**3GPP TSG-WG SA2 Meeting #163 *S2-240xxxx***

**Jeju, KR, May 27th – 31st, 2024 (revision of S2-2406551)**

**Source: Huawei, HiSilicon, … others**

**Title: KI#1 Conclusion: For regenerative-based satellite access**

**Document for: Approval**

**Agenda Item: 19.1**

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

*Abstract: This pCR provides a conclusion for KI#1 to support regenerative-based satellite access.*

# 1. Introduction/Discussion

The below is the consolidated input to SA2#163 for KI1# conclusions. Based on this consolidated input an updated conclusion proposal is made:

// N1/S1 Interface Management

- It is assumed that the existing interface management procedure can be reused to handle the N2 and S1 connections in the Core Network when the gNB/eNB leaves an area served by an AMF/MME (e.g. when setting over the horizon).

* When the eNB/gNB leaves the service area of an AMF/MME (e.g. when setting over the horizon), a procedure to handle the N2 and S1 connections should be supported. Options e.g. disconnecting/suspending/performing configuration update of the N2/S1 connections are considered in SA2.

NOTE 1: How does the AMF/MME handle the notifications sent by RAN will be determined in the normative phase, based on e.g. feedback from RAN3.

- Enhancements to N2 and S1 interface procedures are to be determined by RAN3. SA2 specifications can be aligned during the normative phase.

* + A graceful disconnection towards the old MME/AMF can also be applied, but it is up to RAN3 to decide, whether the RAN needs a graceful disconnection or a SCTP shutdown or any other mechanisms can be applied to gracefully remove the S1 or NG application layer context.

- For N2/S1 connection management in regenerative based satellite access, the following principles are agreed:

- For N2/N1 connection setup/disconnect，gNB/eNB has the ephemeris information

 gNB/eNB determines when the N2/N1 disconnection procedure will be started ,

 gNB/eNB determines when the N2/N1 set up procedure will be started

- For N2/N1 connection suspend/resume, gNB/eNB has the ephemeris information

 gNB/eNB starts the suspend before the connection is about to lost

 gNB/eNB starts the resume after the connection is available

 gNB/eNB knows when the connection is about to lost and when the connection is available.

 SCTP should be enhanced in order to support the suspend/resume of N2/S1 connection

KI1\_Cat1\_P2: Support of a procedure to handle the N2 and S1 connections in the Core Network when the gNB/eNB leaves an area served by an AMF/MME (e.g. when setting over the horizon) is for RAN3 decision.

- Support of N2/S1 connection setup/disconnect as the RAN node moving into/leaving an area served by AMF/MME.

NOTE: The N2/S1 disconnect procedure to tear down the existing connection is up to SA3 decision.

- A procedure to handle the N2 and S1 connections when the eNB/gNB leaves the service area of an AMF/MME (e.g. when setting over the horizon) should be supported. Options e.g. disconnecting/suspending/performing configuration update of the N2/S1 connections are considered in SA2. It is up to RAN3 to determine the final option about whether to reuse existing or new mechanisms/procedures.

// Feeder Link Switching

- In case of gNB/eNB IP address change due to soft feeder link switch, it can be supported using existing procedures. There are no normative impacts to SA2 specifications due to this.

- The case of hard feeder link switching can be supported using existing procedures by the eNB/gNB releasing UEs to (E)CM\_IDLE before changing NTN gateway, or by using existing load balancing and/or handover procedures based on the deployment.

- Existing procedures, such as TAU, Registration Request, and load-rebalancing should be used to support UE being served by a new MME/AMF in the event of a feeder link switchover.

- In case of a feeder link switchover, existing procedures like AN Release and S1 Release could be used to release logical NG-AP and S1-AP connections, respectively, as well as User Plane connections and RAN signalling connection between UE and RAN.- During feeder link switchover, the TNL node on the satellite will be triggered to configure the transport association for the target NTN GW feeder link. The details of that are out of scope of SA2.

