**3GPP TSG-WG SA2 Meeting #153E e-meeting *S2-220xxxx***

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**Source: Huawei, HiSilicon**

**Title: Evaluation Update and Conclusion**

**Document for: Approval**

**Agenda Item: 9.24**

**Work Item / Release: FS\_5GSAT\_Ph2 / Rel-18**

*Abstract: The evaluation is updated, taking into account system architecture, for editorial flow and solutions added or updated.*

# 1. Introduction/Discussion

This pCR provides the following changes:

1. Update evaluation for coverage information provisioning in clause 7.4.

2. Refine the structure in clause 7.5 as following:

- 7.5.1 Solutions mapping to requirements, impacts

- 7.5.2 Solutions ranking

- 7.5.3 Evaluations on solutions for general mobility management and/or power saving

- 7.5.4 Evaluations on solutions for overload impacts to target RAT/PLMN (new)

- 7.5.5 Evaluations on solutions for alternative RAT/PLMN selection (new)

 The solutions in the TR target different sub-issues, therefore it is be better to categorize them and evaluate the solutions per category as they are not all solving the same issue. That’s the reason why this contribution proposes the above structure.

3. Add evaluations for solutions that target overload impacts to a target RAT/PLMN and alternative PLMN selection.

In Rel-17, the MME obtains the RAT/TAC specific satellite coverage which is too coarse as a large satellite beam footprint. This contribution proposes the AMF/MME obtains the coverage information based on satellite related information (e.g. satellite ephemeris, satellite footprint), UE location and optionally UE mobility information.

# 2. Text Proposal

It is proposed to capture the following changes vs. TR 23.700-28.

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

# 7 Overall Evaluation

## 7.1 Rel.17 solution for support of discontinuous satellite coverage

Several solutions are documented in the present TR for support of NTN discontinuous coverage. This clause provides a general description of the support for NTN discontinuous coverage in EPS as documented for Release 17 in SA2 and RAN specifications.

Support for IoT NTN discontinuous coverage was introduced in TS 23.401 [5] with CR S2-2109199 [15]. The basic principles of the solution are:

- The UE is assumed to know how the E-UTRAN NTN coverage varies with time based on information defined in TS 36.331 [16] and TS 36.304 [17] (e.g. from the ephemeris data of a satellite access system that the UE is using). The UE may then deactivate its Access Stratum functions in order to optimise power consumption until coverage returns. The UE NAS Periodic Tracking Area Update attempts may be postponed but the PLMN selection timer T is not deactivated as defined in TS 23.122 [13].

- TS 36.331 [16] defines SystemInformationBlockType31-NB and SystemInformationBlockType32-NB that provides ephemeris data and coverage parameters to the UE. SystemInformationBlockType31-NB contains satellite assistance information for the serving cell. SystemInformationBlockType32-NB contains satellite assistance information for up to four cells that is used for prediction of discontinuous coverage.

- TS 36.331 [16] also defines SystemInformationBlockType3 that includes t-Service which is time information on when an NTN quasi-Earth fixed cell is going to stop serving the area it is currently covering.

- TS 36.304 [17] defines the AS idle mode behaviour of the UE as follows: "If the UE has determined that it is out of coverage using available satellite assistance information (e.g. ephemeris parameters and coverage parameters in SystemInformationBlockType32, SystemInformationBlockType31 or other parameters), the AS configuration (e.g. priorities provided by dedicated signalling and logged measurements) is kept, but the UE need not perform any idle mode tasks. It is up to UE implementation to handle running timers. The detection of out of coverage using satellite assistance information is up to UE implementation and once in coverage the UE shall perform all idle mode tasks."

- As in clause 5.3.3.1d of TS 36.331 [16], decoding of SIB31/32 is implicitly mandatory for UE, together with valid GNSS position, to start RRC connection through NTN.

- The MME provides independent control over the Periodic Tracking Area Update/Mobile Reachable Timer and Implicit Detach Timer. These parameters are to be configured on a per-RAT or per-TAC basis.

- It is indicated in a NOTE in TS 23.401 [5] that if a satellite system only provides coverage to a UE for e.g. 20 minutes when a satellite passes, and the maximum time before a satellite again passes any point on the earth is 10 hours, the MME could configure the periodic TAU timer and mobile reachable timer to be just greater than 20 minutes and the Implicit Detach timer to be greater than 10 hours.

