3GPP TSG-RAN WG2 Meeting #112 electronic R2-200xxxx

Online, November 2nd – 13th, 2020

Source: CATT

Title: Summary of email discussion 915 - UE power saving features

Agenda Item: 8.12.3

Document for: Discussion and Decision

# Introduction

This contribution provides a summary of the following email discussion:

* [Post111-e][915][REDCAP] UE power saving features (CATT)

Scope: Discuss UE power saving features: eDRX in idle and inactive and RRM relaxation for stationary devices

Intended outcome: email discussion summary

Deadline: Thursday OCT 15 0700 UTC

# Discussion

# eDRX in idle and inactive

As a follow-up of the offline #111 [1][2], the following agreements on eDRX for REDCAP UEs were achieved in RAN2#111-e:

Agreements:

1. RAN2 study eDRX mechanism for both RRC\_IDLE and RRC\_INACTIVE in this SI. ‎
2. For RRC\_INACTIVE, the DRX cycle is extended to 10.24s as baseline.

Agreements via email - from offline 111:

1. For RRC\_IDLE, the DRX cycle is at least extended to 10.24s. FFS on further extension ‎beyond 10.24s.
2. For RRC\_IDLE and/or RRC\_INACTIVE, if the NR DRX cycle range is extended beyond 10.24s, the LTE ‎eDRX mechanism beyond 10.24s (e.g., PTW, PH, etc.) is used as baseline when NR eDRX cycle is configured beyond 10.24s.

FFS:

1. For RRC\_IDLE and/or RRC\_INACTIVE, FFS on baseline mechanism when the configured NR eDRX cycle is less or equal to 10.24s

From the above it can be seen that the leftover issues to address are:

* For RRC\_IDLE, should the eDRX cycle be extended beyond 10.24s, and if yes, what should be the maximum value?
* For RRC\_INACTIVE, should the eDRX cycle be extended beyond 10.24s, and if yes, what should be the maximum value?
* What baseline mechanism should be used when NR eDRX cycle is less or equal to 10.24s?

### Maximum eDRX cycle in RRC\_IDLE

In LTE, the maximum value of eDRX cycle in RRC\_IDLE is 2621.44s (almost 44 min) for eMTC UEs and 10485.76s (max of Hyper SFN cycle, almost 3 hours) for NB-IOT UEs. In addition, eMTC UEs can connect to 5GC so 5GC already supports extended DRX parameters up to 2621.44s in Registration procedure so there is no additional work expected for CN to support this value.

Based on the above, most companies in [1] supported eDRX cycle in RRC\_IDLE up to 2621.44s, but we can split the question in two:

**Q1.1: Do you agree to extend the eDRX cycle in RRC\_IDLE beyond 10.24s for REDCAP UEs?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes |  |
| OPPO | No | Since longer eDRX cycle would lead to larger paging latency, we don’t think the three use cases for RedCap UEs could tolerate such large paging latency as NB-IoT and eMTC. |
| Huawei, HiSilicon | Yes | A larger eDRX period has large positive impact on UE power consumption in RRC\_IDLE, which is also an essential part of performance requirements for REDCAP UEs.  eDRX cycle beyond 10.24s in RRC\_IDLE is already supported in SA2 and CT1 specifications. |
| ZTE | Yes with comment | If we aim to support years long battery life for Redcap UEs, we think it is necessary to extend the eDRX cycle in RRC\_IDLE beyond 10.24s.  If there is no such requirement, then 10.24s could be sufficient. |
| Futurewei | Yes |  |
| Ericsson | Yes | Regarding OPPO’s comments, one of the use cases (IWSN) in the SID has requirement of multiple years of battery lifetime. Unless it can be shown that 10.24 s eDRX cycle achieves such lifetime, the possibility for longer eDRX should not be dismissed during the study phase, but an analysis of potential gain of extension should be captured in the TR to help with decision e.g. when drafting the potential WI.  There are various different use cases for RedCap which have been agreed to be included in the SID and not all of these need to support long eDRX, i.e. the feature can be optional. |
| Qualcomm | No | RedCap UEs are not equivalent to eMTC/NB-IoT devices. They may not tolerate long paging cycles. As to multi-year battery life requirement of the industrial sensor use case, the RedCap SID does not specify what battery capacity that requirement was based on. Therefore, we do not see how that may translate to requirement on paging cycles.  From our perspective, we do not want to implement features that are not required by target use cases of a SID, because every feature requires development and testing effort, even if a feature may seem trivial enough. |
| ETRI | Yes |  |
| Samsung | Yes |  |
| Intel |  | If we aim to support years long battery life for Redcap UEs, then it is necessary to extend the eDRX cycle in RRC\_IDLE beyond 10.24s. However, we also need to consider the impact due to the long paging latency caused by such extended DRX cycle. |
| Sharp |  | It depends on the requirement of battery life and paging latency. For industrial wireless sensors, according to SID the battery life should last at least few years. However there is no clear requirement on paging latency. |
| NEC | Yes |  |
| LGE | Yes | It depends use cases. Some applications may rarely receive downlink data and paging latency wouldn’t be an issue. In this scenario, UEs can reduce power consumption by supporting long eDRX cycle beyond 10.24s. |
| Nokia | Yes |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |
| vivo | No | RedCap UE may not be delay-tolerant for paging and the target scenario in the SID cannot justify long paging DRX cycle beyond 10.24s. It should not be considered before we identified any potential use case. |

