3GPP RAN WG2 Meeting #121bis-e (draft)R2-2304258

eMeeting April 17th – 26th, 2023

Agenda Item: 7.6.4

Source: InterDigital (Rapporteur)

Title: [DRAFT] Report of [AT121bis-e][115][IoT NTN Enh] Discontinuous coverage enhancements (Interdigital)

Document for: Discussion, Decision

# Introduction

This document is intended address contributions on discontinuous coverage enhancements for non-terrestrial networks submitted to AI 7.6.4, as per the following:

* [AT121bis-e][115][IoT NTN Enh] Discontinuous coverage enhancements (Interdigital)

Scope: Discuss possible discontinuous coverage enhancements based on [R2-2303716](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303716.zip) and possibly including proposals from other contributions as well (, )

Intended outcome: Summary of the offline discussion with e.g.:

* List of proposals for agreement (if any)
* List of proposals that require online discussions
* List of proposals that should not be pursued (if any)

Deadline for companies' feedback: Tuesday 2023-04-25 06:00 UTC

Deadline for rapporteur's summary (in R2-2304258): Tuesday 2023-04-25 08:00 UTC

Proposals marked "for agreement" in R2-2304258 not challenged until Tuesday 2023-04-25 20:00 UTC will be declared as agreed via email by the session chair (for the rest the discussion might continue online in the Wednesday CB session).

# Background

In RAN2#121 the following agreements were made:

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| Agreements:   1. RAN2 can continue to check whether dedicated RRC signalling can be used for providing satellite information corresponding to discontinuous coverage. 2. RAN2 will support enhancements in paging and eDRX, in alignment with the work in SA2 and CT1. FFS on the details 3. RAN2 may consider enhancements for connected UE upon detecting discontinuous coverage (e.g., suspend RLM, RLF detection, and RRC re-establishment process) 4. Companies supporting the store and forward approach can bring a proposal to the plenary for TEI18 or for updating the WID |

# Discussion

## Dedicated RRC signalling for providing satellite information corresponding to discontinuous coverage

The following agreement was reached in RAN2#120:

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| **Agreement:**  RAN2 can continue to check whether dedicated RRC signalling can be used for providing satellite information corresponding to discontinuous coverage |

The following summarizes RAN2#121bis-e contributions discussing this issue:

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| [2] (CATT) Proposal 2：Providing satellite information corresponding to discontinuous coverage via dedicated signaling (not RRC Release message) is not needed, or at least should be de-prioritized. |
| [3] (CMCC) Proposal 1: RAN2 discuss to transfer more satellite assistance information via dedicated signaling, SIB segmentation or multiple SIBs. |
| [10] (Nokia) Proposal 1: RAN2 to discuss the provisioning of additional satellites’ ephemeris via dedicated RRC signalling. |

**Question 1) Do you support introduction of dedicated signalling for providing satellite information corresponding to discontinuous coverage to the UE? If so, please give details.**

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| **Company** | **Yes/No** | **Additional comments** |
| Google | No | SIB32 should be sufficient. |
| MediaTek | No strong opinion | As a NTN cell may cover a large geography area, the system capacity can be a serious concern. To provide more satellite information than 4, network can change the content of SIB32 from time to time.  However, in R-17 satellite vendors wanted to support this. So, we are open to listen their views if they can convince us. |
| CATT | No strong view | Agree with Media Tek, we can follow the view of satellite vendors. |
| Spreadtrum | No | We think such satellite assistance information is common for the UEs stay in the same one cell. Hence, it is straightforward to transfer the relevant information via SIB message. |
| Lenovo | Yes | OK to fulfil the requirements from satellite vendors. |
| Qualcomm | Yes | More than 2/3 satellite information will be needed. In addition, different operators will have different coverage depending on how and where the UE is registered to the service. |
| ZTE | No | We cannot see the clear motivation or justification for providing additional satellites’ ephemeris via dedicated RRC signalling. Meanwhile, the disadvantage is clear, e.g., unnecessary signalling overhead by providing some satellites information which may be common to many UEs.  In [2] and [3], companies have a bit negative views for using dedicated signalling. In [3], company suggest to further consider multiple SIBs or SIB segmentation, but we think the scheme of “multiple SIBs” is already allowed. As mentioned above by MediaTek, network can change the content of SIB32 from time to time in order to provide more satellite information than 4. That’s also one reason why we introduce the satellite ID in SIB32.  In [10], company give a scenario where the 4 satellites in SIB32 define 4 coverage windows within the next 4 hours, but the UE will only trigger uplink data every 12 hours. By use of dedicated RRC signalling, the network could provide the satellite assistance information, which would suit the UE’s traffic profile. However, it may be very unlikely for RAN to predict coverage for a certain UE after that long time. So we don’t think it’s feasible for RAN to provide suitable additional satellite assistance information to UE via dedicated signalling. |
| Xiaomi | No |  |
| NEC | No | We don’t see a strong motivation for this, current broadcast is sufficient. |
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## Enhancements in paging and eDRX

The following agreement was reached in RAN2#120:

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| **Agreement:**  RAN2 will support enhancements in paging and eDRX, in alignment with the work in SA2 and CT1. FFS on the details |