- High Latency Communication (HLCOM) functionality allows support of MT data when NTN with discontinuous coverage is used.

For an example scenario for the UE being in coverage for 20 minutes every 10 hours, (based on the MME knowing that the Tracking Area is associated with that discontinuous coverage IoT NTN system) the MME:

- sets the Periodic TAU timer to 24 minutes and Mobile Reachable Timer to 30 minutes (this limits unecessary paging traffic);

- sets the Implicit Detach Timer to 10 hours (which keeps any PDN connection alive while the UE is out of coverage);

- may use HLCOM by setting the DL Buffering Duration time to the time left before the Implicit Detach timer expires;

- supports SMS message waiting capability and/or Monitoring event: UE Reachability;

- every time coverage "returns" since the UE's Periodic TAU timer would have expired, the UE will perform periodic TAU and therefore inform the MME that is back in coverage. As per TS 23.401 [5] clause 4.3.17.7, "High latency communication" already mandates that when the UE performs a TAU, the MME establishes the user plane to deliver the buffered data.

In Rel.17 the MME is not expected to:

- enable eDRX;

- enable Power Save Mode;

even though it is not prevented by the normative specification.

There is no support for any enhancements for NTN discontinuous coverage in 5GS in rel.17.

## 7.2 Methodology

Considering that the elaborated Key Issues are mentioning some aspects that need to be covered in priority by final selected solution(s) (each may be single self-contained solution or an aggregation of interesting part of proposed solutions), and that it might be possible to assess the solutions according preferable underlying system assumptions, for each Key Issue, proposed methodology is the following:

1. Refine the mapping between solutions and Key Issues, by identifying for each aspect of the Key Issue, if the given solution addresses the aspect or not.

2. Indicate as simply as possible, underlying system assumptions, requirements and impacts as described in clause 7.3.

3. Once solutions are grouped as described above, considerations on preferable system assumptions, in relation with Key Issue aspects may help in determining the conclusion or assembly of parts of solutions for conclusions.

## 7.3 Requirements, Impacts and System Assumptions

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Each solution is based on system assumptions. The following system assumptions, with corresponding justification, are provided:

- A1: Satellite service coverage is determined by the NW.

- Justification:

- More complete information on satellite constellation due to connection with Satellite Network Centre.

- No UE resources required to determine satellite coverage.

- A2: Satellite service coverage is determined by the UE.

- Justification:

- UE can always know its location - NW can only assume or predict UE location.

- A3: For non-static UEs, the UE mobility is known or predicated by the UE.

- A4: For non-static UEs, the UE mobility is known or predicated by the network.

- Justification for A3 and A4:

- If movement is predictable, the parameter adaptation will better correspond to reality

- A5: The solution applies to 5GC.

- A6: The solution applies to EPC.

- Justification for A5 and A6:

- Reuse concepts and avoid procedure divergence.

## 7.4 Coverage Information Provisioning

### 7.4.0 Overview

Coverage information provisioning is a key part to realize the requirements as descried in clause 7.3.

This clause categories related solutions into two types:

1) Coverage information provisioning to UE as described in clause 7.4.1.

2) Coverage information provisioning to core network (AMF/MME) as described in clause 7.4.2.

### 7.4.1 To UE

The solution in Release 17 and Solutions #1, #3, #6, #7, #8, #11 and #16 assume that a UE has access to coverage information allowing the UE to know fairly precisely (e.g. maybe with 1 minute or better accuracy) when coverage at a current or future location will start and end.

The solution in Release 17 relies on broadcast of satellite ephemeris data in a SIB defined in TS 36.331 [16]. The solution is limited to support of ephemeris data for up to 4 satellites. The solution in Release 17 contains the following limitations.

- A UE would be expected to calculate whether and when each satellite will be visible from a UE location and assume that the satellite might be accessed if the satellite is visible (e.g. with an elevation above 10 degrees). This could be a significant processing burden to an IoT UE, at the opposite of KI#2 objective to save power

- There is no information in the SIB on whether a satellite supports only certain PLMNs, only certain countries, is operating only at certain times (e.g. not late at night to reduce operating cost) or whether radio cell coverage is for an entire area of satellite visibility or only for some portion of that area.