**Q1.2: If the Q1.1 answer is “yes”, do you agree to extend the eDRX cycle in RRC\_IDLE up to 2621.44s for REDCAP UEs? If not, suggest another value with justification.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes |  |
| Huawei, HiSilicon | Yes | In both WB-E-UTRAN and NB-IoT, the eDRX cycle of 2621.44s is covered in the extended idle mode DRX value range. Considering the power saving target and traffic scenario of REDCAP, the maximum of 2621.44s is enough for RRC\_IDLE. |
| ZTE | Yes |  |
| Futurewei | Yes |  |
| Ericsson | OK as baseline | The exact value can be agreed and committed to during potential WI phase, with proper coordination with other WGs where needed.  Assuming, like in LTE, that 10 bits would be used for H-SFN, it could be possible to have eDRX cycle up to maximum H-SFN range (i.e. up to 2.9 hours) like for NB-IoT. The cycle lengths should be made as long as reasonable if there are not technical reasons to limit such (arbitrary limits tend to make possible future work more difficult). |
| ETRI | Yes |  |
| Samsung | Yes, as a baseline |  |
| NEC | Yes |  |
| LGE | Yes |  |
| Nokia | OK as baseline |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |

### Maximum eDRX cycle in RRC\_INACTIVE

For eMTC UEs connected to 5GC, eDRX cycles in RRC\_INACTIVE are already supported up to 10.24 sec. One reason for not extending this value further is given in [3] (same argument also used in [4]):

“*For UE in CM-CONNECTED mode with RRC\_INACTIVE, the impacts of eDRX on CN should be considered. The value of eDRX period has impact on NAS signalling transmission in CM-CONNECTED. As specified in 5GS for Rel-15, the smallest NAS retransmission timer is 6s and the maximum retransmission times is 4. To avoid the failure of the procedure, the response from UE in eDRX should be given within 30s after initial transmission. Considering all potential factors, the longest eDRX period without impacting 5GC is set to 10.24s for RRC\_INACTIVE eMTC UE in Rel-16*”.

On the other hand, several companies showed interest in studying extending the eDRX cycle beyond 10.24s in RRC\_INACTIVE [2]. So we check first whether there is interest in RAN2 to extend the eDRX cycle beyond 10.24s in RRC\_INACTIVE, and based on the outcome, we could study with CT1 ways to circumvent the above 5GC limitation. For example, we could send them an LS informing about RAN2’s preference.

**Q1.3: Do you agree it is desirable to extend the eDRX cycle in RRC\_INACTIVE beyond 10.24s for REDCAP Ues?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes | Some REDCAP Ues may remain in RRC\_INACTIVE most of the time. If DRX cycle is extended beyond 10.24s, more UE power consumption can be saved. |
| OPPO | No | See our reply to Q1.1 |
| Huawei, HiSilicon | Yes | RRC\_INACTIVE state can help to reduce CP latency and improve the small data transmission efficiency after Rel-17 small data is available. If eDRX cycle in RRC\_INACTIVE beyond 10.24s is supported, UE will also benefit from power saving gain. If not, the UE cannot benefit at the same time of long eDRX power consumption gain and of small data transmission efficiency gain.  eDRX cycle beyond 10.24 s is not supported in SA2 and CT1 specifications. RAN2 could study solutions with SA2/CT1 to make it feasible. |
| ZTE | No | Considering the impact on NAS re-transmission, we prefer not to support this.  In addition, if eDRX cycle for RRC\_INACTIVE can be large than 10.24s, based on the agreement made last meeting, PTW/PH mechanism will be used. Considering RRC\_INACTIVE UE is required to monitor both RAN paging and CN paging simultaneously (to avoid state mismatch). If the UE has two eDRX cycles larger than 10.24s (one for IDLE, the other for INACTIVE), we need to first discuss how UE behaves because there are two PTWs and PHs.  Regarding the comment from Huawei, it is unclear to us why this is related to small data transmission. |
| Futurewei | Yes |  |
| Ericsson | Yes | Agree with Huawei.  Based on the power consumption analysis presented in [R2-2006913](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs/%0d/R2-2006913.zip) and the fact that it is desirable to achieve at least few years lifetime also for Ues which are in RRC\_INACTIVE, for example to take advantage of the Small Data Transmission feature to be specified in Rel-17, it is beneficial from RAN point of view to have longer eDRX in RRC\_INACTIVE.  The SI should focus on studying what is desirable and possible from RAN side – for possible SA/CT impact we should coordinate with the relevant groups, provide our input and ask for solutions and feasibility (a response should not be a requirement to conclude the study however).  Regarding specific issues mentioned with NAS timers, if the CN is aware that the UE is not reachable, the NAS timers and any other impacted procedures can be handled properly. Also, it should be noted that the referred sections of earlier CT1 LS only mentions there are impacts on the CN/CT side, but they do not say it would not be feasible. |
| Qualcomm | No | Similar to RRC Idle, we don’t see use cases that require long paging cycle for RRC Inactive (see our reply to Q1). In addition, since UE is still required to monitor RAN paging outside PTW in RRC Inactive, extending UE’s eDRX cycle does not actually save UE power.  Given that CT1 also have concern on the impact of longer eDRX cycle on CN, we think it’s better we don’t extend the maximum eDRX cycle in RRC Inactive beyond the current limit of 10.24 sec. |
| ETRI | No | The impact on NAS re-transmission should be minimized. If the UE needs long battery lifetime, it is appropriate to transit in RRC\_IDLE state. |
| Samsung | Yes |  |
| Intel | No | Agree with ZTE. |
| Sharp | No | The RedCap Ues remaining in RRC\_INACTIVE most of time may not need very long DRX cycle to achieve very long battery life, for example wearables. The RedCap Ues need long battery life may not remain in RRC\_INACTIVE most of time, for example industrial wireless sensors. |
| NEC | No | Agree with ZTE’s comment, the NAS re-transmission impact should be considered. |
| LGE | No | For power saving, it would be better to transit to RRC\_IDLE because the UE is in CM\_CONNECTED in RRC\_INACTIVE. |
| Nokia | Yes |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |
| vivo | No | See reply to Q1.1. Besides, the impact on NAS re-transmission should be considered. |

