3GPP TSG-RAN WG2 #115-e draftR2-2108881

**Electronic meeting, 16th – 27th August 2021**

Agenda Item: 8.12.3.1

Source: vivo

Title: Summary of [AT115-e][105][REDCAP] eDRX cycles (vivo)

Document for: Discussion and Decision

# Introduction

The document summarizes the following offline discussion:

* [AT115-e][105][RedCap] eDRX cycles (vivo)

Initial scope: Based on company contributions in 8.12.3.1, discuss the expected behaviour for different (RAN and CN) eDRX cycles lengths, assuming eDRX cycle in INACTIVE <= 10.24s

Initial 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)

Initial deadline (for companies' feedback): Wednesday 2021-08-18 04:00 UTC

Initial deadline (for rapporteur's summary in R2-2108881): Wednesday 2021-08-18 08:00 UTC

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# Discussion

## Configuration of eDRX cycle for RRC\_IDLE and RRC\_INACTIVE

In RAN2#113bis-e, RAN2 made the following agreements on eDRX cycle for RRC\_IDLE and RRC\_INACTIVE:

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| Agreement:  At least for eDRX cycle, the configurations of the eDRX for RRC\_IDLE and RRC\_INACTIVE can be different (FFS for PTW, e.g. length and starting point, when eDRX cycles are longer than 10.24s) |

In LTE, RAN configures the UE in RRC-INACTIVE with an eDRX cycle up to the value of IDLE eDRX cycle. In RAN2#113e meeting, RAN2 asked SA2 and CT1 whether it is feasible to extend the maximum eDRX cycle length for RRC\_INACTIVE beyond 10.24s. CT1 has provided the following reply in LS [1]:

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| CT1 could not reach consensus on feedback regarding the feasibility of extending extended DRX in RRC\_INACTIVE up to 10485.76 seconds. |

According to Chair guidance for this offline discussion, we assume eDRX cycle in INACTIVE <= 10.24s for now.

Based on company contributions in 8.12.3, different companies have different preferences on the supporting configurations of IDLE and INACTIVE eDRX.

From Rapporteur point of view, supporting the following configuration by default is agreeable for all companies.

* Configuration 0: Only IDLE eDRX is configured without INACTIVE eDRX

While, Companies [2][4][6][7][9][10][12][13][15] point out that the INACTIVE eDRX cycle should be no longer than IDLE eDRX cycle; and when IDLE eDRX is not configured, the INACTIVE eDRX should not be configured. Company [8] Pointed out that the configuration INACTIVE eDRX could be configured only and it seems that company [8] also supported INACTIVE eDRX cycle longer than IDLE eDRX cycle. Company [15] proposed when both eDRX cycle are no longer than 10.24s, same eDRX cycle value should be set for both idle and inactive.

1. Companies are invited to comment on whether the following configurations are allowed or not:

* Configuration1: Only INACTIVE eDRX is configured without IDLE eDRX
* Configuration2: Both INACTIVE and IDLE eDRX are configured, and INACTIVE eDRX cycle is longer than IDLE eDRX cycle
* Configuration3: Both INACTIVE and IDLE eDRX are configured, and INACTIVE eDRX cycle is equal to IDLE eDRX cycle
* Configuration4: Both INACTIVE and IDLE eDRX are configured, and INACTIVE eDRX cycle is shorter than IDLE eDRX cycle