The following summarizes RAN2#121bis-e contributions discussing solution directions:

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| [1] (Apple) Proposal 1: RAN2 to discuss whether to address the mismatch issue between PTW and actual coverage time. |
| [2] (CATT) Proposal 4：Enhancements on paging and eDRX should be supported to avoid UE monitoring paging during the UE unreachability periods, and to guarantee the UE reachability during the coverage periods.  [2] (CATT) Proposal 5：The calculations related with paging/eDRX (e.g., PH/PO, PH or PTW) should not be changed. |
| [6] (Huawei) Proposal 1: NW should be able to configure multiple Paging Time Windows during an eDRX cycle. |
| [7] (Interdigital) Proposal 2: PTW can be adjusted with co-ordination between UE and NW to account for UE unreachability periods.  [7] (Interdigital) Proposal 3: RAN2 to down select between the following options for PTW adjustment:  - Option 1 (configurable offset)  - Option 2 (updated PTW calculation)  - Option 3 (UE/NW autonomous adjustment)  - Option 4 (other?) |
| [8] (Lenovo) Proposal 2: RAN2 to consider enhancements to PSM/eDRX for aligning PSM/eDRX duration with coverage interruption period at UE. |
| [10] (Nokia) Proposal 3: The PSM and eDRX configurations can be configured to align with the estimated UE unreachability period  [10] (Nokia) Proposal 4: Network can extend the paging before/after the coverage window if the UE does not respond to paging within the estimated coverage window.  [10] (Nokia) Proposal 5: UE can extend the paging monitoring outside the estimated coverage window if radio coverage is available. UE may report to the network to realign the paging monitoring and coverage windows. |
| [14] (Spreadtrum) Proposal 1: In order to ensure that the UE can be reachable when paging arrives, the PTW should aligns with the time duration of coverage and the following two options can be taken into further consideration:  Option 1: both UE and network adjust PTW based on a predefined rule  Option 2: network provides multiple PTW info |
| [16] (Xiaomi) Proposal 2: UE determines the paging cycle only based on UE specific DRX/eDRX configured by AMF if the AMF takes the UE coverage information into consideration when configures the UE specific DRX/eDRX. |
| [17] (ZTE) Proposal 1a: If legacy eDRX is used for keeping alignment between UE and NW during discontinuous coverage, in order to align the starting time of PTW with the out-of-coverage period or unreachability period, it’s suggested to introduce a configurable offset to shift the starting time of PTW. |

The following detailed options are proposed, based on the contributions listed:

- Option 1 (configurable offset) [17], [14]

- Option 2 (updated PTW calculation) [7], [14]

- Option 3 (multiple PTW during an eDRX cycle can be configured) [6], [14]

- Option 4 (UE/NW autonomous adjustment + UE may report to the network to realign the paging monitoring and coverage windows) [10]

- Option 5 (UE determines the paging cycle only based on UE specific DRX/eDRX configured by AMF) [16]

As a first step, the above solutions can be put into 3 solution categories. If one of the below options can be selected, then

* Option A: Updated PTW configuration (options 1, 2, 3)
* Option B: UE autonomous adjustment (option 4)
* Option C: No RAN impact (option 5)
* Other?

**Question 2) Do you support?**

* **Option A: Updated PTW configuration (details FFS, e.g. configurable offset, updated PTW calculation, multiple PTW configurations)**
* **Option B: UE autonomous adjustment (details FFS, e.g. extend the paging monitoring, report to NW)**
* **Option C: No RAN impact (revert the agreement from last meeting)**
* **Other? (please describe)**