* For the case when the feeder link switches without AMF/MME changing, if the eNB/gNB IP address changes, SA2 assumes that the existing procedures can be reused, e.g.:
	+ For gNB control plane, the multiple TNL associations per AMF capabilities can be reused, by selecting a new TNL association (provided by AMF), the NB can send a RAN CONFIGURATION UPDATE message with its new IP address to remove the old TNL association (with the old feeder link), and then AMF can associate the new IP address with the new TNL association for the gNB by recognizing the Global RAN Node ID; UE context can be retained;
	+ For eNB control plane, as the multiple TNL associations between an eNB and an MME are not supported, eNB can send S1 SETUP REQUEST with its new IP address to the MME, the MME can then reestablish a new S1-MME instance for this eNB; UE context can be retained;

Editor’s note 1: the eNB case should be revisited if RAN 3 decide to support the multiple TNL association mechanism in E-UTRA, otherwise, a service interruption period is expected in NAS layer for MME.

* + For gNB/eNB user plane, gNB/eNB can update the AN tunnel Info to the UPF/S-GW (via AMF and SMF/MME) by sending PDU SESSION RESOURCE MODIFY INDICATION/ E-RAB MODIFICATION INDICATION to include all affected PDU sessions/ E-RAB IDs per UE level. If RAN3 develops other procedures for AN tunnel update, alignment work at SA2 is needed.

NOTE 2: For the user plane, the feeder link switch in a hard way will result in a service interruption period using existing procedures, a data buffer notification mechanism (per UE level or per node level) is to be decided in normative phase.

* For the case of the feeder link switch with AMF/MME changing, it is considered to be rare and can be solved though deployment.

NOTE 3: it is assumed that one gNB/eNB can only be connected to one AMF per PLMN, such assumed deployment option can be captured as information during normative phase.

- gNB/eNB IP address change due to feeder link switch can be supported using existing N2 and S1 procedures. There are no normative impacts to SA2 specifications due to this.

* In the regenerative payload configuration, the feeder link switchover, due to eNB/gNB moving, might require a reconfiguration of connections, the RAN needs transitions between different NTN GWs and potentially between MMEs/AMFs. The RAN serving the same UEs across two MMEs/AMFs can be considered as corner case and is avoidable by careful deployment, in this case, RAN can apply any of the principal to deal with the connected/idle UEs.
	+ The RAN can keep the UEs idle (i.e. make S1/NG release) and move to new MME/AMF.
	+ The RAN can trigger HO, when it realizes, it is going to leave a tracking area due to its own movement, if no target RAN is available, UEs needs to be put to idle state and all PDU/PDN session needs to be released.
	+ The TNL connection setup/update will help both RAN and MME/AMF to exchange their broadcast TA, MME-ID/AMF-ID, PLMN support, slice support, RAN global node ID etc…
* NTN-GW change in Regen architecture: The RAN can connect to different NTN-GW while connected to same MME/AMF while serving the UE. The following conclusion applies for normative:
	+ The change of NTN-GW may cause a change of the RAN node’s IP address. Which is avoidable by assigning a globally unique IP address to the RAN.
	+ If not, during the change of IP address of the RAN, RAN can perform S1/NG configuration update to notify MME/AMF on the additional TNL IP address. Additionally, it can reduce (make it zero) the weightage of the previous TNL.
	+ For the active PDU session, a HO procedure can be triggered by RAN to make SAE-GW/UPF aware of the new DL tunnel information. Whether a group-based tunnel change principle can be applied or not is up to RAN3. But the procedure to handle HO and PDU session modification must follow existing procedure.
* KI1\_Cat1\_P3: NB/eNB IP address change (if any) due to soft feeder link switch can be supported using existing procedures.
* KI1\_P7: Scenario of hard feeder link switch can be addressed by existing procedures, data buffering in UPF can be discussed during normative phase.
* Support of hard/soft feeder link switch by re-using per R-17 existing procedures. For supporting soft feeder link switch, a new N2/S1 connection with the new RAN node covering the area is set up before the old connection is disconnected.

- The existing procedures should be re-used to support the gNB/eNB IP address change due to soft feeder link switch.

// Cell Mapping

- It is assumed that the AMF/MME can treat the Mapped Cell IDs as per Rel-17.

* The AMF/MME can treat the Mapped Cell ID as per rel-17. AMF/MME needs an enhanced way to determine/formulate the recommended cells by recognizing the correct TAI serving Global RAN Node ID as Assistance Data for Paging.

NOTE 4: How does the AMF/MME determine the correct mapped cell IDs as recommended cells will be determined in normative phase based on e.g. feedback from RAN3.