**Q1.4: If the Q1.3 answer is “yes”, which maximum eDRX cycle value would you suggest for RRC\_INACTIVE?**

|  |  |  |
| --- | --- | --- |
| Company | Max eDRX value | Comments |
| CATT | 2621.44s | For consistency with RRC\_IDLE |
| Huawei, HiSilicon | 2621.44s | For consistency with RRC\_IDLE. But we are also open to other values. We think the final decision on the maximum eDRX cycle value should consider the opinion of CT1 and SA2. |
| Futurewei | 2621.44s | For consistency with RRC\_IDLE |
| Ericsson | Similar to RRC\_IDLE as baseline | A similar extension as in RRC\_IDLE can be considered as baseline (to achieve similar gains). The details can be worked out during the normative phase in coordination with other impacted WGs. |
| Samsung | 2621.44s | For consistency with RRC\_IDLE |
| Nokia | RRC\_IDLE as baseline |  |
| Xiaomi | RRC\_IDLE as baseline Yes |  |
| Lenovo | RRC\_IDLE as baseline. |  |

**Q1.5: If the Q1.3 answer is “yes”, would you agree sending an LS to CT1 informing them about RAN2’s preference?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Futurewei | Yes |  |
| Ericsson | Maybe | If the eDRX cycles are extended beyond 10.24 s, then CT1 and at least also SA2 should be informed. RAN3 should be informed as well.  RAN2 should focus on studying possible mechanisms to lower UE power consumption and evaluate the impact and gain of such mechanisms. Any LS sent during this stage should not hinder further work in RAN2.  Therefore, on timing of such an LS, if RAN2 can achieve consensus, the LS could potentially be sent during study phase to inform the relevant WGs that RAN2 is looking into further extensions of eDRX cycles. However, it is possible to conclude the study part from RAN2 point of view without LS response now, but later during the potential WI. |
| Samsung | Yes |  |
| Nokia | At some point |  |
| Xiaomi | Yes | As there is potential impact due to the NAS retransmission time limitation, we think the SA/CT WG should be involved. |
| Lenovo | Yes |  |

### eDRX mechanism when cycle ≤ 10.24s

A first aspect to clarify is what should be the lowest eDRX value for RRC\_IDLE and RRC\_INACTIVE. If we follow the LTE principle, there is only one value lower than 10.24s, i.e. 5.12s.

**Q1.6: Do you agree the lowest value of eDRX cycle is 5.12s for RRC\_IDLE and RRC\_INACTIVE REDCAP UEs?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes | As in LTE. |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes | As in LTE. |
| ZTE | Yes |  |
| Futurewei | Yes |  |
| Ericsson | Yes |  |
| Qualcomm | Yes |  |
| ETRI | Yes |  |
| Samsung | Yes |  |
| Intel | Yes |  |
| Sharp | Yes |  |
| NEC | Yes |  |
| LGE | Yes |  |
| Nokia | Yes |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |
| vivo | Yes |  |

Then, The issue of the eDRX mechanism when cycle ≤ 10.24s was discussed in [2] with associated proposals B and C:

|  |
| --- |
| Range 1: when NR eDRX cycle is < 10.24s  In this case it seems straightforward, i.e., the LTE eDRX mechainism for 5.12s should be baseline.  **Proposal B For RRC\_IDLE and RRC\_INACTIVE, the LTE ‎eDRX mechanism for 5.12s is used as baseline when NR eDRX cycle is configured below 10.24s.**  Range 2: when NR eDRX cycle = 10.24s  This case, as discussed, may depend on whether in NR the maximum range value is greater than 10.24s, which is still open for now. So we put it FFS at this stage.  **Proposal C FFS on baseline mechanism when the configured NR eDRX cycle is equal to 10.24s.** |

Although the proposals didn’t seem to be too controversial, the main feedback was that they should be clarified, especially “the LTE eDRX mechanism for 5.12s is used as baseline”. Therefore we suggest a more explicit wording, as in [5]:

**Proposal A: For UE in RRC IDLE/INACTIVE and eDRX cycle is less than 10.24s, paging monitoring is based on eDRX cycle (taking eDRX cycle as T in PF/PO formula). PTW, PH, if any, are not used.**

**Q1.7: Do you agree with proposal A?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes |  |
| Futurewei | Yes |  |
| Ericsson | Not entirely correct | PTW and PH do not need to be used.  However, it is not explicitly clear based on the formulation how the paging is monitored, and the actual T used in the calculation in TS 38.304 depends on whether the UE is in RRC\_IDLE or RRC\_INACTIVE, i.e., in idle the shortest cycle between UE-specific and upper layer configured paging cycle, and in inactive the shortest between UE-specific, upper layer configured and RAN paging (gNB configured).  This is a detail which can be agreed and specified during the normative phase in any case. |
| Qualcomm | Yes |  |
| ETRI | Yes |  |
| Samsung | Yes |  |
| Intel | Yes |  |
| Sharp | Yes |  |
| NEC | Yes |  |
| LGE | Yes |  |
| Nokia | Yes |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |
| vivo | Yes |  |

For the special case of eDRX cycle = 10.24s, it seems straightforward that, for a given RRC state (Idle or Inactive), if eDRX cycle > 10.24s is supported in this RRC state (depending on Q1.1 and Q1.3), we then follow the LTE principle that PTW, PH would be used. Otherwise they would not. We can therefore similarly reformulate the proposal C separately for each state as follows:

**Proposal B1: For UE in RRC IDLE and eDRX cycle is equal to 10.24s:**

* **If eDRX cycle > 10.24s is not supported (as outcome of Q1.1), paging monitoring is based on eDRX cycle (taking eDRX cycle as T in PF/PO formula);**
* **If eDRX cycle > 10.24s is supported (as outcome of Q1.1), paging monitoring involves PTW, PH, similar to the LTE ‎eDRX mechanism beyond 10.24s**