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| **Company** | **A/B/C/other** | **Additional comments** |
| Google | B | Option A is totally out of RAN2 scope, as the PTW configuration is provided via the NAS signalling.  Option B is acceptable to us. But there might be a need to instruct UE how to ‘autonomously adjust’ the PTW (e.g., extending the PTW by how much, shifting the PTW to the left or to the right), and such an instruction can be provided in the NAS signlaing, together with the PTW configuration. Therefore, we think Option B also has some NAS impact. |
| MediaTek | Option C | Update to PWT configuration can help to align the UE paging monitoring and coverage window, however, option A is in scope of SA2 and not in scope of RAN2.  Option B seems cannot guaranttee the successful paging receiving. We believe RAN2 has no impact on this aspect. |
| CATT | Option B or Optino A | For Option B, we have the same view with Google.  We can accept a offset for PTW, but without PTW formula change. |
| Spreadtrum | A | We think option A is easy for UE and network to use the same scheme to determine the available PTW. For example, in the method of configurable offset, the available PTW can be determined by shifting PTW with a predefined rule. |
| Lenovo | Option B | Agree with Google’s view. |
| Qualcomm | Option C | Agree with MediaTek. We have not identified from the SA2 Rel-18 work, what RAN needs to do. Such enhancement has to be done with coordination with SA2. |
| ZTE | Option A  Option B is infeasible | For paging function with eDRX configuration, UE and NW should have explicit alignment on the PTW window (e.g., Paging Hyperframe (PH), a starting position within the PH (PTW\_start) and an ending position (PTW\_end)). PTW window determination is defined in TS 36.304. The UE cannot autonomously adjust the PTW window by itself. Misalignment of PTW window between UE and NW would either result in unnecessary UE power consumption (UE monitors but NW doesn’t transmit paging) or missing of paging (NW transmits but UE doesn’t monitor). So we think Option B is obviously infeasible.  For Option A, as Rapp classifies several different options into Option A, e.g., configurable offset, updated PTW calculation, multiple PTW configurations, we understand the “*Updated PTW configuration*” is only a high level description for Option A, and it is not limited to just discussing PTW parameters configuration (e.g., the eDRX cycle provided to UE via NAS signalling and provided to RAN via S1 signalling).  In the scenario of discontinues coverage, for UE in RRC\_IDLE, on one hand, the network needs to avoid paging UEs during UE unreachability period. On the other hand, NW also needs to page UEs as soon as possible after coverage is resumed. In current RAN2 specifications, the starting time of PTW is mainly determined by UE ID. That may make it not easy to align the PTW\_start with the end of the out-of-coverage period. Therefore, it’s better to also consider the discontinuous coverage information in the PTW window determination.  Within Option A, we think a configurable offset to PTW\_start would be a simple optimization. That is, a configurable offset can be introduced to shift the starting time of PTW to align with the end of the out-of-coverage period. |
| Xiaomi | None | We agree that currently the start position of PTW is controlled by AS not NAS. Unless we let NAS to set the start position or AS to modify the start position, the PTW cannot be aligned with the discontinuous coverage. Either way there would be a lot of spec changes, so perhaps not to support eDRX but only PSM.  Option A: Not sure how it works. Does it mean to add PTW start position configuration in NAS signnaling?  Option B: More discussion is needed. |
| NEC | A | PTW offset is currently calculated based on UE-ID, so it cannot be ealier or later as NW wants (to make sure PTW start point fall within the coverage window), so changing the way of deriving PTWs might be needed at least.  As for adjustment and realigning, it seems to be an optimization if there’s issue the caluculated PTW may not be suitable after a period of time. |
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## UE assistance information

The following summarizes RAN2#121bis-e contributions discussing UE assistance information and UE unreachability period:

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| [1] (Apple) Proposal 2: UE assistance information can be used for PTW adjustment.  [1] (Apple) Proposal 3: Send an LS to SA2/CT1 on unevenly distributed coverage period caused by unevenly distributed satellite from multiple satellites. |
| [5] (Google) Proposal 3 A RRC\_CONNECTED UE can inform the network of the remaining time that the UE will be within the satellite coverage before entering an unreachability period, using a RRC message (e.g., UEAssistanceInformation). |
| [7] (InterDigital) Proposal 7: RAN2 to discuss whether it can be assumed that reporting of UE unreachability period in Registration Request can be kept sufficiently (i.e. to support AS based solutions) up to date and takes into consideration UE mobility, or whether this needs to be confirmed with SA2. |
| [9] (NEC) Proposal 1: Consider to support UE providing assistance information on being out-of-coverage. |
| [17] (ZTE) Proposal 1b: The out-of-coverage period or unreachability period should be informed to RAN, e.g., from core network node, to assist RAN to provide a more appropriate paging schedule for UE in idle mode.  [17] (ZTE) Proposal 2d**:** The UE in connected mode could provide out-of-coverage period or unreachability period information as an assistance to the network (eNB). |

Given that SA2 have already agreed UE reporting of the unreachability period, we may not need to introduce any further RAN information. However, based on the above proposals, we may additionally need RAN assistance information and/or this information may need to be provided to RAN for PTW calculation. In addition we may need to check with SA2 whether the reported UE unreachability is sufficient for RAN needs.

**Question 3a) Do you assume RAN assistance information is needed in addition to UE unreachability period in Registration Request? If so, please indicate what/why.**

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| **Company** | **Y/N** | **Additional comments** |
| Google | Y | As pointed out in our paper, it may take some time for eNB/gNB to release a connected state UE after the UE has entered an unreachability period, if the eNB/gNB only relies on the TA timer, the RRC inactivity timer, or any other T311-like timer to trigger an AN release procedure. However, as none of these timers aligns UE’s unreachability pattern, it is very likely the network still regards the UE as being in the connected state for an extra period after the UE has entered an unreachability period. Therefore, it is beneficial if the connected UE can inform the network of the remaining time that the UE will still be within the satellite coverage before entering an unreachability period. |
| MediaTek | N | We think the unreachability period reported from UE should be enough. |
| CATT |  | Not strong view. But we need more discussion on the scenario or use case. |
| Spreadtrum | N | We think the reported unreachability period is sufficient for PTW determination. |
| Lenovo | No strong opinion | We think it is better to leave it open in case additional info is identified to be necessary. |
| Qualcomm | See comment | If it is about UE unreachability period, then No.  But it is about release assistance information to RAN, same today’s RAI, then Yes. |
| ZTE | Yes | In R17, UE and NW determines the UE unreachability period by themselves. There is no way for them to align their understaning. In R18, this aspect has been optimized.  For R18, SA2 has defined UE out-of-coverage period or unreachability period in their study. That is, either UE or CN nodes can determine such UE unreachability period based on the information they can obtain, e.g., satellite coverage information (satellite constellation, satellite orbit data etc.) and/or UE location/mobility/trajectory information etc. The determined unreachability period also needs to be notified to the peer node (e.g., via NAS signalling). However, we want to indicate that UE unreachability period reported in Registration Request can only be acquired by CN, but not by RAN.  For UE in idle mode, as mentioned in our comments for Q2, we think RAN needs the information of unreachability period to configure a suitable offset for UE and NW to shift the starting time of PTW to align with the end of the UE unreachability period.  For UE in connected mode, as mentioned in our below comments for Q5, we have similar view as Google that, if NW can acquire more information about UE unreachability period, NW can gracefully release UE to RRC\_IDLE state timely.  Therefore, we think UE unreachability period should be informed to RAN. We are open to discuss which side, UE or CN node, is suitable to provide such information to RAN. |
| Xiaomi |  | It is dependent on Q2, if eDRX solution is not used for discontinous coverage, then no need for eNB to know additional information. |
| NEC | See comment | For paging purpose, reporting of UE unreachability period in Registration Request should be enough, CN will then configure eDRX/ PTW accordingly.  For RRC connection management purpose, it is good for UE to report the relevant assistance information before being out of coverage. |
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**Question 3b) Do you agree that clarification from SA2 (i.e. with an LS) is needed regarding using, in RAN, the UE unreachability period reported in Registration Request?**