* Impacts on the paging procedure in Regen Architecture
	+ Due to configuration updates from RAN on every change of serving tracking area, the MME/AMF shall use the latest received RAN ID vs tracking area coverage information when selecting any RAN node for paging.
* KI1\_Cat1\_P4: AMF/MME can treat the Mapped Cell IDs as per Rel-17.
* Support of reusing mapped cell id which can be treated as per Rel-17 in AMF/MME.

- The AMF/MME can treat the Mapped Cell ID as per rel-17.

// RAT Type Identification and impacts

- It is assumed that the Core Network can determine, if required, that regenerative satellite access is being by network implementation, e.g. based on access type, the eNB/gNB used, satellite backhaul category etc., and no new RAT Types are introduced.

- The AMF and SMF may need to be informed of the regenerative payload type to assist in CN PDB determination and PCF’s policy decisions. However, introducing new RAT types is not required.

* Impact to QoS due to Regen Architecture
	+ In Regen architecture, path delay in N3/S1-U is more than the transparent architecture due to the placement of RAN in satellite instead of ground in transparent payload mode.
	+ This will affect the CN-PDB in the overall PDB requirement for any QoS. RAN can calculate PDB = CN-PDB + AN-PDB + (REGEN offset delay), i.e. AN PDB = PDB – (CN-PDB + REGEN offset delay). The REGEN offset delay can be configured in RAN based on the feeder link delay it might experience between UPF on the ground and the satellite. or the CN-PDB can be assumed to have larger values in both static and dynamic QoS rules when sending from Core to RAN.
* KI1\_P8: There is no need to introduce new RAT type for regenerative payload satellite access.

// Other Aspects

- While certain network optimization might be useful, leveraging existing satellite ephemeris information for facilitating the discovery of RAN node for UE paging appears to be more efficient.

// Proxy / IWF

- A deployment may use a Link Layer Proxy (LLP), e.g. as described in solution#9, as an implementation option with no normative changes required, to minimise the impacts of regenerative satellite access to 5GC/EPC, documented in an informative annex in 5GC/EPC. The informative annex will document the following LLP characteristics:

- The LLP acts as an GTP-U tunnel endpoint between RAN and UPF/P-GW.

- NG/S1-AP enhancements for regenerative satellite access are used between the LLP and gNB/eNB only.

- Non UE-associated messages between on-board RAN and the AMF are handled by the LLP as follows:

- For non UE-associated Interface Management related NG/S1-AP messages between a gNB/eNB and AMF/MME, they are terminated/initiated by the LLP, including NG/S1AP Setup, NG/S1AP Configuration Update, etc.

- For non UE-associated Configuration Transfer related NG/S1-AP message (who’s contents is relayed by AMF/MME transparently), they are relayed by LLP without involving the AMF/MME, including Uplink/Downlink RAN Configuration Transfer, etc.

- For other non UE-associated NG/S1-AP messages between RAN and AMF/MME, they are relayed by the LLP and the LLP replaces RAN node ID, if there is any, with LLP IDs (with same format of RAN node IDs).

- UE associated NG/S1-AP messages between on-board RAN and the AMF/MME are relayed by the LLP and the LLP replaces RAN node IDs with LLP IDs (with same format of RAN node IDs), RAN UE NGAP IDs with and LLP UE NGAP IDs, user plane tunnel information, if there is any, with LLP user plane tunnel information.

- Paging messages from an AMF/MME are sent by the LLP to gNB/eNBs on satellites which cover the TAIs in the paging message.

- Xn and N2 handover procedures are reused and the LLP does not replace *Target ID* in HANDOVER REQUIRED with the LLP.

- The Intermediate GW is considered an implementation choice. It acts as an “earth-fixed” eNB/gNB towards the CN and performs AMF/MME/UPF functions towards the moving eNB/gNB. It can use existing N2/N3/S1 interfaces and propagate R18 ULI information for NTN. CN S1/N2 handover procedures remain unaffected by its use. If deployed, it should be transparent to the CN.

For solutions in Cat.2) the following principles of system behaviour apply:

- Intermediate GW plays the role of “earth fixed” eNB/gNB towards the CN.

- Intermediate GW uses existing N2/N3/S1 interfaces to connect to CN. Other interfaces between the intermediate GW and the moving eNB/gNB are out of scope of SA2 and possible modifications to existing S1/N2/N3 interfaces need to be determined by RAN3 as per LS S2-2405600.

- Intermediate GW is responsible for propagating the additional ULI information to AMF/MME with the mapped cell-id and TAC information as is the case in existing NTN architecture defined in TS 23.501 [2] and TS 23.401 [5].