- There is no charging capability - this is a free service to all UEs.

- There is no security - a fake base station could broadcast the SIB to spoof coverage or out of coverage at incorrect times.

- The SIB seems to be restricted to one satellite RAT only and may not support coverage from all satellite RATs.

- The limitation to 4 satellites could limit coverage information to only a short period in the future (e.g. 2 hours).

The number of satellites RAN broadcasts ephemeris data for will be increased from 4 in Rel-17 to 8 in Rel-18.

Solutions #15, #17, #21, #22 address the provision of coverage information to a UE as an alternative to the solution in Release 17. The solutions may overcome the limitations of the solution in Release 17 as shown in clause 6.15.4. The solutions are not RAN based solution but instead rely upon support from the CN and/or an external server (e.g. supported by a satellite operator).

Whether and how the provisioned coverage information is used by the UE has to be defined in cooperation with the RAN and CT working groups and until that is done whether the solutions are required is still to be determined.

### 7.4.2 To Core Network (AMF/MME)

Solutions #1~#6, #9, #11, #15, #17, #19, #21 and #22 assume that the CN (e.g. MMEs, AMFs, or other network entities) has access to coverage information allowing the CN to know when UEs will be in or out of coverage. There are several mechanisms supporting the provision/acquisition of coverage information. From RAN, from pre-configuration, from NWDAF, from 5G dedicated coverage provision network function, from AF and from 3rd party server.

Solution #1, Solution #4 and Solution #5 propose methods to address the acquisition of coverage information from RAN. Solution #1 suggests that the coverage information may be derived by the AMF based on the satellite assistance information from RAN, e.g. satellite id, satellite ephemeris. Solution #4 and Solution #5 both suggest to enable the provision of satellite coverage information to the AMF by RAN via existing UE Location Reporting procedures. However, all these solutions have RAN dependency.

Solution #2 proposes to obtain coverage information (yes, no, closest coverage date) from an external server by the MME. or external server by AMF.

Solution #3 and #15 proposes to pre-configure the coverage information in the AMF/MME. Solution #3 proposes to re-use the RAT/TAI specific configuration in Rel-17. It is not accurate to set power saving parameters if using such a coarse configuration.

Solution #19 proposes the AMF/MME obtain coverage time information from an AF.

that the AMF obtains ephemeris or estimate of in/out NTN coverage ing This solution only applies to 5GC and impacts on NWDAF are introduced.

Solution #22 proposes to obtain a coverage map from a 3rd party server via a new CMNF or NEF. The impacts on the introduction of a new NF or impacts in the NEF are introduced.

As the UE location information and UE mobility information are specific to a PLMN, it is not appropriate and secure to expose such information to 3rd party. By comparison, the satellite related information (e.g. Satellite ephemeris, Satellite footprint) are public which can be provided to the AMF/MME. Based on satellite related information, UE location, UE mobility information, the AMF/MME determines the coverage information.

## 7.5 KI Requirements Solution Evaluations

### 7.5.1 Solution Mapping to Requirements and Impacts

Table 7.5-1 shows the requirements that are applicable to mobility management that each solution supports. Note that Table 7.5-1 does not show how well the requirements can be supported or the magnitude of the impacts, only that requirements can or cannot be supported to a degree and that there is or is not some types of impact.