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| **Company** | **Y/N** | **Additional comments** |
| Google | Y | As far as we know, the unreachability period is reported by the UE in the **Mobility Registration Update** procedure, and currently is only used by the NAS layer, for determining the periodic registration update timer, the e-DRX config, and the MICO mode config. It might be good to have SA2’s clarification on whether the unreachability period is also intened for the RAN usage, and on the means for passing this information to the RAN node (if it is also intended for RAN). |
| MediaTek | Y | It would be helpful for RAN2 check if any additional information is needed. |
| CATT | Y |  |
| Spreadtrum | Y | A clarification from SA2 is helpful in the respect of understanding the mechanism of PTW determination. |
| Lenovo | Y |  |
| Qualcomm | Y |  |
| ZTE | N | We see not so much need/help to ask SA2. RAN2 can decide whether additional information would be needed based on the analysis on our own procedures, e.g., paging procedure defined in TS 36.304 and RRC connection release procedure defined in TS 36.331. If something is identified and need to be provided from core network, we can further check with SA2 and RAN3. |
| Xiaomi | Y | A clarification is needed whether the unreachability period will be used for eDRX solution, and if so, how. |
| NEC | See comment | Clarification is always welcome. But we are not sure about the purpose of this question, do we intend to send a LS asking for clarification about unreachability period report in registration requrest generally?  If unreachability period report will impact PTW configuration, SA2 should inform us.  If unreachability period is useful from RAN, RAN2 can ask to make this information available in RAN.  If SA2 believe unreachability periodi should be made available to RAN, then SA2 shall inform us what it will be used for. |
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## Enhancements for connected UE

The following agreement was reached in RAN2#120:

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| **Agreement:**  RAN2 may consider enhancements for connected UE upon detecting discontinuous coverage (e.g., suspend RLM, RLF detection, and RRC re-establishment process) |

The following summarizes RAN2#121bis-e contributions discussing this issue:

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| |  | | --- | | [1] (Apple) Proposal 4: UE follows legacy operation in declaring RLF upon entering coverage gap. | |
| [7] (Interdigital) Proposal 4: For eMTC and NB-IoT: RLM, RLF detection, and RRC re-establishment are suspended during a UE unreachability period.  [7] (InterDigital) Proposal 5: For eMTC: To avoid always sending the UE to RRC\_IDLE/RRC\_INACTIVE during a UE unreachability period, introduce an activation time in RRC Reconfiguration to allow handover between cells occurring before and after a UE unreachability period.  [7] (Interdigital) Proposal 6: For eMTC: Consider how discontinuous coverage impacts CHO. |

**Question 4) Do you think any enhancement is needed to allow a UE in RRC Connected to stay in RRC\_CONNECTED during/after a coverage gap? (Details FFS, e.g. suspend RLM/RLF, activation time in RRC Reconfiguration, CHO enhancement)**

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| **Company** | **Y/N** | **Additional comments** |
| Google | N | In the opposite way, we propose in our paper [5] that UE in RRC\_CONNECTED shall transition into RRC\_IDLE autonomously and immediately upon entering a coverage gap, by skipping/terminating the RLM/RLF scheme. Otherwise the UE may end up wasting its power by staying in the connected state for extra time. |
| MediaTek | N | This is not needed, as suspending RLM can left to UE implementation. The coverage gap is assumed to be long, keep UE in RRC connected mode during the unreachability period is not power optimized. |
| CATT | No strong view | But maybe we can just discuss the case that UE will transition to RRC\_IDLE firstly, with other case lower priority. |
| Spreadtrum | N | It is simple for UE to release from RRC connected mode at the start time point of coverage gap and, any enhancements are not expected. |
| Lenovo | N | We see no essensity to have this, especially considering that the coverage gap could be long. |
| Qualcomm | N | We are not clear in proposal. |
| ZTE | N | We have sympathy with above comments. It’s better to move UE to RRC\_IDLE state ASAP when discontinuous coverage starts. |
| Xiaomi | N |  |
| NEC | N | There is no big gain to keep UE in RRC-connected mode comparing to send the UE to RRC\_INACTIVE mode. So we prefer that NW send the UE to RRC inactive mode when coverage gap is coming, this does not require any enhancement |
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## RRC Release

Several companies have proposed enhancements to RRC Release in this meeting.