- In order to support handover between satellites connected to the same or different Intermediate GWs, existing S1/N2 handover procedures to support intra- or inter-intermediate GW mobility are used.

NOTE: An example of how the intermediate GW can be documented in normative specifications is shown in Annex A.

Editor’s Note: Other principles of system behaviour are FFS.

For Cat 2 architecture that having a new NF (InterWorking Function) added:

* The new NF is considered to play the role of “earth fixed” eNB/gNB towards the CN with existing N2/N3/S1 interfaces reused, and play the role of “AMF/MME or UPF/S-GW” towards the eNB/gNB with Cat.1 interface management solutions reused. No normative work is needed.

NOTE 5: the detailed deployment solutions can be captured as information in normative phase.

KI1\_Cat2\_P1: Solutions which propose an intermediate IWF or proxy (called Intermediate GW for convenience) between the moving eNB/gNB and CN are to be considered as optional deployment option.

KI1\_Cat2\_P2: The intermediate GW shall play the role of “earth fixed”eNB/gNB towards the CN and the role of AMF/MME/UPF towards eNB/gNB.

KI1\_Cat2\_P3: The Intermediate GW shall use existing N2/N3/S1 interfaces to connect to CN.

KI1\_Cat2\_P4: The intermediate GW shall propagate existing R18 ULI information for NTN.

KI1\_Cat2\_P4: CN S1/N2 handover procedures must not be impacted.

KI1\_Cat2\_P5: If intermediate GW has no impact on specification, SA2 can document it in informative Annex in TS 23.501 [2] and TS 23.401 [5] during the normative phase of the work as a deployment option.

KI1\_Cat2\_P6: If intermediate GW is deployed as implementation choice it shall be transparent for CN side.

* Architecture with an intermediate IWF or proxy (called IWF hereafter) that used to hide onboard RAN node mobility is used as an optional deployment option and can be documented in informative Annex in TS 23.501 [x] and TS 23.401 [x] with the following restrictions:

- IWF acts as earth fixed RAN node towards CN and as AMF/UPF/MME/SGW towards RAN. Existing N2/N3/S1 interfaces is supported to connect IWF and CN.

- Support of ULI information as per Rel-18 transmission for the IWF.

- Support of reusing S1/N2 based handover procedures as IWF changes.

- It is based on the conclusion of RAN3 whether the intermediate IWF or proxy is documented in informative Annex in TS 23.501 [2] and TS 23.401 [5] during the normative phase of the work.

# 2. Text Proposal

It is proposed to capture the following changes vs. TR 23.700-29.

\* \* \* \* First change (all new) \* \* \* \*

# 8 Conclusions

## 8.1 Conclusion for KI#1 Support of Regenerative-based satellite access

The conclusion for supporting gNB/eNB on-board the satellite is based on the following principles:

- When the eNB/gNB leaves the service area of an AMF/MME (e.g. when setting over the horizon) any new procedures or updates to existing procedures to handle the N2/S1 connection will be defined by RAN3. SA2 will align its specifications once this has been determined by RAN3.

- gNB /eNB IP address change due to feeder link switch can be supported using existing N2 and S1 procedures. There are no normative impacts to SA2 specifications due to this.

- RAN transitioning between different NTN GWs, TAIs and potentially between MMEs/AMFs can be supported by using existing procedures, e.g. the eNB/gNB releasing UEs to (E)CM\_IDLE before changing NTN gateway, or by using existing load balancing, trigger handover when it realizes it is going to leave a tracking area due to its own movement, etc.

- AMF/MME can treat the Mapped Cell IDs as per Rel-17.

- The Core Network may need knowledge of when regenerative payload type is used to assist in CN PDB determination and policy decisions. Introducing new RAT types is not required and it is assumed the CN can determine this when required.

* A deployment may use an intermediate IWF or proxy (called IWF hereafter) that used to hide onboard RAN node mobility as an optional deployment option and which will documented in informative Annex in TS 23.501 [x] and TS 23.401 [x]:

- The IWF acts as earth fixed RAN node towards CN and as AMF/UPF/MME/SGW towards RAN. Existing N2/N3/S1 interfaces are supported to connect IWF to CN and to connect IWF to RAN.

- Support of ULI information as per Rel-18 transmission for the IWF.

- Support of reusing S1/N2 based handover procedures as IWF changes.

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