**3GPP TSG-RAN WG2 Meeting #116-e R2-21xxxxx**

**Online, Nov 1st – Nov 12th, 2021**

**Agenda item: 9.2.2**

**Source: MediaTek Inc.**

**Title: Summary of 9.2.2 Non continuous coverage**

**Document for: Discussion and Decision**

# 1 Introduction

This document is aimed at providing a summary of contributions submitted in Section 9.2.2 of IoT-NTN, identify potential agreements, open points, potential alternatives, and further enhancements. The 19 contributions [2] ~ [20] are summarized.

**Note-1**: RAN Plenary (RP) recommendations are to keep scope small when assessing the proposals, i.e. focus on essential enhancements. Non-essential enhancements should be considered only if impact is small.

* [AT116-e][027][IoT-NTN] Non continuous coverage (Mediatek)

Scope: Ph1 Treat documents under 9.2.2. Identify easy agreements, potential agreements (need discussion), potential alternatives, blocking points, Open issues (Note should only capture Open Issues that must be resolved in the end). Pave the way for on-line Discussion.

Intended outcome: Report

Deadline: Ph1 Monday W2

Deadline for company’s input: **Friday Nov 05 11:00 UTC**

Deadline for rapporteur’s summary: **Friday Nov 05, 20:00 UTC**

# 2 Contact Information

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# 3 Non Continuous Coverage

In the RAN2#115-e meeting [1], the following agreements on discontinuous coverage were agreed.

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| --- |
| * 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). * Satellite 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. * 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. * It is FFS to what extent it need to be specified the details of UE’s prediction of discontinuous coverage and its ability to detect when it is back in coverage. * 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. |

As it has been already agreed [1] that discontinuous coverage without excessive power consumption will be supported, at least for Idle Mode, and satellite assistance information will be used to assist the UE for predicting this discontinuous coverage. The details of satellite assistance types and UE’s prediction was FFS and any applicable agreements in NR-NTN can be reused. However, as there is no significant discussion and progress in NR-NTN regarding discontinuous coverage, it is pertinent that the discussion is carried out in IoT-NTN.

3.1 Satellite Assistance and Coverage Prediction

A vast majority (14/19) of the contributions [2], [3], [4], [5], [6], [7], [8], [10], [11], [14], [16], [17], [18], [19] have suggested to provide satellite ephemeris for assisting the UE with discontinuous coverage. Note that RAN-1 has already mentioned that satellite ephemeris could be in the form of either Position-Velocity (PV) information or Orbital Parameters. Hence, based on these contributions the rapporteur would like to ask the following question:

**Question 1: Do companies agree that satellite ephemeris (either PV information or Orbital Parameters) will be useful to the UE for predicting coverage discontinuity?**