The following summarizes RAN2#121bis-e contributions discussing this:

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| [2] (CATT) Proposal 3：RRC Release message can be updated to enhance discontinuous coverage. |
| [3] (CMCC) Proposal 2: The UE can provide the out-of-coverage information to RAN node for e.g, optimization on RRC release or paging.  [3] (CMCC) Proposal 4: A new cause value ‘Release due to discontinuous coverage’ is introduced in RRCRelease message. |
| [10] (Nokia) Proposal 8: RAN2 to discuss support for UE request for RRC connection release based on DC estimation. FFS support for implicit RRC connection release. |
| [11] (Qualcomm) Proposal 2 Reuse NR MUSIM timer T346g behavior, i.e., upon expiry of the out-of-coverage timer, the UE performs the actions upon leaving RRC\_CONNECTED, with release cause 'other'. |
| [12] (Rakuten) Proposal 3a: eNB to initiate RRC release based on relative UE location with respect to beam footprint, Proper cause value have to be added into spec.  [12] (Rakuten) Proposal 3b: UE itself release network based on configured Timing Advance (TA) value communicated by NTN cell. Proper cause value needs to be added in to spec. |
| [17] (ZTE) Proposal 2a: A new release reason, e.g., ‘Release due to discontinuous coverage’ as that introduced in RAN3, can be introduced in RRC release message for indicating UE to stop the subsequent AS layer processes after it is released to idle mode.  [17] (ZTE) Proposal 2b: An AS-NAS interaction (e.g., an indication from AS to NAS) also needs to be introduced for indicating UE to stop the subsequent NAS layer processes after it is released to idle mode due to discontinuous coverage.  [17] (ZTE) Proposal 2c: The legacy IE extendedWaitTime can be reused to stop the subsequent NAS layer processes after UE is released to idle mode due to discontinuous coverage. The extension to the value range of extendedWaitTime needs to be discussed. |

**Question 5) Do you agree to enhance RRC Release for the discontinuous coverage? (Details FFS, e.g. new cause value, UE timer/trigger)**

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| **Company** | **Y/N** | **Additional comments** |
| Google | - | It depends on the specifc proposal. So far we didn’t see a significant merit for enhancing the RRC Release message. |
| MediaTek | N | UE knows it is or will be in unreachability state, therefore a release cause is not needed. There is no merit in this. |
| CATT | Yes with comments | We think we have to make the question clearer, whether the enhancement on RRC Release is needed or not. The enhancement may be, e.g., indicaing more detail discontinuous coverage information, or including new release casue, there are the different cases. We cannot discuss the two cases together. |
| Spreadtrum | N | A new cause value is not needed since the UE can get to know the exact time info related to discontinuous coverage. The existing mechanism for triggering RRC release can be reused. |
| Lenovo | Y | We think it is necessary at least for UE providing the out-of-coverage information. |
| Qualcomm | N | UE knows it is DC if there is no coverage. What is the purpose of new release cause? |
| ZTE | Y | If only relying on the information in SIB32, it may be not easy to always ensure that UE and the NW maintain a very consistent understanding on the discontinuous coverage. If no any enhancement is made, UE just quietly leaves the network when it loses coverage. This may cause network resources to be hung for a period of time, which is bad to resource efficiency.  We can see SA2 already has had some study on this issue, for example, Solution #1 in [TR 23.700-28 V18.0.0] mentions that, when a connected mode UE detects it is about to leave network coverage, it may use an existing AS procedures (we assume it can be Release Assistance Information) to request release from RRC\_CONNECTED. Meanwhile, another possible way is that, if the RAN detects that the UE in CM-CONNECTED is about to be out of network coverage based on the coverage information (RAN may have more information about discontinuous coverage), the RAN may trigger the RAN release procedure to move UE into CM-IDLE state before entering the non-coverage area.  We think it would be beneficial to support such graceful release. However, if the release is triggered by RAN and follows legacy procedure in Uu interface, UE may not exactly know whether this release is a normal release or a special one due to that coverage is about to stop. On one hand, when UE back to idle, AS layer in UE may still perform the normal processes, e.g., paging monitoring or cell measurement. On the other hand, NAS may trigger another connection setup procedure if it keeps receiving the data from application layer (this may be highly possible as the connection is just interrupted by NW). In the case of discontinuous coverage, it’s obvious these AS or NAS layer processes should be stopped as the current coverage is coming to an end soon.  Therefore, in order to avoid UE’s attempt for any legacy AS or NAS layer processes after it was deliberately released by the network due to discontinuous coverage, we suggest to let eNB indicate a special release reason to UE in RRC release message, e.g., a same reason ‘Release due to discontinuous coverage’ as that introduced in RAN3. Moreover, an AS-NAS interaction (e.g., an indication from AS to NAS) is also needed to inform the NAS layer about such special release. |
| Xiaomi | N |  |
| NEC | Y | UE can providing assistance information to eNB on being out-of-coverage, then based on the out-of-coverage information:   * Network can explicitly release the UE, or * if RLF is detected after the indication, UE can skip the cell search during T311 and leave RRC\_CONNECTED directly |
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## Others