Table 7.5-1: Support of Mobility Management Requirements for KI#1 and KI#2

|  |  |  |
| --- | --- | --- |
| Solutions | Requirements | Impacts |
|  | R1 | R2 | R3 | R4 | R5 | R6 | I1 | I2 | I3 | I4 | I5 | I6 |
| Solution #1: Power Saving based on AMF awareness of coverage information | Y | Y | N | N | Y | Y | Y | Y | Y | Y | Y |  |
| Solution #2: predictive Power Saving Mode | N | Y | N | N | Y | Y | N | Y | Y | Y | N |  |
| Solution #3: Power Saving based on UE awareness of coverage information | Y | Y | N | N | Y | Y | Y | Y | N | Y | Y |  |
| Solution #4: Mobility Management enhancement based on coverage information and UE location | N | N | N | N | N | Y | N | N | Y | Y | Y |  |
| Solution #5: Power Saving based on updating parameters before releasing signalling connection | U | Y | N | N | Y | Y | N | N | Y | Y | Y |  |
| Solution #6: Discontinuous coverage architecture | Y | Y | N | N | Y | Y | Y | Y | Y | Y | Y |  |
| Solution #7: Utilizing discontinuous coverage wait timer for satellite discontinuous coverage scenario | Y | U | N | Y | Y | Y | Y | Y | N | Y | Y |  |
| Solution #8: Leaving Coverage Notification | Y | U | N | N | Y | Y | Y | Y | N | Y | Y |  |
| Solution #9: Modification of Timers when in or out of Coverage | U | Y | N | N | Y | Y | N | Y | Y | Y | N |  |
| Solution #10: UE Reachability Events with Expected in Coverage Time | This solution is not applicable to mobility management |
| Solution #11: Combined UE Management Architecture | Y | Y | N | N | Y | Y | Y | Y | Y | Y | Y |  |
| Solution #12: Minimize discontinuous coverage by inter-RAT handover processing | N | N | Y | N | N | N | N | Y | N | Y | Y |  |
| Solution #13: Applicability of no service in discontinuous coverage | N | N | Y | N | N | N | N | Y | N | Y | N |  |
| Solution #14: Wait timer for discontinuous coverage | N | N | N | Y | N | N | N | Y | N | Y | N |  |
| Solution #15: Solution to support Provision of Coverage Data to a UE | This solution only assists other solutions to support mobility management |
| Solution #16: Solution to support a UE Triggered Generalized Unavailability Period | Y | Y | N | Y | Y | Y | Y | Y | N | Y | Y |  |
| Solution #17: Solution with event list coverage information over NAS | This solution only assists other solutions to support mobility management |
| Solution #18: Response to Nnef\_ParameterProvision request containing Maximum Latency | This solution is not applicable to mobility management |
| Solution #19: AMF/MME awareness of coverage times based on AF parameter provisioning | Y | Y | N | N | Y | Y | N | N | Y | Y | N |  |
| Solution 20: UE-specific Dynamic Tracking Areas | N | N | N | N | N | N | N | Y | N | Y | N |  |
| Solution #21: NWDAF assisted power saving mechanism for UE in discontinuous NTN coverage | Y | Y | N | N | Y | Y | Y | Y | Y | Y | N |  |
| Solution #22: Coverage data transfer in 5GS and EPS | Y | N | N | N | Y | Y | Y | Y | Y | Y | N |  |
| Solution #23: Handling of the UE attempt to Connected mode | N | N | N | Y | N | N | N | N | N | N | N |  |
| NOTE: Y = Yes, N = No, U = Unknown (not clarified by the solution), N/A = Not Applicable  |

### 7.5.2 Solution Categorisation

The 23 solutions can be categorised as following:

- General mobility management and/or power saving solutions.

 This category corresponding to the requirements of R1, R2, R5 and R6.

 Solutions#1, #2, #3, #4, #5, #6, #8, #9, #10, #11(combined solution), #15, #16(mobility management and/or power saving part of this solution), #19, #20, #21 and #22 solve how to configure mobility management and/or power saving parameters, e.g. periodic MRU/TAU timer, active time, eDRX, sub-area paging.

- Alternative RAT/PLMN selection.

 This category corresponding to the requirements of R3.

 Solutions #12 and #13 describe alternative RAT/PLMN selection.

- Overload impacts to target RAT/PLMN.

 This category corresponding to the requirements of R4.

 Overload may occur when UEs go out of satellite coverage and alternative satellite coverage or RAT/PLMNs coverage is selected. This may also occur when many UEs move into coverage at the same time as the satellite coverage moves relative to the earth. Solutions #7, #14, #16 (overload part of this solution) and #23 solve the overload impacts to target RAT/PLMN.

### 7.5.3 Solutions for general mobility management and/or power saving

This clause evaluates whether solutions have any limitations that might restrict their use or cause them to fail. All the solutions can be categorised into two types as following:

1. CN (AMF/MME) determines mobility management and/or power saving parameters.

 In solutions #1, #2, #3, #4, #5, #6, #9, #11(combined solution), #19, #21 and #22 the CN determines mobility management and/or power saving parameters for the UE.