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| **Company’s name** | **Allowed configuration(s) [y/n]** | | | | **Comments, if any** |
| **1** | **2** | **3** | **4** |
| Qualcomm | Y | - | Y | Y | From UE’s perspective, Configuration 2 results in the same paging monitoring periodicity as Configure 3 |
| OPPO | N | N | Y | Y | We think the restrictions on eDRX configuration for LTE-M should also apply to RedCap. |
| Huawei, HiSilicon | N | N | Y | Y | As described in TS23.501, INACTIVE eDRX cycle shall be not be longer than IDLE eDRX cycle |
| Xiaomi | No | No | Y | Y | We think C1 is invalid as in LTE.  For C2, we think TR 23.724 has captured it very clear that the UE negotiates with AMF for idle mode e-DRX cycle for CN paging and negotiates with the gNB for inactive mode e-DRX cycle for RAN paging while the latter should be up to the value used for the UE's idle mode e-DRX cycle as provided by the AMF. |
| Intel | y (\*1) | y (\*1) | y | y | From specification point of view, we do not see the need to limit any configuration understanding that it can be left up to network implementation to decide which configuration is or not manageable to reach a UE in INACTIVE via CN paging if it were needed.  In addition, current discussion assumes that eDRX can be configured for a UE in INACTIVE. However it is important to keep in mind CT1’s input i.e. “CT1 could not reach consensus”. Therefore it is not clear to us whether CT1 may be in favor to enable any eDRX operation (above or below 10.24sec) in INACTIVE.  (\*1) In addition, for configurations 1 and 2, we understand that they can only be feasible if CN is aware that the UE is configured with eDRX for INACTIVE. This way, CN could allow/handle longer DL reachability delays when using CN paging to reach a UE in INACTIVE that is configured with eDRX cycle (which may be ≤10.24 sec or >10.24 sec). If SA2/CT1 were ok with this operation (which currently is unclear based on CT1 latest LS as previously explained) and RAN2 could ask them whether RAN needs to provide to CN any related information, such as, option (1) when a UE in INACTIVE supports eDRX, option (2) when a UE in INACTIVE is configured with eDRX or option (3) when a UE in INACTIVE is configured with eDRX with its corresponding eDRX configuration. |
| Samsung | N | N | Y | Y | Support OPPO and Huawei |
| LGE | N | N | Y | Y | We think it is reasonable that Idle eDRX has longer value than Inactive one, and that assumption is simple for the UE operation. |
| Sequans | N | N | Y | Y | This seems to be in line with current spec and CT response. We don’t see a good reason to try and change this. |
| Nokia | Y | - | Y | Y |  |
| ZTE | N | N | Y | Y | Agree with OPPO and Huawei, and we see no benefit to support configuration 1 and 2.  To facilitate RAN paging, it is possible to configure a shorter eDRX cycle for INACTIVE. But to configure a larger INACTIVE eDRX cycle has no UE power saving gain because the UE still needs to monitor CN paging with shorter eDRX cycle (for IDLE). |
| MediaTek | N | N | Y | Y | For 1 and 2, as CN may not be aware of the eDRX cycle for RAN, RAN cannot relax the UE paging monitoring by itself. UE would still have to monitor the CN paging, so the RAN Inactive configuration would be redundant. |
| CATT | N | N | Y | Y | We see no scenario supporting cfg #1 and #2. |
| Apple | Y | Y | Y | Y | Same view as Qualcomm on 2 and 3. Also we do not see any need to prevent gNB configure eDRX independent of CN eDRX config, although some co-odrination between gNB and AMF is needed. |
| Futurewei | N | N | Y | Y | Agree with OPPO and Huawei. |

## PH/PTW calculation

When eDRX cycle is longer than 10.24s, according to the agreement in RAN2#113bis-e, PH and PTW will be used and the paging operation in E-UTRAN/5GC can be re-used as baseline:

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| Agreement：  2. eDRX feature, including the related parameters (i.e. PH, PTW. H-SFN) and corresponding paging operation defined for E-UTRA/5GC is used as baseline to enable eDRX >10.24sec for both RRC\_IDLE and RRC\_INACTIVE in NR/5GC |

**PH calculation**

Company [3] proposed reusing the LTE mechanism as baseline, i.e.

PH\_CN: H-SFN mod TeDRX,\_CN,H= (UE\_ID\_H mod TeDRX\_CN,H)

- where TeDRX\_CN,H is equal to IDLE eDRX cycle.

1. When IDLE eDRX cycle is longer than 10.24s, companies are invited to provide their views on whether agree to reuse the PH calculation from legacy LTE formulation?