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| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| Lenovo, Motorola Mobility | Agree | The current agreed formats of ephemeris data are useful but not sufficient to the UE for predicting coverage discontinuity. |
| Xiaomi | Agree | The ephemeris data can be used by UE to predict the non-continuous coverage. |
| Nokia | Agree with comments | RAN2 may need to discuss whether the ephemeris covers the whole constellation or only the next satellite or multiple future satellites available for coverage since the SIB size is quite limited in IoT NTN.  For example, for NB-IoT, the maximum SIB and SI message size is 680 bits per 36.331. Based on RAN1 WA, the size of PV information and orbital parameters is 17 bytes and 18 bytes separately. This means one SI can accommodate only 4 or 5 satellites ephemeris information. Furthermore, sending the 680 bit is also heavy and smaller value would be preferred considering the coverage requirement. We are not sure the SI can accommodate enough number of satellites for discontinuous coverage prediction since it depends on the constellation and UE preference for waking up.  So, we suggest rewording the proposal as:  *The satellite ephemeris (either PV information or Orbital Parameters) will be useful to the UE for predicting coverage discontinuity. FFS on ephemeris information broadcast in SIB.* |
| Huawei, HiSilicon | Agree with comments | At least information about the serving satellite and the next satellite is needed. |
| Qualcomm | Disagree | System information TBS is limited (see *si-TBS-r13* and *si-TB-r13*). Max TBS for eMTC is 936 bits and for NB-IoT is 680 bits.  RAN1 working assumption is to support Position and velocity state vector ephemeris format [17 bytes payload] and Orbital parameter ephemeris format [18 byte payload].  Now this means network can broadcast maximum of 4 satellites orbital information in a SI message. This is not sufficient to estimate the coverage gap for UE.  It is not clear how all information is provided in system information for IoT UEs. Also, it is not clear what is impact on SIB acquisition delay?  If UE is provided with 4 satellite ephemeris/orbital information but the UE in IDLE mode finds coverage from 5th satellite for which it has no ephemeris stored, it is not clear how it is called non-continuous coverage. Alternatively, the UE might not find the 5th (or 6th etc) satellite because ephemeris was not provided leading to unnecessary loss of coverage.  We think a better solution is needed, probably in Release 18. |
| Apple | Agree | Ephemeris information can be used to predict coverage. The question of what needs to be sent in SIB is a different one, in our opinion. It is not clear to us that system information is the best way to send ephemeris. This issue is not yet resolved for NR NTN as well, and we can wait for more progress in that feature before coming to a decision here. |
| Spreadtrum | Agree | The ephemeris data is useful to predict discontinuous coverage. The ephemeris data of both the serving satellite and the subsequent satellites should be provided. |
| ZTE | Agree | For each satellite, either PV information or Orbital parameters can be used for UE to predict the coverage of the satellite. Besides, the reference location and the footprint size of the cell can be used for UE to compare the distance (between UE and the cell) with the cell radius, and then determine the timing information of coverage discontinuity.  We also agree with Huawei the information about the serving satellite and the next satellite is needed. For saving signalling overhead, we tend to assume only one next satellite is enough. |
| Ericsson | Agree | It would be very challenging for discontinuous coverage with sparse satellite constellation without this. |
| Intel | Partially agree | Since the assumption could be only one or two satellites are used in IoT NTN, at least the orbital information can be used to predict the coverage status. For PVT format, it’s about instantaneous position of satellite, so it cannot be used for prediction. |
| Interdigital | Agree for earth-moving case. | For quasi-earth fixed case the start/stop times seems more appropriate and simpler. |
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**<Rapporteur Summary>**

Some contributions (9/19) [2], [4], [6], [8], [9], [10], [11], [15], [20] have also mentioned the use of start and end of satellite coverage. The majority of these contributions mentioned the use of coverage start and end time for primarily Quasi-Earth Fixed satellites. However, it should be noted that with UEs distributed across a large satellite cell (satellite beam spot), it might be difficult to estimate the exact coverage start and end time for all the UEs. Hence, based on these contributions, the rapporteur would like to ask the following question:

**Question 2: Do companies think that besides satellite ephemeris information, providing the start and end of satellite coverage is also needed, at least for Quasi-Earth Fixed satellites?**

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| **Company** | **Yes / No** | **Additional comments** |
| Lenovo, Motorola Mobility | Yes | The current agreed formats of ephemeris data may only help UE in deriving the position or orbit of satellites. With ephemeris data only the UE cannot accurately predict its coverage interruption period, especially for NGSO satellites the cells could be either moving or quasi-fixed.  For the quasi-fixed cells, broadcasting the stop serving time of the serving satellite was discussed and agreed to be used for service link switch issues in NR NTN. Such information could also be used as satellite assistance information. Additional information may include the start serving time of upcoming satellites. |
| Xiaomi | Yes | We think the coverage start time is the time of UE coming back to the coverage, in other words, the start time is about the upcoming satellites, and the end time is the time of UE leaving the serving cell coverage.  For quasi-earth fixed cell, the coverage start and end time is the same for all the UEs in the same cell，so the timing can be used for all UEs to predict the non-continuous coverage. |
| Nokia | Yes with comment | In our view, providing the start and end of satellite coverage is only needed for Quasi-Earth Fixed satellites. |
| Huawei, HiSilicon | Yes with comment | The start time is for the upcoming satellite, and the end time is for the current satellite. |
| Qualcomm | Yes | This would be an improvement but still falls short of being a complete solution.  However, we think providing start time for upcoming satellite and elevation angle is helpful for UE. Assumption is reference location is anyway will be broadcast by cell for other purposes as well. |
| Apple | Yes |  |
| Spreatrum | Yes | We think the start of satellite coverage should be provided at least. If the start of satellite coverage is included, the length of serving time can be optionally included. |
| ZTE | Yes | If the information about the start and end of satellite coverage is provided, it can simplify UE’s prediction. |
| Ericsson | More details are needed | So far the discussion on this has not been detailed enough on how it would work. Only start and end time would not be enough, considering mobility of the UE.  We think it could be tricky to only supply the time when the start and end of the satellite coverage along with the satellite ephemeris information. Instead the UE should be supplied with the satellite ephemeris along with geometric information to represent the coverage so that UE can calculate this instead.  The geometric information so that UE can calculate at least the start time are location points along with elevation angles upon where the satellite activates the location points, along with a coverage radius. |
| Intel | Yes with comments | In our view, earth-moving cell should be the typical scenario for discontinuous coverage. Even for quasi-earth fixed cell, it’s not enough to only provide cell start and end time, the beam size and beam centre location are also needed for coverage prediction. |
| Interdigital | Yes | We think this is needed instead of, not in addition to, for quasi-earth moving case. |
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**<Rapporteur Summary>**