**Q1.8: Do you agree with proposal B1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes | We prefer to keep the LTE principle. |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes | Extended DRX in Idle mode is already supported in EPC and for eMTC connected to 5GC and we prefer to reuse existing DRX mechanism (based or PH and PTW) in both cases. |
| ZTE | Yes |  |
| Futurewei | Yes |  |
| Ericsson | Yes | Agree with Huawei – but also this is a detail and it is enough to capture in TR that we try to follow the existing principles. The details can be agreed during the normative phase. |
| Qualcomm | Yes |  |
| ETRI | Yes |  |
| Samsung | Yes |  |
| Intel | Yes |  |
| Sharp | Yes |  |
| NEC | Yes |  |
| LGE | Yes |  |
| Nokia | Yes |  |
| Xiaomi | Yes |  |
| Lenovo | Yes |  |
| vivo | Yes |  |

**Proposal B2: For UE in RRC INACTIVE and eDRX cycle is equal to 10.24s:**

* **If eDRX cycle > 10.24s is not supported (as outcome of Q1.3), paging monitoring is based on eDRX cycle (taking eDRX cycle as T in PF/PO formula);**
* **If eDRX cycle > 10.24s is supported (as outcome of Q1.3), paging monitoring involves PTW, PH, similar to the LTE ‎eDRX mechanism beyond 10.24s**

**Q1.9: Do you agree with proposal B2?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| CATT | Yes | We prefer to keep the LTE principle. |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes | We assume that the values (PTW, eDRX cycle) for one UE can be different in RRC\_IDLE and RRC\_INACTIVE and that some optimizations may be needed to maximize the PTW overlap. |
| ZTE | Yes wth comments | First, we would like to clarify the term “eDRX cycle” in this question.  In LTE, irrespective of RRC\_IDLE or RRC\_INACTIVE, the UE only has one eDRX cycle (after NAS coordination with core-network). This eDRX cycle can be used to calculate PTW/PH. When UE is in Connected mode, the core-network can send this Idle eDRX cycle to RAN, then RAN node can decide UE specific inactive eDRX cycle when releasing the UE to inactive mode, this inactive eDRX cycle is provided by “ran-PagingCycle-v1610” field in RRCRelease message (with value 5.12s or 10.24s).  Therefore, if eDRX cycle >10.24 for Inactive (in Q1.3) is not supported (as in LTE), and we decide to follow LTE principle, then we understand Proposal B2 can be rephased as:  **Proposal B2: For UE in RRC INACTIVE and INACTIVE eDRX cycle is equal to 10.24s:**   * **If IDLE eDRX cycle > 10.24s is not supported (as outcome of Q1.1~~3~~), paging monitoring is based on eDRX cycle (taking eDRX cycle as T in PF/PO formula);** * **If IDLE eDRX cycle > 10.24s is supported (as outcome of Q1.1~~3~~), paging monitoring involves PTW, PH, similar to the LTE ‎eDRX mechanism beyond 10.24s (i.e. PTW is calculated based on IDLE eDRX cycle)**   However, if eDRX cycle >10.24 for Inactive (in Q1.3) is supported, as we responsed to Q1.3, we should first discuss how UE behaves under two PTWs, and then discuss the mechanism when “inactive eDRX cycle” is equal to 10.24s. |
| Futurewei | Yes |  |
| Ericsson | Yes | Again, the general principles can be captured as alternatives or solutions in the TR, but the exact details can be agreed to during the normative phase.  Note that there is no > 10.24 s eDRX for RRC\_INACTIVE currently specified, but we assume similar mechanism could be used as for RRC\_IDLE. |
| Qualcomm | Yes |  |
| ETRI | Yes |  |
| Samsung | Yes |  |
| Intel | Yes with comments | LTE does not support eDRX cycle>10.24s for INACTIVE. Therefore we need to discuss whether to support it first, and to understand how to support it before making agreements on how to handle eDRX cycle >10.24 s. |
| Sharp | Yes |  |
| NEC | Yes |  |
| LGE | Yes |  |
| Nokia | Yes |  |
| Xiaomi | Yes | Yes, the general principles of PTW,PH can be used, but the details need further studied since in LTE eDRX cycle beyond 10.24s is not introduced for INACTIVE |
| Lenovo | Yes |  |
| vivo | Yes |  |

# RRM relaxation for stationary devices

Chairman summarized the issues in this section as follows:

For which Stationary UEs can RRM relaxation be considered? Only “truly fixed” Ues or slowly moving ones as well?

Should RRM relaxation on serving cell be considered?

How to identify the target Ues?

What kind of measurement relaxation criteria can be considered?

Based on the above summary and the various proposals in contributions [4][6]-[17], we address below the following issues:

* Scope of “stationary” Ues
* How is “stationary” identified/assessed?
* RRM relaxation in RRC\_IDLE/INACTIVE
  + Neighbor cells
  + Serving cell
* RRM relaxation in RRC\_CONNECTED

### Scope of stationary Ues

Different levels of mobility could be considered for REDCAP Ues, for example:

* Level 1: still device at fixed location (e.g. fixed static sensor)
* Level 2: moving (e.g. rotary) device at a fixed location (e.g. camera, robot) [12]
* Level 3: temporarily fixed device (e.g. smart watch at night) [RAN2#111-e on-line comment]
* Level 4: device is moving around slowly (e.g. medical wearables)

Therefore, the first question we need to answer is whether the scope of “stationary” only includes Level 1, or includes up to 2 or 3 or 4 of above levels of (low) mobility. Or other types of mobility?

