**3GPP TSG-RAN WG2 Meeting #117-e R2-22xxxxx**

**Online, Feb 21st – March 03rd, 2022**

**Agenda item: 9.2.3.1**

**Source: MediaTek Inc.**

**Title: Discontinuous Coverage Open Issues Input**

**Document for: Discussion and Decision**

# 1 Introduction

This document is aimed at providing the open issues, related to Discontinuous Coverage, submitted in R2-2202053 [1] in IoT-NTN, identify potential agreements, alternatives, and further enhancements. This is also available in OI 3.1 ~ OI 3.4 under Section 9.2.3.1 of R2-117-e Agenda v3.docx.

* [Pre117-e][013][IOT-NTN] Discontinuous Coverage Open Issues Input (MediaTek)

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# 2 Discussion

RAN2 agreements related to IoT NTN’s Discontinuous Coverage are mentioned below.

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| **RAN2 115-e [2]**   1. RAN2 confirms that the following will be supported: discontinuous coverage without excessive UE power consumption and without excessive failures / recovery actions. It is expected that this need to be taken into account at least for Idle mode. The requirement is applicable for all reference scenarios (GEO, MEO and LEO). 2. Sattelite assistance information will be used by the UE for predicting coverage discontinuity. The details of the assistance information is FFS. FFS whether any applicable agreements made in NR-NTN can be reused. 3. The details of UEs actions when predicted to be out of coverage is FFS, e.g., stopping unnecessary cell search in the Idle mode, and FFS to what extent this need to be specified. 4. It is FFS to what extent it needs to be specified the details of UE’s prediction of discontinuous coverage and its ability to detect when it is back in coverage. 5. RAN2 sends an LS to SA2 and CT1 (cc: RAN3) for the possible alignment work in their specification due to the support of discontinuous coverage. |
| **RAN2 116-e [3]**   1. Satellite Ephemeris Parameters (not same as for L1 pre-compensation, for the constellation, not just single satellite) is needed for the UE for predicting coverage discontinuity. Other info, e.g., beam info, elevation angle, reference location or corresponding is FFS. 2. Providing the start-time of (incoming) satellite’s coverage and end-time of serving satellite’s coverage is needed for Quasi-Earth Fixed satellites. 3. From RAN2 point of view, the existing power saving mechanisms e.g., DRX, PSM, eDRX, relaxed monitoring, and WUS can be reused in IoT-NTN. Minor enhancements in existing power saving mechanisms to support discontinuous coverage is FFS. |
| **RAN2 116bis-e [4]**   1. The contents of the ephemeris / assistance info for non-continuous coverage:   Confirm that we Reuse the satellite ephemeris orbital parameters, already agreed for UL pre-compensation, for multiple satellites (Ref L1 params from R1).   1. FFS on the maximum number of satellites, whose ephemeris information will be provided. 2. FFS whether avg ephemeris (using same format as instant) + alamanc can be used (Gatehouse Proposal) 3. FFS how to signal this (new SIB for this particular purpose, dedicated signalling). 4. FFS if to introduce additional new parameters like satellite footprint reference point on ground, satellite coverage radius etc. |

3.1 Number of Satellites Considered

In RAN2 #116-e it was agreed that satellite ephemeris parameters “for the constellation, not just single satellite” is needed for the UE for predicting coverage discontinuity. Hence, for providing the UE with sufficient information, there should be an upper bound of the maximum number satellites. The joint contribution in R2-2200623 [5] has suggested that ephemeris information of up to 5 satellites are sufficient for the UE to predict the coverage discontinuity with a good accuracy. Hence, based on this discussion, the rapporteur ass the following question:

**Question 1: Do companies agree that five is a reasonable number for the maximum number of satellites whose ephemeris information will be provided? Please provide an alternative number and associated comments and arguments for disagreement.**