 For Solution #1(when UE is about to leave coverage), #19(EPC part) and #21(UE initiates part), if the UE is in RRC CONNECTED state and accessing then 5GS sends an RRC message when it is about to leave coverage (e.g. step 0 in Figure 6.1.2.1-1). A UE accessing EPS sends a TAU message when it is about to leave coverage (e.g. step 0 in Figure 6.1.2.2-1).

 In solution #1, the procedures can also be applied at other times before moving the UE to CM-IDLE. The UE will enter CM-CONNECTED (for example to send TAU/Periodic Registration based on the previously provided periodic registration time, or to send UL traffic) while in CM-CONNECTED the parameters can be updated and the Active Timer can be used while in coverage.

 In solutions #5, #19(5GC part) and #21(AMF initiated part), the AMF/MME triggers the power saving parameters update to UE before UE leaves satellite coverage.

 In Solutions #2, the UE computes its current and extrapolated location depending on its local knowledge and PSM configuration, and sends this information to the MME. The MME configures the power saving parameters based on the coverage information for the UE. Solution #2 applies to the case that the UE mobility is known or predicated by the UE.

 For Solution #3, the UE uses existing PSM. eDRX or MICO procedures to cause the MME/AMF to treat the UE as unavailable during periods of no coverage. The MME/AMF is not aware if the UE is requesting PSM, eDRX or MICO procedures out of coverage or for power saving. Therefore, as acknowledged in clause 6.3.3, the AMF/MME needs to honour the UE request and is not able to provide different PSM, eDRX or MICO parameters back to the UE, which is a limitation and also prevents incorrect configuration. That could mean, for example, that when out of coverage occurs rarely, support of PSM, eDRX or MICO the reachability latency may not be perfect from a network perspective.

 For Solution #4, the AMF/MME obtains the latest UE location before UE becomes CM-IDLE to perform paging optimisation, i.e. sub-area based paging.

 For Solution #6, the AMF can receive an unreachability period from both the UE (step 2 in Figure 6.6.2-1) and NWDAF (step 3 in Figure 6.6.2-1). ). If the two periods are significantly different (e.g. because the NWDAF unreachability period is based on an assumed UE trajectory not used by the UE, or vice versa), then the AMF will have to resolve this and has chance to correct. Depending upon how the AMF resolves this, Solution #6 may become rather similar to Solution #16 which also uses an unreachability period sent by the UE to an MME or AMF.

 For solution #9, the AMF/MME sends power saving parameters to UE before the UE leaves satellite coverage. This solution reduces the signalling interactions between UE and AMF/MME with the impact on UE.

 For Solution #11, the "5GS UE Leaving Coverage Procedure" in clause 6.11.2.1 has 3 possible triggers: the RAN can detect the UE is about to leave coverage (step 1a), the UE can detect impending out of coverage (step 1b), or the AMF can detect the UE is about to lose coverage (step 1c). This implies the UE, RAN and AMF are aware of the coverage related data and determining when the UE will go out of coverage, which helps with the cases where not one entity knows all the information. Sending the Registration Request some time in advance of leaving coverage should be more efficient if the UE would otherwise be in IDLE state shortly before loss of coverage and is supported.

2. UE determines information and sends it to CN for use.

 Solution #16 is similar to other solutions that provide UE awareness of unavailability due to coverage restrictions and requires that the CN follows exactly what the UE has provided as the timings. The relies upon the UE having full knowledge of its mobility patterns and if they are not known to the UE then the solution will malfunction.

### 7.5.4 Solutions for overload impacts to a target RAT/PLMN

As described in solution #23, in order to prevent access overload to the source satellite system, the NW can apply the existing mechanisms specified in clause 5.19 of TS 23.501 [2] and access control and barring specified in clause 5.2.5 of TS 23.501 [2]. No normative work is needed for this solution.

### 7.5.5 Solutions for alternative RAT/PLMN selection

This is related with the discussion in Release 17 on deactivation of AS functions. It is better to wait the Rel-17 conclusion before making Rel-18 conclusion.

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