**Q2.1-a: Does the scope of “stationary” only include Level #1, or includes up to Level #2, or #3 or #4 (low) mobility levels? If you would foresee other types of (low) mobility in scope, please add further levels/suggestions.**

|  |  |  |
| --- | --- | --- |
| Company | Up to level #? | Comments |
| CATT | 4 | We think all four levels are associated with devices in the scope of REDCAP Ues, and so should be considered when studying RRM relaxation. |
| OPPO | 4 | We think all four levels can be addressed and we don’t see the need for separate relaxation schemes for different mobility levels, i.e., we can handle “low-mobility” and “stationary” in a unified manner. |
| Huawei, HiSilicon | 4 | We think stationary REDCAP Ues includes all four levels. |
| ZTE | 4 | We are fine to study all above cases for RRC\_IDLE/INACTIVE Ues.  But for RRC\_Connected Ues, we prefer not to spend much time study it, if companies have strong willing to support RRM relaxation in RRC\_Connected state, to avoid network performance degradation, we think only level 1 needs to be considered. |
| Futurewei | 4 | We are fine to study all 4 cases. |
| Ericsson | 3 / 4 | We assume levels 3 and 4 correspond to current “low mobility” criterion.  However, it is not clear from the description what level 4 exactly corresponds to. If level 4 falls under current “low mobility” criterion then our reply is up to level 4. However, level 4 could correspond to a walking/running person meaning cell changes or handovers can be possible, that is, something more than “low mobility”.  In practice, it may be difficult to distinguish between level 3 and 4 at least based on measurements.  Also, it should be kept in mind a RedCap UE might not fall under any of the levels above, i.e. there can be use cases with fast moving or high mobility (“Level 5” and higher). |
| Qualcomm | 3 | We think level 4 is already covered by Rel-16 low mobility criterion and should not be considered stationary. But Ues in level 1~3 can use additional enhancements, knowing they are stationary. |
| ETRI | 3/4 | Level 4 may be supported when the criteria for level 4 can be clearly distinguished from Rel-16 low mobility. |
| Samsung | 4 | SID considers wearables as one of RedCap devices, but does not restrict their mobility. |
| Intel | 1/2 | We should focus on fixed location. For low speed UE, it should be covered by power saving WI. |
| Sharp | 4 | We are fine to study all the levels. |
| NEC | 4 | We are fine to study all the cases. |
| LG | 4 | Up to level 4 is can be scope of RedCap devices.  We have one question to examples above – what is example of camera in level 2? It seems CCTV using camera can be level 1. |
| Nokia | 3 / 4 | No other categories still from stationary/non-stationary |
| Xiaomi | 4 | We are open to study all these cases. |
| Lenovo | 4 | We are fine to all the levels. |
| vivo | 4 | We think all the above cases which are in the scope of RedCap should be discussed. Technically, there is not much difference between “true” stationary UEs and “slow mobility” UEs. Meanwhile, there is no need to differentiate these two kinds of UEs during the solution design. |

The next question is whether such (low) mobility range should be addressed by different levels of relaxation. And if yes, how many? For example, if all above four mobility types are in scope, each could be addressed by a different level of relaxation. Or only two relaxation levels could be considered, one for the still devices at fixed location (type 1, “truly fixed”) and another for the other three mobility types. Etc.

**Q2.1-b: How many relaxation levels would you consider to address the above scope of mobility?**

|  |  |  |
| --- | --- | --- |
| Company | Number of relaxation levels? | Comments |
| CATT | 2 | We should allow distinguishing the “truly fixed” from other slightly moving UEs. |
| OPPO | 1 | We think multiple relaxation levels would increase the UE complexity when performing criteria checking, which will cause more power consumption. |
| Huawei, HiSilicon | 2 | It is too complex to introduce different relaxation level for different “stationary” level. We think at most 2 relaxation levels can be define for truly fixed UE and other three mobility types separately. |
| ZTE | 1 | We should try best to find unified solution for both stationary and slowly moving UEs. |
| Futurewei | Up to 2 | We are open to up to 2 relaxation levels. Beyond that, the incremental gain may not justify the complexity added. |
| Ericcson | - | Instead of talking about relaxation levels or such concepts, we think it would be reasonable to provide configuration flexibility so that it would be possible and up to network to configure UEs for different use cases, e.g. when/if it is possible for NW understand that there are “truly fixed” UEs. |
| Qualcomm | Up to 2 | As far as RRM relaxation is concerned, we don’t see a need to differentiate among Level 1~3. Level 4 should have its own relaxation level. |
| ETRI | 2 | RRM relaxation level should be allowed to distinguish the “truly fixed” from other mobility type. |
| Samsung | 2 | In this release, we can just have 2 relaxation levels, distinguishing truly fixed devices and mobile devices. |
| Intel | 1 | Unified solution is preferred. |
| Sharp | 2 | To distinguish the "truly fixed" UEs from others. |
| NEC | 2 | The real fixed UE should be studied separately. |
| LG | Up to 2 | For the simplicity, maximum relaxation level should be two, but further discussion is needed how to design RRM relaxation. |
| Nokia | - | No levels, stationary/non-stationary is sufficient |
| Xiaomi | 1 | A unified solution is sufficient |
| Lenovo | Up to 2 | It is efficient to perform relaxation based on maximum 2 levels. But we think the details on mapping of stationary level1-4 to relaxation level 1-2 should be further discussed based on all specific UE cases. |
| vivo | 2 | We are open to whether have only one relaxation level or two. If we concluded two relaxation level finally, the “true stationary” should be distinguished from other use cases. |

### How is “stationary” identified?

There are essentially two main options for how the “stationary” criterion is identified:

* Option 1: a UE non-mobility attribution (subscription information): [4][7] (reported to network in Msg5), [11].
* Option 2: evaluated by criterions based on measurements: [6][9][10][12][17][14]

It can be noted that with option 1, there is no need to reuse the R16 triggers (e.g. low mobility) in RRC IDLE/INACTIVE since the “stationary” criterion is expected always true for that UE.