**Question 6) Companies may list any other discontinuous coverage enhancements that should be discussed in the table below.**

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| **Company** | **Additional comments** |
| Google | As mentioned in Q4, we propose that **UE in RRC\_CONNECTED shall transition into RRC\_IDLE autonomously and immediately upon entering a coverage gap, by skipping/terminating the RLM/RLF scheme**, and would like to know other companies’ views. |
| Spreadtrum | The existing PSM mechanism should be enhanced for the consideration of power saving. E.g., early PSM can be taken into further discussion when the radio link is released before the start time point of coverage gap. |
| Qualcomm | We are ok to look into what google mentioned but prefer a proper mechanism, for example, see the autonomous release in MUSIM. |
| ZTE | After finishing some basic issues, RAN2 can further discuss whether and how to reduce the impact to target cell/RAT/system due to large number of UEs triggering access to other cell/RAT/system when losing coverage at the similar time. Such discussion might be mainly from RAN perspective and besides the wait time scheme mentioned in SA2. |
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# Conclusions

<To be generated based on company input>

# References (In alphabetical order by company)

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| **Reference** | **TDoc** | **Title** | **Company** | **Proposals** |
| [1] | [R2-2303407](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303407.zip) | Support on discontinuous coverage in IoT NTN | Apple | Proposal 1: RAN2 to discuss whether to address the mismatch issue between PTW and actual coverage time. |
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|  |  |  |  | Proposal 2: UE assistance information can be used for PTW adjustment. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: Send an LS to SA2/CT1 on unevenly distributed coverage period caused by unevenly distributed satellite from multiple satellites. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: UE follows legacy operation in declaring RLF upon entering coverage gap. |
|  |  |  |  |  |
|  |  |  |  | Proposal 5: During T311, UE does not perform cell search if UE is in coverage gap. |
|  |  |  |  |  |
|  |  |  |  | Proposal 6: RAN2 to discuss whether to support discontinuous coverage scenario in inactive state. |
| [2] | [R2-2302560](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302560.zip) | Discussion on enhancements to discontinuous coverage | CATT | Proposal 1：Some enhancement is needed for HARQ process with HARQ enabling when there is no enough time for ACK/NACK feedback because of the incoming coverage hole. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2：Providing satellite information corresponding to discontinuous coverage via dedicated signaling (not RRC Release message) is not needed, or at least should be de-prioritized. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3：RRC Release message can be updated to enhance discontinuous coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4：Enhancements on paging and eDRX should be supported to avoid UE monitoring paging during the UE unreachability periods, and to guarantee the UE reachability during the coverage periods. |
|  |  |  |  |  |
|  |  |  |  | Proposal 5：The calculations related with paging/eDRX (e.g., PH/PO, PH or PTW) should not be changed. |
|  |  |  |  |  |
|  |  |  |  | Proposal 6：Then enhancement for connected UE upon coming of discontinuous coverage should be de-prioritized. |
| [3] | [R2-2303520](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303520.zip) | Discussion on the discontinuous coverage for IoT-NTN | CMCC | Proposal 1: RAN2 discuss to transfer more satellite assistance information via dedicated signaling, SIB segmentation or multiple SIBs. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: The UE can provide the out-of-coverage information to RAN node for e.g, optimization on RRC release or paging. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: The UE out-of-coverage information can be kept by RAN node when the UE enters into idle mode. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: A new cause value ‘Release due to discontinuous coverage’ is introduced in RRCRelease message. |
| [4] | [R2-2303735](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303735.zip) | Enhancements to discontinuous coverage | Ericsson | Proposal 1 Provide measurement assistance information, e.g., PCI or carrier frequency, in SIB32 to facilitate cell selection and reduce service interruption after an NTN coverage gap. |
| [5] | [R2-2304081](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2304081.zip) | Discussion on the UE Unreachability Periods | Google Inc. | Proposal 1 The UE AS notifies the UE NAS at the time when the UE is about to leave the network coverage, and/or when the UE is back to the network coverage. The UE AS may include the information regarding how long the UE would be out of network coverage while notifying the UE NAS of leaving the network coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2 Upon determining that the UE has entered an unreachability period, a RRC\_CONNECTED UE transitions to RRC\_IDLE immediately without starting T310 or T311. If T310 or T311 has been started already upon the determination, the UE stops T310 or T311 and transitions to RRC\_IDLE directly. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3 A RRC\_CONNECTED UE can inform the network of the remaining time that the UE will be within the satellite coverage before entering an unreachability period, using a RRC message (e.g., UEAssistanceInformation). |
| [6] | [R2-2303963](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303963.zip) | Discussion on discontinuous coverage | Huawei, HiSilicon | Proposal 1: NW should be able to configure multiple Paging Time Windows during an eDRX cycle. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: The network can derive multiple coverage windows and takes them into account when paging a UE. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: UE enters RRC\_IDLE if the remaining serving time is less than a threshold in discontinuous coverage scenario. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: UE stops the AS idle mode tasks related to TN only when there is no TN cells in the discontinuous coverage. |