It is expected that the UEs should be able to use the assistance information to predict the coverage discontinuity, stop any cell search and enters in the dormant state. 8/19 contributions [2], [3], [7], [8], [10], [17], [18], [19] mention that the details of UE’s prediction on discontinuous coverage should up to the UE implementation. One contribution [6] mentions the UE behaviour upon being in the no cell available state following the discontinuous coverage or satellite visit time needs to be clarified. Based on this information the rapporteur would like to ask the following question:

**Question 3: Do companies agree that the details of UE’s prediction of discontinuous coverage should be left on UE implementation?**

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| **Company** | **Yes / No** | **Additional comments** |
| Lenovo, Motorola Mobility | Yes | How to predict the coverage discontinuity based on available information is UE implementation. |
| Xiaomi | Yes | How to predict non-continuous coverage based on assistance information should be left to UE implementation. |
| Nokia | Yes with comments | For coverage window prediction, it is fine to leave this to UE implementation, but the UE and NW need to be synchronized for paging in terms of the coverage window, e.g. based on the UE reporting the estimate to the NW. Furthermore, a key issue is the prediction inaccuracy in some UEs as mentioned by R2-2104863. We understand UE’s prediction error may impact at least paging since NW would assume when the UE is reachable for paging based on UE’s prediction while UE is actually out of coverage. We suggest rewording the proposal as below:  *The details of UE’s prediction of discontinuous coverage should be left to UE implementation. UE and NW need to be synchronized for paging in terms of the UE’s coverage window prediction.* |
| Huawei HiSilicon | Yes with comment | We agree that the details of UE’s prediction of discontinuous coverage can be left to UE implementation.  We still need to clarify the UE behaviour when in no coverage, i.e. stop all usual AS idle mode functions (can be very simple, similar to PSM description). |
| Qualcomm | No | Such solution where UE’s prediction of discontinuous coverage is left on UE implementation can be proprietary and should not be documented in specs without specifying a complete system level solution involving CT1 and SA2.  Otherwise, it will be problematic for future enhancement as UE and CN must be synchronized for paging to work and it will not be possible to change legacy behaviour. |
| Apple | Yes | The UE should inform the network prior to going out of coverage. This way the network can avoid needlessly paging the UE. |
| Spreadtrum | Yes |  |
| ZTE | Yes | We are generally fine with Nokia’s suggestion, but think “coverage window” seems too specific. So our further suggestion is:  *The details of UE’s prediction of discontinuous coverage should be left to UE implementation. UE and NW need to be synchronized for paging in terms of the UE’s coverage prediction.* |
| Ericsson | Yes with comments | It is up to UE implementation, but we need to make sure that all information is sufficient for the UE to estimate this. Only start and stop time would not be enough. |
| Intel | Yes |  |
| Interdigital | Yes | However we should specify when e.g. “UE may choose not to measure” etc. |
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**<Rapporteur Summary>**

3.2 Paging Issues

A few contributions [7], [17], [18] have pointed out the problems associated with paging, e.g. UEs could be unreachable. However, as pointed out in [7] and [18], the network can simply consider the UE unreachable (e.g., for paging purposes) till such time as the UE establishes an RRC connection. The question is whether RAN2 needs to specify anything regarding this paging aspect. Based on this, the rapporteur would like to ask the following question:

