPS Optimisation under S&F Satellite Operation

The procedure for MO data transport in Control Plane CIoT EPS Optimisation under S&F Satellite Operation is shown in the Figure 6.18.2-3



**Figure 6.18.2-3: MO data transport in Control Plane CIoT EPS Optimisation** **under S&F Satellite Operation**

1. The UE is ECM-IDLE.
2. When the service link is available, the UE establishes an 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.
3. The NAS PDU sent in step 1 is relayed to the MME by the eNodeB using a S1-AP Initial UE message.
4. The MME checks the integrity of the incoming NAS PDU and decrypts the data it contains. The MME stores the UL data until the feeder link is available.
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 4 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 is not aware of pending MT traffic and S1-U bearers are not established, the following steps can be skipped. Otherwise, Downlink data may arrive at the P-GW and the P-GW sends them to the MME via the S-GW.
11. If Downlink data are received in step 9, the MME encrypts and integrity protects the Downlink data, and store the DL data until the service link is available.
12. If the service link is available, the MME sends Paging message to the eNB, and the UE is paged by the eNB.
13. RRC connection is established.
14. The UE sends Control Plane Service Request NAS message over RRC Connection request and S1-AP initial message.
15. Downlink data are encapsulated in a NAS PDU and sent to the eNodeB in a S1-AP Downlink NAS Message.
16. The eNB sends an RRC Downlink data message including the Downlink data encapsulated in NAS PDU to UE.

#### 6.18.2.4 Procedure for MT Data Transport in Control Plane CIoT EPS Optimisation under S&F Satellite Operation

The procedure for MT data transport in Control Plane CIoT EPS Optimisation under S&F Satellite Operation is shown in the Figure 6.18.2-4:



**Figure 6.18.2-4: MT data transport in Control Plane CIoT EPS Optimisation under S&F Satellite Operation**

1. The UE is EPS attached and in ECM-Idle mode.
2. The S-GW receives downlink data for a UE.
3. SGW stores the DL data.
4. If the Serving GW is buffering data in step 2, the Serving GW sends a Downlink Data Notification message to the MME to establish the S11-U connection. SGW can send a Downlink data notification message to each satellite when the feeder link is available. Based on the Ephemeris and UE context (e.g. the current Tracking Area List), MME determines whether the UE will be reachable. If the satellite will cover UE’s current Tracking Area List, MME responses to the SGW with a Downlink Data Notification Ack message. Otherwise, a NACK message will be sent to SGW.
5. If the MME determines the UE will be reachable, Step 4-15 of Figure 6.18.2-3 as described in clause 6.18.2.3 is triggered to deliver DL data to the UE.

6.18.3 Impacts to Services, Entities and Interfaces

This solution impacts the following entities.

UE:

* Indicate its capability to support the S&F satellite operation in the Attach Request message.

eNB:

* Indicate it is in the S&F satellite operation mode in the SIB.

MME:

* Indicate its capability to support the S&F satellite operation in the Attach Accept message.
* Receive and Store the UL data when service link is available, and forward the UL data when feeder link is available.
* Receive and Store the DL data when feeder link is available, and forward the DL data when service link is available.
* Complete the NAS procedure of the attach procedure without setting up GTP-C tunnels between the MME and SGW/PGW when service link is available.
* Synchronize the UE states and UE context with the LSS.
* Store the IMSI and current TAI for the rejected UE.
* Send the the rejected UE’s IMSI and current TAI to LSS, and retrieves the subscription and authentication vectors from the LSS.
* Store the UL data.

LSS (New network function):

* Synchronize the UE states and UE context with the onboard MME.
* Provide the rejected UE’s subscription and authentication vectors to the onboard MME.
* Synchronize the UE subscription and security credentials with the onboard HSS.

HSS (onboard the satellite):

* Synchronize the UE subscription and security credentials with the onboard HSS.

SGW:

* Store the DL data.

**\* \* \* \* End of Changes \* \* \* \***