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| Company | Agree / Disagree | Comments |
| Lenovo, Motorola Mobility | Agree | We are fine with the number addressing operators’ needs. |
| InterDigital |  | We don’t have a very strong view but it is not very clear where the number 5 comes from, even reading the referenced document – the examples given are 3 satellites and 10 satellites and the only analysis is the number of bytes.  We should allow signalling of as many satellites as necessary considering a typical maximum eDRX configuration, and how many satellites are likely to pass in this time. If we are not able to do a proper evaluation, then allowing a higher maximum number of satellites e.g. 8 to be signalled and let the operator decide how many need to be signalled in their deployment, because the number needed will vary depending on e.g. density of satellites, as well as distance from earth, orbit speed, and eDRX configurations. |
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3.2 Sharing of Satellite Ephemeris Information

Once the ephemeris information is finalized, the next step is to determine how to provide this information to the UEs. This information can be provided either using a new SIB [6], [7], [8], [9], [10], [11] or dedicated RRC Signalling [5] as well. The advantage of using RRC signalling lies in the relative easiness of signalling modifications and updates in future releases. Hence, based on this discussion, the rapporteur asks the following proposal:

**Question 2: Companies are requested to mention their preference for providing this ephemeris information between the two options mentioned below:**

* **Option-1: Using a new SIB.**
* **Option-2: Dedicated RRC Signalling.**

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| Company | Option-1 / Option-2 | Comments |
| Lenovo, Motorola Mobility | Option-1 is preferred  Open to Option-2 | We see some benefits of using RRC signalling not only for future updates but also for reducing SIB size and UE power consumption of SIB reception.  However, the Satellite Ephemeris Information is necessary for discontinuity prediction, so that UE can avoid unnecessary actions (e.g. cell searching in IDLE or reestablishment attempt in CONNECTED) when NW coverage is absent. From this perspective the Satellite Ephemeris Information needs to be broadcast for IDLE UEs.  We think RRC signalling can be useful as a supplement, but considering the progress of Rel-17 (unless we can make quick discussion and decisions in this meeting), we would like to study Option-2 in further releases. |
| InterDigital | Option 1 | Discontinuous coverage enhancements seem primarily for UIEs in Idle/Inactive, at least in Rel-17, and therefore system information is the correct place to signal this. |
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3.3 Using Average Ephemeris and Almanac Information

During RAN2 116bis-e [4] it was discussed that instead of using instantaneous ephemeris information across multiple satellites, it will be better to use an average ephemeris and almanac information. However, the size and feasibility of specifying almanac needs to be taken into account. Hence, based on the discussion during RAN2 116bs-e, the rapporteur asks the following question:

**Question 3: Companies are requested to mention their preference for using this average ephemeris and Almanac information between the options given below:**

* **Option-1: Use only average ephemeris across multiple satellites.**
* **Option-2: Use average ephemeris and almanac across multiple satellites.**
* **Option-3: Do not use average ephemeris and almanac, rely only on instantaneous ephemeris of multiple satellites.**
* **Option 4: Allow the option to signal any of the above options**

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| Company | Option-1 / Option-2 / Option-3 | Comments |
| Lenovo, Motorola Mobility | Option-3 | The instantaneous ephemeris of the serving satellite has to be provided to the UE for TA pre-compensation and UL sync, and it has to be accurate enough. The instantaneous ephemeris of neighbour satellites is also needed for purposes other than discontinuity prediction. Therefore we do not see the necessity to introduce average ephemeris for discontinuity prediction.  If the ephemeris size is a major concern, we prefer to reduce the size by only providing the different or delta values. That is, for example, satellites in the same constellation could be on the same orbit, and in this case the instantaneous ephemeris of neighbour satellites may only include the parameters that are different from the serving satellite ephemeris (e.g., only ***Mneighbour***), or only include the delta values compared to the serving satellite ephemeris (e.g., ***ΔMneighbour = Mneighbour - Mserving***). |
| InterDigital | Option 4 | It might not be possible to conclude, and the answer may be different depending on the deployment, therefore the sensible option would be to allow the option for the operator to choose which way to signal. |
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3.4 UE Behaviour in Discontinuous Coverage

UE behaviour during discontinuous coverage is discussed in RAN2 116bis-e [4]. The options for UE behaviour can be broadly classified into two categories:

1. UE’s behaviour during the coverage discontinuity is left on UE implementation [6], [7], [13].
2. Specify UE behaviour during discontinuous coverage [8], [10], [12], [14]. This includes maintaining AS states, running related timers and informing NAS about coverage discontinuity etc.