**Question 4: Do companies think RAN2 needs to do anything regarding Paging aspects with coverage discontinuity?**

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| **Company** | **Yes / No** | **Additional comments** |
| Lenovo, Motorola Mobility | No, and | This may depend on the final solution of assistance information. If the network and UE have aligned understanding of coverage discontinuity (e.g. time period of coverage interruption at UE), RAN2 will not need to specify more for paging. |
| Xiaomi | No | We think the other group is more feasible to handle paging issue since the paging message is from the core network, can CN will not page UE when UE in the non-continuous coverage. |
| Nokia | Yes | As agreed in the SI, UE and NW should be synchronized w.r.t. when the UE is awake and reachable for paging. Thus, RAN2 need to discuss how NW synchronize with UE for paging about UE's coverage ON/OFF in discontinuous coverage. Furthermore, the UE coverage prediction error (as comment in Question3) should also be considered for paging. |
| Huawei, HiSilicon | No | Paging aspects should be discussed in SA2 |
| Qualcomm | No | We do not think MT call service would work without system level solution including other working groups SA2/CT1/RAN3.  It depends on progress in other working group how network knows the discontinuous coverage. |
| Apple | Yes | The UE should inform the network prior to going out of coverage. This way the network can avoid needlessly paging the UE. |
| Spreadtrum | Yes | Similar comments as Nokia. |
| ZTE | No | Similar view as Qualcomm. |
| Ericsson | Yes | There are risks that with certain eDRX and PSM patterns that UE becomes unreachable for a too long time with respect to the discontinuous coverage and we think it would be difficult to rely on periodicities for this. Therefore we think that there needs to be something introduced in order to allow for more frequent monitoring at for instance the beginning or end of a coverage period. |
| Intel | No | Same view with QC |
| Interdigital | Yes | It may not always be possible to align PTW with “in coverage” times therefore some modification to PTW may be needed, e,g, to extend or shift the PTW to occur before the coverage gap. This may however not be possible to complete in R17 so we may need to postpone to R18. |
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**<Rapporteur Summary>**

# 4 Power Savings

During the Study Item phase, power savings was discussed and it was agreed that existing power saving mechanisms, like DRX, PSM, eDRX, relaxed monitoring, and WUS can be reused without enhancement. Enhancements can be considered, if found needed, to support discontinuous coverage. A few contributions in [2], [12], [14], [20] mentioned about power savings and its enhancements. Based on these contributions, the rapporteur would like to ask the following question.

**Question 5: Do companies agree that 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?**

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| **Company** | **Yes / No** | **Additional comments** |
| Lenovo, Motorola Mobility | No | The existing mechanisms can be used for discontinuous coverage, but some minor enhancements are needed. For example:   * Relaxed monitoring   To use relaxed monitoring it is required that less than 24 hours have passed since measurements for cell reselection were last performed and the UE has performed intra-frequency or inter-frequency measurements for at least TSearchDeltaP after selecting or reselecting a new cell. To leverage relaxed monitoring for discontinuous coverage, the cell quality tolerance (SSearchDeltaP) has to be large enough to forbid further measurement. Meanwhile TSearchDeltaP is better to be shorter (now at least 5min) for efficient power saving.   * PSM   The Active Time (T3324) and periodic TAU/RAU timer (T3412) can only be configured in attach or TAU/RAU procedure, and misalignment between T3324/T3412 configuration and coverage interruption period may cause unnecessary measurement for cell selection/reselection or TAU/RAU without coverage.  Another potential issue is that even if the network is aware of the coverage interruption period for a specific UE, it may be difficult to configure the PSM duration appropriately using standard mechanism. According to TS24.008, the value range of T3324 (as GPRS timer 2) is {0~31}\*{2s,1min,10min} i.e. 0s~310min. And the duration of PSM is restricted by periodic TAU timer T3412 (as GPRS timer 3) with value range {0~31}\*{2s,30s,1min,10min,1h,10h,320h(extended)}. Consider the Walker constellation mentioned in R2-2101248 as an example, the average coverage interruption period is 8 hours (6 planes, 1 satellite per plane). For a coverage interruption period around 8 hours (e.g. 7.5 hours), network can only configure T3412 at a granularity of 1 hour (i.e. 7 or 8 hours), and the maximum misalignment can be 0.5 hour. |
| Xiaomi | Yes | UE can recommend the preferred PSM/eDRX configuration based on the UE prediction of the non-continuous coverage and then the CN will provide the proper PSM/eDRX configuration, and the configuration could match the non-continuous coverage. |
| Nokia | Yes with comments | We think the existing power saving mechanisms can be reused with enhancements. For example, to support discontinuous coverage, we share companies view that at least enhancement to existing PSM, eDRX need to be discussed. (e.g. to save UE’s power, NW should align the eDRX/PSM configuration with the non-continuous coverage to decide when UE should perform paging monitoring.) Furthermore, RAN2 should consider removing the Rel-16 restriction of only using WUS in last serving cell as even for stationery UE there will be cell reselection due to cell mobility, which would lead to disabling of WUS monitoring for the UE. |
| Huawei, HiSilicon | Yes with comments | We agree that we do not need enhancements to DRX, PSM, eDRX, relaxed monitoring, and WUS features. But we still need to specify the behaviour of the UE in discontinuous coverage, i.e. stop all these functions. |
| Qualcomm | Yes with comment | If there is no discontinuous coverage enabled, we think these mechanisms can be re-used, e.g., for GEO.  In case of discontinuous coverage, we think PSM can be re-used but won’t work as intended for core network. |
| Apple | Yes | We don’t think anything needs to be done from RAN2 perspective but agree that it is not clear how PSM will likely need to be enhanced. However that topic is out of RAN2 scope. |
| Spreadtrum | Yes with comment | For the case of discontinuous coverage, some minor enhancements are needed for these functions. In order to obtain the alignment understanding between UE and NW, some related configuration and signalling should be specified. |
| ZTE | Yes | Firstly, we can agree existing power saving mechanisms e.g. DRX, PSM, eDRX, relaxed monitoring, and WUS can be reused in IoT-NTN.  We have sympathy with some thoughts from Xiaomi and Nokia, but tend to assume they are mainly SA2/CT2 work. For example, it seems more suitable to let UE recommend the preferred PSM/eDRX configuration via NAS.  Now RAN2 can just wait for progress from other groups.  About WUS, we prefer to keep same strategy between IoT NTN and IoT. According to the historical discussion, it’s not easy to say removing the Rel-16 restriction of only using WUS in last serving cell would bring more power saving. It can be the case for the mentioned UE (e.g., the UE that changes to another new cell). But it may cause more power consumption for the UEs that originally be in the new cell, due to false wake up. |
| Ericsson | Yes | We think for Rel-17 that the current mechanisms can be reused and in particular for discontinuous coverage they could be reused as it would be up to UE implementation to wake up at the right time.  For WUS and relaxed monitoring we are not quite sure how it would function for moving cells etc but for Rel-17 we think that it would be acceptable. |
| Intel | Yes | But CN should be involved to make adaptation of these mechanisms. |
| Interdigital | Yes? | We assume that enhancements can be considered in Rel-18. NW can disable e.g. relaxed monitoring if it doesn’t work well. eDRX may need to be enhanced, but as mentioned above it might be too late to complete this in R17. |
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**<Rapporteur Summary>**