| [7] | [R2-2303716](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303716.zip) | IoT-NTN discontinuous coverage enhancements | Interdigital, Inc. | Proposal 1: For eMTC and NB-IoT: A UE in R17 is allowed not to perform RRC\_IDLE mode tasks during a UE unreachability period. Consider whether to explicitly clarify that this means that if a UE in RRC\_IDLE or RRC\_INACTIVE determines it is in a UE unreachability period, the UE may choose not to perform measurements of the serving cell or neighbour cells, and may postpone moving to “any cell selection” state, and is allowed not to attempt to monitor paging occasions which occur during a UE unreachability period. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: PTW can be adjusted with co-ordination between UE and NW to account for UE unreachability periods. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: RAN2 to down select between the following options for PTW adjustment: |
|  |  |  |  | - Option 1 (configurable offset) |
|  |  |  |  | - Option 2 (updated PTW calculation) |
|  |  |  |  | - Option 3 (UE/NW autonomous adjustment) |
|  |  |  |  | - Option 4 (other?) |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: For eMTC and NB-IoT: RLM, RLF detection, and RRC re-establishment are suspended during a UE unreachability period. |
|  |  |  |  |  |
|  |  |  |  | Proposal 5: For eMTC: To avoid always sending the UE to RRC\_IDLE/RRC\_INACTIVE during a UE unreachability period, introduce an activation time in RRC Reconfiguration to allow handover between cells occurring before and after a UE unreachability period. |
|  |  |  |  |  |
|  |  |  |  | Proposal 6: For eMTC: Consider how discontinuous coverage impacts CHO. |
|  |  |  |  |  |
|  |  |  |  | Proposal 7: RAN2 to discuss whether it can be assumed that reporting of UE unreachability period in Registration Request can be kept sufficiently (i.e. to support AS based solutions) up to date and takes into consideration UE mobility, or whether this needs to be confirmed with SA2. |
| [8] | [R2-2303253](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303253.zip) | On mobility and power saving issues for discontinuous coverage | Lenovo | Proposal 1: RAN2 to consider enhancements to UE reporting its prediction of coverage interruption to the network. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: RAN2 to consider enhancements to PSM/eDRX for aligning PSM/eDRX duration with coverage interruption period at UE. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: RAN2 to consider enhancements to disable CONNECTED neighbour cell measurement for NB-IoT UE before coverage interruption due to discontinuous coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: RAN2 to consider enhancements to RRC connection recovery configuration before coverage interruption, so that UE can recovery RRC connection when coverage restores. |
| [9] | [R2-2303111](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303111.zip) | Considerations on Supporting Discontinuous Coverage | NEC Europe Ltd | Proposal 1: Consider to support UE providing assistance information on being out-of-coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: Consider enhancements to existing IoT features such as PUR, to support periodical, brief connection in IoT-NTN discontinuous coverage. |
| [10] | [R2-2303193](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303193.zip) | On RAN impacts for Discontineous coverage enhancements | Nokia, Nokia Shanghai Bell | Proposal 1: RAN2 to discuss the provisioning of additional satellites’ ephemeris via dedicated RRC signalling. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: RAN2 to include footprint information for the earth-moving cell in discontinuous coverage as an optional field in SIB31. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: The PSM and eDRX configurations can be configured to align with the estimated UE unreachability period |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: Network can extend the paging before/after the coverage window if the UE does not respond to paging within the estimated coverage window. |
|  |  |  |  |  |
|  |  |  |  | Proposal 5: UE can extend the paging monitoring outside the estimated coverage window if radio coverage is available. UE may report to the network to realign the paging monitoring and coverage windows. |
|  |  |  |  |  |
|  |  |  |  | Proposal 6: RAN2 to discuss how to handle UE movement within the same TA during discontinuous coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 7: RAN2 to consider provisioning cell availability information to enable moving and cold start UEs to determine cell search and reselection measurement period(s) to enhance energy-saving potential. |
|  |  |  |  | Connected mode functionality impacts for DC related enhancements |
|  |  |  |  |  |
|  |  |  |  | Proposal 8: RAN2 to discuss support for UE request for RRC connection release based on DC estimation. FFS support for implicit RRC connection release. |
|  |  |  |  |  |
|  |  |  |  | Proposal 9: RAN2 to discuss UE behaviour when the UE has limited remaining GNSS validity duration and the remaining discontinuous coverage time is also short. |
| [11] | [R2-2303042](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303042.zip) | RRC release procedure in discontinuous coverage | Qualcomm Incorporated | Proposal 1 If the UE is able to predict when the discontinuous coverage starts, reuse NR MUSIM procedure to leave RRC\_CONNECTED state where the UE indicates the out-of-coverage to network and starts an out-of-coverage timer. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2 Reuse NR MUSIM timer T346g behavior, i.e., upon expiry of the out-of-coverage timer, the UE performs the actions upon leaving RRC\_CONNECTED, with release cause 'other'. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3 Further discuss the details on the values of the out-of-coverage timer and message to carry out-of-coverage information. |