Hence, the rapporteur raises the following question:

**Question 4: Regarding UE behaviour in Discontinuous Coverage companies are requested to mention their preference between the two options mentioned below:**

* **Option-1: Leaving UE behaviour during discontinuous coverage on UE Implementation**
* **Option-2: Specify UE behaviour (maintaining AS states, running related timers and informing NAS) during discontinuous coverage.**

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| Company | Option-1 / Option-2 | Comments |
| Lenovo, Motorola Mobility | Option-2 | At least for the UEs in IDLE, the UE behaviour during discontinuous coverage cannot rely on implementation. When an IDLE UE approaches coverage discontinuity or coverage holes, neighboring cell measurement triggering is mandatory when serving cell quality is lower than threshold, and UE will keep on measuring/scanning until it finds a suitable/acceptable cell when the coverage restores (could be hours after).  Besides, although the process of discontinuity prediction can be UE implementation, UE may need to inform NW about the results for aligned understanding, so that the NW will not try to page UE during discontinuous coverage. |
| InterDigital | Option 2, however | The question has been framed in an incomplete way. The question appears to address the UE behaviour in RRC\_CONNECTED only while neglecting Idle/Inactive behaviour – if in RRC\_CONNECTED we leave to UE implementation, then the network does not know whether e.g. UE just returns to idle, whether it maintains timers (and so may trigger RLF later) or whether it maintains the AS context and attempts to reconnect once coverage returns – the network has to know the UE behaviour in order to act accordingly ( e.g. locally release the connection after RLF would be triggered ). Hence we have to choose what to do – if we specify nothing, then UE should just continue to run the timers and may eventually trigger RLF if the coverage gap is sufficiently long. Another approach is to trigger RLF and/or go to idle mode immediately, and yet another options is to pause all timers and resume when back in coverage.  Since it is unlikely to converge in the last meeting we would suggest that the RRC\_CONNECTED UE behaviour is the same as legacy (so i.e. just trigger RLF after out of sync and timers expire – NOT leave to implementation) and we look at enhancements in R18.  What we do think needs to be specified is the idle mode behaviour and we address this in a contribution. In summary, the UE should be allowed not to perform measurements and not to monitor paging while in a discontinuous coverage gap. This will also allow some power saving in the RRC\_CONNECTED case, because once UE triggers the RLF/re-establishment there is no need to perform a cell search until back in coverage. |
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# 5 Conclusion

**<Will be updated after companies’ responses>**

# 6 References

1. R2-2202053 Summary of [Post116bis-e][087][IoT-NTN] Open Issues
2. R2-115e Chair Notes EOM
3. R2-116e Chair Notes EOM
4. R2-116bise Chair Notes Jan 28 EOM\_rev2
5. R2-2200623: On Discontinuous coverage in IoT-NTN, MediaTek Inc.
6. R2-2200217: Discussion on remaining issues on Non continuous coverage, Intel Corporation
7. R2-2200252: Discussion on the support of discontinuous coverage for IoT over NTN, OPPO
8. R2-2200440: Details on the support of the discontinuous coverage, Qualcomm Incorporated
9. R2-2200850: Discussion on open issues for support of Non continuous coverage, CMCC
10. R2-2201009: Discussion on remaining aspects of discontinuous coverage in IoT NTN, Nokia, Nokia Shanghai Bell
11. R2-2201599: Discontinuous coverage in IoT NTN, Ericsson
12. R2-2200694: Remaining FFSs on discontinuous coverage in IoT NTN, ZTE Corporation, Sanechips
13. R2-2201181: Support of discontinuous coverage, Apple
14. R2-2201453: Discussion on non-continuous coverage, Huawei, HiSilicon.