**Q2.2: Which of Option 1 or 2 do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| CATT | 2 | We think there can still be different classes of such REDCAP UEs regarding mobility and configurable R16 thresholds would allow distinguishing e.g. “truly fixed” and slightly moving Ues. |
| OPPO | 2 | We could use the “stationary” criterion for NB-IoT Ues as a baseline for RedCap Ues. |
| Huawei, HiSilicon | 2 | Firstly, we want to clarify that reporting UE non-mobility attribution to network only make sense for RRM measurement relaxation in RRC\_CONNECTED, which is relevant to Q2.5. For the UE in RRC\_IDLE or RRC\_INACTIVE, there is no need to report anything to the network.  Secondly, we think using UE non-mobility attribution as “stationary” criterion is too limited because it depends on subscription information. This criterion is not applicable for “Level 3” mobility type defined in Q2.1. So, we would like to use some criterions based on measurement, which could be used in more scenarios. |
| ZTE | 2 for idle/inactive | For idle/inactive Ues, we think the Rel-16 “low mobility” criterion (Option2) can almost be reused.  For connected Ues (if supported), since we prefer to only consider “truly fixed Ues”, we think it can be indicated via subscription information, and core-network can forward the “stationary” information to NG-RAN by using the below exsiting IE in NG-C interface.  *In Expected UE ehavior:*   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Expected UE Mobility | O |  | ENUMERATED (stationary, mobile, …) | Indicates whether the UE is expected to be stationary or mobile. |   *.* |
| Futurewei | 2 |  |
| Ericsson | 2 | We think the existing criteria for low mobility can be used with further study on whether some adjustments or configuration possibilities can be extended for RedCap Ues, cf. our previous reply as well. |
| Qualcomm | 2 | Option 1 does not support level 3. |
| Samsung | 2 | UE needs to monitor its mobility in RRC\_IDLE and RRC\_INACTIVE, in order to relax RRM measurement. To this end, we can introduce Rel-16 low mobility criterion as baseline. |
| Intel | 1 | If we only consider the true stationary UE, then the subscription information is sufficient. |
| Sharp | 2 |  |
| NEC | 1 | The measurement criteria takes a long time to evaluate whether the UE is a real fixed device. |
| LG | Both | Based on the examples described in section 2.2.1, such Ues in level 1 or 2 may not need evaluation of “stationary”. They just need indicate its status to network. Also level 3 Ues could indicate to the network that it is in stationary state temporarily.  Level 3 and 4 Ues need evaluation of stationary state, so option 2 is also needed. |
| Nokia | 2 |  |
| Xiaomi | 2 | The existing evaluation mechanism for low mobility can be considered as a baseline. |
| Lenovo | 2 | We prefer to use the legacy criteria on measurement as baseline. |
| vivo | Both | Both options can be supported. They are not conflict. It seems option1 doesn’t support Level 3 and 4. Thus, option 2, similar as the “low mobility” criterion in Rel-16 with different threshold could be used as the baseline.  If majority companies prefer only option 2, we are also fine. |

### RRM relaxation in RRC\_IDLE/INACTIVE

### Neighbor cells

We discuss first the RRM relaxation for neighbor cells, which is already supported in legacy. From the contribution review, all companies seem to support reusing the R16 legacy procedures as a baseline. The difference comes when considering whether REDCAP UEs can use the legacy mechanisms “as is” [8][16], or whether some enhancements should be introduced to the existing mechanisms to specifically address REDCAP Ues [6][9][11][12][14][15]. Among the proposed enhancements, some examples are:

1. For redcap Ues, introduce an additional (more stringent) threshold for low mobility criterion [6]
2. Allowing different relaxation levels depending on whether REDCAP UE is in cell center or at cell edge [10]
3. Allow configuring independently (decoupling) the relaxation of normal and REDCAP Ues [11]
4. If low mobility criterion is met for redcap Ues, the Ues can stop measurements on neighbour cells within T (T>>1) hours [15].
5. Multi-beam: enabling further relaxation via limiting the number of monitored RS (beams) [10][14]

Note 1: Enhancement #5 might be better discussed in RAN4 since it addresses the relaxation method rather than the relaxation trigger.

Note 2: Enhancement #1 assumes option 2 in Q2.2.

Anyways, the very first thing to decide is whether we introduce any enhancements to R16 RRM relaxation procedure in support of neighbor cells measurement relaxation of REDCAP Ues. Hence we have two options:

* Option 1: Support studying R16 NR RRM relaxation procedures (taken as baseline) enhancements
* Option 2: No support (nothing new is needed on top of R16).

**Q2.3: Which of Option 1 or 2 do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| CATT | 1 | We are supportive of at least configuring new “low mobility” thresholds for the “low mobility” criterion in order to distinguish stationary Ues from R16 “low mobility” Ues. |
| OPPO | 1 | We support to study RRM measurement relaxation enhancement for stationary RedCap Ues, e.g. consider measurement relaxation on some beams in the case when UE is fixed at a certain beam. |
| Huawei, HiSilicon | 1 | Some enhancements can be studied, for example:  1. New criterion and relaxation scheme for purely stationary UE can be considered further.  2. The number of measured SSB can be reduced to avoid unnecessary detection and measurement with some information provided by the network. |
| ZTE | 1 | We are ok to study measurement relaxation enhancement for RedCap Ues, but impact on other WGs should be limited. |
| Futurewei | 1 |  |
| Ericsson | 1 | Cf. our previous reply, we can further study whether there should be more configuration options for RedCap regarding RRM relaxation of neighboring cell measurements. We can capture our findings in the TR for further decision. |
| Qualcomm | 1 |  |
| ETRI | 1 | Agree with OPPO and Huawei. |
| Samsung | 1 | Some enhancement would be needed for RedCap devices. |
| Intel | 1 |  |
| Sharp | 1 |  |
| NEC | 1 |  |
| LG | 1 | R16 RRM relaxation is for mobile NR Ues, so further enhancement for RedCap devices is needed. |
| Nokia | 1 | Beam aspects are not accounted in Rel-16. |
| Xiaomi | 1 |  |
| Lenovo | 1 |  |
| vivo | 1 | Rel-16 RRM relaxation should be used as the baseline. Any further enhancements, e.g. different relaxation levels or methods, different relaxation configurations, different criteria threshold, etc. could be studied for RedCap specific use cases. |