| [12] | [R2-2304160](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2304160.zip) | Discussion on Enhancements related to discontinuous coverage | Rakuten Mobile, Inc | Proposal 1: UEs should be provided with satellite ephemeris data for neighbor cells in 2 groups, “Default Neighbor ephemeris data” shall contain limited amount of neighbors & “Extended Neighbor Ephemeris Data” may contain more than default neighbors till defined by network. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: NB IoT UEs should use extended satellite ephemeris data to calculate T3212 extended timer value along with T3324 for activating PSM. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3a: eNB to initiate RRC release based on relative UE location with respect to beam footprint, Proper cause value have to be added into spec. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3b: UE itself release network based on configured Timing Advance (TA) value communicated by NTN cell. Proper cause value needs to be added in to spec. |
| [13] | [R2-2303052](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303052.zip) | Enhancements to discontinuous coverage | Samsung R&D Institute UK | Proposal 1: Measurement assistance information can be provided to control how the UE shall perform idle mode tasks (i.e. whether a UE can power down specific frequencies during discontinuous coverage) in a discontinuous coverage NTN. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2(a): The UE verifies whether it has sufficient coverage time to complete a given RRC procedure (or a new connection establishment). |
|  |  |  |  |  |
|  |  |  |  | Proposal 2(b): The UE initiates a given RRC procedure if it has sufficient coverage time to complete this procedure. Otherwise, the UE will not initiate the procedure or will wait for the next available satellite coverage period. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: Discontinuous coverage-related information is provided in a re-direct message when being re-directed to a discontinuous coverage network. |
| [14] | [R2-2303576](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303576.zip) | Discussion on power saving enhancements for supporting discontinuous coverage | Spreadtrum Communications | Proposal 1: In order to ensure that the UE can be reachable when paging arrives, the PTW should aligns with the time duration of coverage and the following two options can be taken into further consideration: |
|  |  |  |  | Option 1: both UE and network adjust PTW based on a predefined rule |
|  |  |  |  | Option 2: network provides multiple PTW info |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: From RAN2 point of view, the existing PSM mechanism needs to be enhanced in order to get better power effect. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3：The PSM starting mechanism needs to be modified to adapt to the scenario of discontinuous coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: A time threshold needs to be introduced for UE to determine whether to start T3324 timer. |
| [15] | [R2-2303476](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303476.zip) | Discussion on enhancement to discontinuous coverage for IoT NTN | Transsion Holdings | Proposal 1 RAN2 needs to consider the RACH congestion issue as a large number of UEs may try to access the NTN cell at the next satellite’s service start time. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2 The discontinuous coverage wait timer can be used in AS to avoid RACH congestion. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3 The CN should be aware of the UE’s discontinuous coverage period to CN to avoid paging issues. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4 The satellite assistance information or the discontinuous coverage information predicted by UE can be provided to CN for paging. |
| [16] | [R2-2303437](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303437.zip) | Enhancements to discontinuous coverage | Xiaomi | Proposal 1: The assistance information of target cells can be provided to UE in advance for UE performing cell selection/reselection when UE returns to coverage and the assistance information could be frequency, PCI and SSB configuration. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2: UE determines the paging cycle only based on UE specific DRX/eDRX configured by AMF if the AMF takes the UE coverage information into consideration when configures the UE specific DRX/eDRX. |
|  |  |  |  |  |
|  |  |  |  | Proposal 3: AMF provides the UE out of coverage period to the gNB. |
|  |  |  |  |  |
|  |  |  |  | Proposal 4: If UE is in discontinuous coverage, UE should go to RRC idle when detects radio link problem. |
| [17] | [R2-2302822](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302822.zip) | RAN2 enhancements for discontinuous coverage | ZTE Corporation, Sanechips | Proposal 1a: If legacy eDRX is used for keeping alignment between UE and NW during discontinuous coverage, in order to align the starting time of PTW with the out-of-coverage period or unreachability period, it’s suggested to introduce a configurable offset to shift the starting time of PTW. |
|  |  |  |  |  |
|  |  |  |  | Proposal 1b: The out-of-coverage period or unreachability period should be informed to RAN, e.g., from core network node, to assist RAN to provide a more appropriate paging schedule for UE in idle mode. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2a: A new release reason, e.g., ‘Release due to discontinuous coverage’ as that introduced in RAN3, can be introduced in RRC release message for indicating UE to stop the subsequent AS layer processes after it is released to idle mode. |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  | Proposal 2b: An AS-NAS interaction (e.g., an indication from AS to NAS) also needs to be introduced for indicating UE to stop the subsequent NAS layer processes after it is released to idle mode due to discontinuous coverage. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2c: The legacy IE extendedWaitTime can be reused to stop the subsequent NAS layer processes after UE is released to idle mode due to discontinuous coverage. The extension to the value range of extendedWaitTime needs to be discussed. |
|  |  |  |  |  |
|  |  |  |  | Proposal 2d**:** The UE in connected mode could provide out-of-coverage period or unreachability period information as an assistance to the network (eNB). |