# 5 Other Aspects

Other aspects in discontinuous coverage include

* Specifying assistance information that UE can provide to enable the network to detect when and where the UE will be back in coverage [11]
* Extension and updates of related timers, e.g. T301, T320 or T322 [14]

However, these details of UE assistance and timer extensions can be discussed once some more progress and agreements in discontinuous coverage are made.

# 7 Conclusion

**<To be updated after responses from the companies are collected Rapporteur Summary>**

# 8 References

1. RAN2-115-e ChairmanNotes EOM Rev2.
2. R2-2109504 Discussion on discontinuous coverage for IoT over NTN OPPO
3. R2-2109640 Discussion on remaining issues on non-continuous coverage Intel Corporation
4. R2-2109702 Discussion on the support of discontinuous coverage for IoT NTN CATT
5. R2-2109821 Contents and delivery options for Satellite Assistance Information for NTN Gatehouse, Sat.
6. R2-2109965 Satellite visit time for non-continuous coverage Qualcomm Incorporated
7. R2-2110071 Support of discontinuous coverage Apple
8. R2-2110114 Remaining FFSs on discontinuous coverage in IoT NTN ZTE Corporation, Sanechips
9. R2-2110130 Discussion on the issue of non-continuous coverage Spreadtrum Communications
10. R2-2110262 Discussion on support of Non continuous coverage CMCC
11. R2-2110313 Assistance information for NTN discontinuous coverage Lenovo, Motorola Mobility
12. R2-2110314 Enhancement for idle UE power saving in discontinuous coverage Lenovo, Mot. Mobility
13. R2-2110315 RRC connection handling for discontinuous coverage in IoT NTN Lenovo, Motorola Mobility
14. R2-2110544 Power Saving in Discontinuous Coverage for NB IoT NTN Rakuten Mobile, Inc
15. R2-2110549 Support of Discontinuous Coverage for IoT-NTN Interdigital, Inc.
16. R2-2110705 On aspects of discontinuous coverage in IoT NTN Nokia, Nokia Shanghai Bell
17. R2-2110834 Discontinuous coverage in IoT NTN Ericsson
18. R2-2110922 On Discontinuous coverage in IoT-NTN MediaTek Inc.
19. R2-2110977 Discussion on non continuous coverage Huawei, HiSilicon
20. R2-2111112 Discussion on discontinuous coverage Xiaomi