### Serving cell

RRM relaxation of the serving cell has already been introduced in NB-IoT but would be a new feature for NR. It is supported to be further studied in contributions [8][14][15][17]. On the contrary, [10] suggests to not study this feature because it raises too many issues to study for the TU budget of the SI. Examples of associated issues are:

1. Mobility performance impact: with serving cell RRM measurement relaxation, UE may not be able to timely evaluate measurement results for cell reselection [10][14];
2. Serving cell RRM measurement relaxation would make the evaluation for neighbour cell relaxation less stable and accurate [10][14];
3. The serving cell measurements are used to trigger the neighbour cell RRM measurements relaxation; But for the serving cell itself, which reliable metric should be used to trigger its RRM measurement relaxation?

Clearly issues #1&2 should be studied in RAN4 while RAN2 could focus on issue#3. So this issue could be addressed according to the following options, where at least option 3 would trigger an LS to RAN4:

* Option 1: don’t support studying RRM relaxation of the serving cell for REDCAP UEs
* Option 2: support studying in RAN2 RRM relaxation of the serving cell for REDCAP UEs
* Option 3: study RRM relaxation of the serving cell for REDCAP UEs in RAN4 first

**Q2.4: Which of above options do you support?**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| CATT | 3 | RAN2 could agree the potential scope of such relaxation (e.g. only mobility levels 1-3 in Section 2.2.1) and send an LS to RAN4 checking if any RRM relaxation of the serving cell would be possible without mobility impact. |
| OPPO | 1 | Given that serving cell measurement relaxation may lead to too late cell reselection and make the evaluation for neighbouring cell relaxation less stable, we don’t support to study relaxation for serving cell. |
| Huawei, HiSilicon | 3 | Agree with CATT. Serving cell RRM measurement relaxation for UE in RRC\_IDLE/INACTIVE can be considered with minimizing impacts on mobility performance. |
| ZTE | 1 | We are wondering about the power saving gain vs performance impact. By configuring eDRX, we think the periodicity of serving cell measurement can already be relaxed. |
| Futurewei | 3 | Agree with CATT and Huawei. |
| Ericsson | Can be down-prioritized | Additionally, in RRC\_INACTIVE there can be impact on the small data transmission feature, e.g. impact on the success rate. In RRC\_CONNECTED, we could potentially look into work being done in Rel-17 UE PS WI.  We can study the options from RAN2 side and list the outcome in the TR, however we are fine to down-prioritize based on similar reasoning as mentioned in OPPO and ZTE comments, also considering the RAN2 impact related to issues 1-2. |
| Qualcomm | 3 | Agree with CATT. |
| ETRI | 3 |  |
| Samsung | 1 or 3 | We do not support serving cell relaxation, but are also fine to send LS to RAN4 as CATT's suggestion. |
| Intel | 2, 3 | From RAN2 perspective, we can identify potential enhancements, and then ask RAN4 for the confirmation. |
| Sharp | 3 | Agree with CATT. |
| NEC | 3 | Agree with CATT. |
| LG | 3 | We are fine with studying measurement relaxation on serving cell. Agree with CATT to check possible mobility impact. |
| Nokia | 1 | Reselections are delayed and this affects network performance negatively |
| Xiaomi | 3 |  |
| Lenovo | 3 | Agree with CATT. |
| vivo | 2, 3 | In many use cases, low-end RedCap UEs are stationary or moving around slowly. In these use cases, the measurement relaxation for serving cell can be further considered for power saving as we have done for NB-IoT. Rel-16 RRM relaxation and the mechanism in NB-IoT can be considered as the starting point.  Regarding the concern on the impact to accuracy mentioned by some companies, our thinking is that the relaxation for serving cell can only be used in some critical scenarios, e.g. level 1 or 2 in 2.2.1. But anyway, we are fine to check with RAN4.  Regarding the adulting on the power saving gain mentioned by some companies, we have provided some initial evaluation of serving cell RRM relaxation in idle mode in [R2-2006693]. The simulation results show it is possible for RedCap UEs to process SSBs in serving cell once per 5.12 seconds and about 10% power saving gain can be achieved. Companies are also invited to further evaluate the power saving gain. |

### RRM relaxation in RRC\_CONNECTED

This would be a new feature as it is currently supported neither in LTE nor in NR.

As a first step, we primarily focus on relaxing RRM measurements of neighbor cells, since serving cell relaxation should be first solved in Idle/Inactive.

Studying RRM Relaxation in RRC\_CONNECTED is supported in [6][8][14][16], and also [10][11] [14] who additionally think it can be fully left to NW implementation/configuration. [8] suggest reusing the R16 mechanism as baseline.

Thus we foresee three options for addressing this feature:

* Option 1: There is benefit in relaxing RRM measurements of neighbour cells in RRC\_CONNECTED for REDCAP UEs and associated specification and performance impacts should be studied.
* Option 2: There is benefit in relaxing RRM measurements of neighbour cells in RRC\_CONNECTED but it can be all left to NW implementation/configuration and there is no need to study anything.
* Option 3: There is no benefit in relaxing RRM measurements of neighbour cells in RRC\_CONNECTED so there is no need to study anything.