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| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes | We are fine with reusing LTE’s formula |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes | Reuse the legacy LTE formulation, including the calculation of UE\_ID\_H |
| Xiaomi | Yes |  |
| Intel | Yes | We do not see any strong reason to change this for an NR UE in IDLE configured with eDRX > 10.24sec |
| Samsung | Yes |  |
| LGE | Yes |  |
| Sequans | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes |  |
| CATT | Yes |  |
| Apple | Yes | Reusing the LTE formula is the way to go. |
| Futurewei | Yes |  |

**PTW calculation**

Regarding on the calculation of PTW\_start for RRC\_IDLE, companies [2] [4] [6] [7] [10] [11] [13] [15] assumed the LTE PTW\_start calculation method can be reused as the baseline:

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| PTW\_start denotes the first radio frame of the PH that is part of the PTW and has SFN satisfying the following equation:  SFN = 256\* ieDRX, where  - ieDRX = floor(UE\_ID\_H /TeDRX,H) mod 4 |

However, the companies [8] [12] proposed other methods for PTW\_start calculation: Company [12] pointed out fixing the number of possible PTW\_start position in a hyper-frame to 4 (i.e. 256 SFNs between each other) introduces some limitations for the network configuration of eDRX for multiple UEs. They proposed that RAN2 to select from the following options regarding the PTW\_start positions:

* Option A: Configurable by the network
* Option B: Fixed to multiples of 128 SFNs
* Option C: Fixed to multiples of 256 SFNs as in LTE (with a potential cost of non-uniform distribution of POs)

Company [8] proposed to ask SA2/CT1 if NR eDRX start location of a UE in IDLE can be changed to be a multiple of a configurable value to be decided by the network.

1. Companies are invited to show your preference among the following options on PTW\_start calculation?

- Option1: Re-use LTE PTW\_start calculation formula (i.e. Fixed to multiples of 256 SFNs)

- Option2: Fixed to multiples of 128 SFNs

- Option3: Configurable by the network

- Option4: Others (if you prefer other methods, please provide your comments)

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| **Company** | **Option (s)** | **Comments / arguments** |
| Qualcomm | 1, 3 | We are fine with reusing LTE’s formula as baseline. We can support Option 3 as an enhancement too if it has strong support. |
| OPPO | Option 3 | Reusing LTE PTW\_start calculation formula is always feasible, however, we think that paging load among different POs in time domain should be well balanced and therefore we prefer to have PTW\_start configurable by the network. |
| Huawei, HiSilicon | Option1 | Reuse LTE formula  Option 2 is not preferred, since it causes different handling between LTE and NR in the CN. But we are fine if majority wants option2. |
| Xiaomi | Option1 |  |
| Intel | See comment | This email discussion explained that focuses on “eDRX cycle in INACTIVE <= 10.24s for now”. However, it is not clear to us whether this discussion may also refer to INACTIVE scenario as some of the references above also discussed the PTW start definition considering both (and not only IDLE).   * If PTW operation is only enabled for UE in IDLE, we are ok re-using same calculation as in LTE or if majority of companies prefer changing LTE calculation, we have slightly preference for a configurable value (as explained in option 3) if SA2/CT1 were ok with this. * If PTW operation is enabled for both IDLE and INACTIVE, we understand that multiple inputs would need to be discussed as explained in [8]: UE ID, T eDRX cycle, and the factor accounted in the formula (fixed vs variable). |
| Samsung | 1 | Prefer Option 1 as in LTE, but we are also fine to ask SA2/CT1 |
| LGE | Option 1 |  |
| Sequans | 1 (3 OK if fine with SA/CT) | Prefer to reuse LTE (Opt. 1) but are fine to use a configurable value if there is enough support and it is fine from CN POV. 2 just seems a possible special case of 3 |
| Nokia | 1, 3 |  |
| ZTE | see comments | The number of possible PTW\_start within a hyper frame depends on the minimal value of PTW length. For example, if the minimal PTW length is 1.28s, it is reasonable to have 8 PTW\_start locations in order to distribute PTW more uniformly within a hyper frame.  In current 38.413, minimal value of PTW\_length is 1.28s for LTE and 2.56s for NB-IoT. Per our understanding, the minimal value of PTW length relates to the time synchronization between CN and RAN. Thus we are unsure whether the minimal value of PTW length can be reduced. If it is specified as 2.56s or 1.28s for RedCap, then 4 or 8 PTW\_start locations are enough. |
| MediaTek | 1, 2, 3 | Our preference would be option 2 or 3 to allow the network to better distribute its paging load. But if there is not enough support for those, option 1 (LTE mechanism) can be reused. |
| CATT | 1 | This can be the starting point. Further enhancements may be considered, e.g. whether an SFN-offset is needed to cope with multiple beams support. |
| Apple | 1 | We can start with this for now (same as CATT). Needs discussion once SA2 confirms the support/no-support of >10.24s INACTIVE eDRX. |
| Futurewei | Option 1 |  |

