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.  |

**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.  |
|  |  |  |

### 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.  |

**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.  |
|  |  |  |

**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 |  |
|  |  |  |

### 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. |

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 < 10.24sIn 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 = 10.24sThis 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 |  |

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. |

**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. |

# 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.  |

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. |

### 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. |

### 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. |

### 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. |

### 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. |

# 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  |
|  |  |
|  |  |
|  |  |

# 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