**Q2.5: Which option do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| CATT | 3 | 1) The time spent in RRC\_CONNECTED for redcap Ues is expected to be short. 2) RRM is not the main contributor to UE power consumption in RRC\_CONNECTED. 3) Anyways, we also agree that the network can reduce the RRM measurement objects via dedicated signaling to reduce UE power consumption on RRM (option 2) |
| OPPO | 1 | Note that, the existing s-measure mechanism in both LTE and NR was just specified for reducing neighbor cell measurements in connected mode. We think connected mode neighbor cell measurement relaxation is also beneficial for UE power saving and should be studied. |
| Huawei, HiSilicon | 2 | RRM measurement relaxation for neighboring cells in RRC\_ CONNECTED state can yield power saving gain with risk of degrade the network performance.  We think the relaxation need strictly controlled by the network and network may decide it based on its strategy and history information, so maybe it can be left to NW implementation/configuration. |
| ZTE | 3 > 2 | We also think compare to other UE activities, RRM measurement is not main contributor to UE power consumption. So we prefer not to consider RRM relaxation for Connected Ues.  If network can obtain “expected UE eighbor” information (as responsed to Q2.2), the network can take appropriate action (option2), thus we don’t think anything new is needed. |
| Futurewei | 2 | Relaxing RRM measurements of neighbor cells, while reducing UE power consumption, may have impact on network performance, therefore, should be carefully managed by network implementation. |
| Ericsson | 1/2 | We think RedCap UE staying for long periods in RRC\_CONNECTD might not be a very common use case, therefore, although there can be potential for gains in this area, this option could be down-prioritized.  We share the view with Huawei and Futurewei that we should be careful when it comes to NW performance, and one option could be to leave possibilities to NW to configure possible RRM relaxation carefully. |
| Qualcomm | 2 but with comments | Network has full control in neighbor cell measurement in RRC Connected. However, some UE assistance information for UE to indicate its preference is good to have (e.g. indication of UE’s stationarity or mobility related information) |
| ETRI | 1/2 | Neighbor cell measurement relaxation in RRC\_CONNECTED can be useful if it is controlled by network configuration. |
| Samsung | 2 or 3 | We barely expect the benefit for RRM relaxation in RRC\_CONNECTED, since RedCap device would stay RRC\_INACTIVE or IDLE for most of the time. Besides, in my understanding, RRM measurement is not main power consumption in RRC\_CONNECTED. However, we are also fine to leave it to NW implementation. |
| Intel | 1 | For stationary UE, e.g. fix location, do not see the problem to relax the RRM measurement for Connected state for both serving and neighboring cells. |
| Sharp | 1 | We are not sure whether the existing signaling and procedures are sufficient or not for relaxing RRM measurements of eighbor cells in RRC\_CONNECTED for RedCap Ues at this early stage, so we are fine to study. |
| NEC | 2/3 | We barely see the benefit for RRM relaxation in RRC\_CONNECTED, since RedCap device would stay RRC\_INACTIVE or IDLE for most of the time. |
| LG | 1 | Current measurement is RRC\_CONNECTED is only based on network configuration and the network would adjust the measurement configuration based on measurement repot by Ues. If UE is allowed to perform less measurements without any instant permission by the network, it can reduce the signaling and UE performs relaxed measurement quicker. |
| Nokia | 1 | We think connected mode neighbor cell measurement relaxation is also beneficial for UE power saving. Relaxation should be under network control. |
| Xiaomi | 1 | We think the similar RRM measurement relaxation mechanism specified in RRC-IDLE mode in Rel-16 power saving WI should be studied in RRC-CONNECTED mode. |
| Lenovo | 1/2 | Neighbor cell measurement relaxation in RRC\_CONNECTED will leading to RedCap UE power saving, it is fine that relaxation is under network control to avoid the impact to mobility. |
| vivo | 1 | In study phase of Rel-16 Power Saving, RRM relaxation in connected mode has also been studied and evaluated. Considering potential impacts on UE mobility performance and limited scope in WI, it has not been specified. There are many stationary use cases for RedCap UEs. We are ok to study RRM relaxation in connected mode for “true” stationary UEs. In this case, there is no impact to the system performance. |

# Other

Companies are welcome to bring any other issue related to eDRX or RRM relaxation of REDCAP UEs that they believe relevant to this email discussion.

**Q2.6: Any other relevant issue to discuss?**

|  |  |
| --- | --- |
| Company | Issue description |
| Ericsson | We’d like to focus on providing input to the TR 38.875 on the various options and not so much on trying to already select preferred options for possible standardization during WI. The WI scope should be discussed based on the studies, and the exact details of various features can be discussed and agreed in the normative phase, and we can for now focus on aspects which can be captured as the study outcome in the TR. |
|  |  |
|  |  |

# Conclusion

# Reference

1. R2-2008193 Summary of offline 111 - DRX aspects; CATT
2. R2-2008216 Summary of offline 111 - DRX aspects - second round; CATT
3. R2-2007346 Discussion on eDRX for RRC\_INACTIVE and RRC\_IDLE; Huawei, HiSilicon
4. R2-2006748 Use cases target to extend paging DRX cycle and relax measurements for stationary devices; Intel Corporation
5. R2-2006905 Introduction of eDRX for Redcap UE; ZTE Corporation, Sanechips
6. R2-2006607 Power saving enhancements for RedCap UEs; Qualcomm Inc
7. R2-2006662 RRM relaxation for stationary devices; Samsung
8. R2-2006693 RRM relaxation for power saving; vivo, Guangdong Genius
9. R2-2006731 Discussion on UE Power saving for Redcap Devices; Xiaomi Communications
10. R2-2006788 Discussion on RRM relaxation; OPPO
11. R2-2006902 Consideration on RRM relaxation for Redcap UE; ZTE Corporation, Sanechips
12. R2-2008130 Reducing power consumption in RedCap devices; Ericsson
13. R2-2007111 Impact of power-saving aspects on RedCap UEs; Apple
14. R2-2007347 RRM measurement relaxation for REDCAP UE; Huawei, HiSilicon
15. R2-2007471 RRM relaxation for stationary UE with reduced capability; Lenovo, Motorola Mobility
16. R2-2007561 Power saving and battery lifetime enhancement for REDCAP UE; Nokia, Nokia Shanghai Bell
17. R2-2007745 Considerations on RRM for reduced capability UEs; LG Electronics France