As for PTW\_end, companies [13][15] proposed that the equation for PTW\_end defined in LTE can be reused as baseline for NR, i.e. PTW\_end is radio frame satisfying SFN = (PTW\_start + L\*100 - 1) mod 1024, where L is PTW length configured by upper layers.

1. When IDLE eDRX cycle is longer than 10.24s, companies are invited to provide their views on whether agree to reuse the PTW\_end calculation from legacy LTE formulation?

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| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes | The PTW\_end is calculated based on provided PTW\_start and PTW length |
| Xiaomi | Yes |  |
| Intel | Yes |  |
| Samsung | Yes |  |
| LGE | Yes |  |
| Sequans | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Futurewei | Yes |  |

Companies [6][15] proposed that since multi-beam PO are introduced in NR, one PO consists a set of PDCCH monitoring occasions that may span cross radio frame boundary. Hence, if the PTW\_start and PTW\_end location is calculated just in the radio frame boundary as LTE, it may cause the issue that the PTW starts from the middle of one PO or ends at the middle of one PO, which will lead paging missing. Companies [6][15] proposed RAN2 to discuss the solutions to resolve this issue, e.g.

1. Using the LTE PTW calculation formula, and if there are one or two PO(s) not entirely in the PTW, the PTW is extended to covers these PO(s).
2. Defining new PTW calculation formula for NR, and so on.
3. Companies are invited to provide their views on whether this issue should be addressed in RAN2: when determining the PTW\_start and/or PTW\_end, the multi-beam PO may be located outside the PTW, which will cause the paging missing?

- If Yes, please provide your views on solutions,

- If No, please provide your reason.

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| **Company** | **Yes / No** | **Comments** |
| Qualcomm | No | We agree that in theory it is possible for part of a PO to be located outside PTW, with certain PTW configurations. That may result in one less PO for UE. However, if network thinks this shortage of one PO is critical, it can compensate the shortage by configuring a longer PTW. That seems a simpler way (pure network implementation, no spec impact) to fix the issue than studying a new PTW formula. |
| OPPO | No | Considering the multiple beam impact, a PO in NR is defined as 'S' consecutive PDCCH monitoring occasions, where 'S' is the number of actual transmitted SSBs.  A PF may consist one or multiple PO, the number of which is configured by NW, and the starting location of each PO in a PF is also configured by NW.  The notes below are given in TS38.304.  NOTE 1: A PO associated with a PF may start in the PF or after the PF.  NOTE 2: The PDCCH monitoring occasions for a PO can span multiple radio frames.  Based on the notes, the association between PO and PF are fixed under a certain PCCH configuration.  If the PTW length are always [integral](javascript:;) [multiple](javascript:;)s of radio frame length, both PTW\_start and PTW\_end location would be located in the radio frame boundary. Whether to regard a PO as part of PTW totally depends on whether its associated PF is within the PTW. We don't need to care whether the actual location of the PO is within the PTW. So we see no issue here. |
| Huawei, HiSilicon | No | The probability of this case is low and it can be handled via NW implementation.  We think we have already agreed to exclude this. |
| Xiaomi | No | We do not think there is a critical issue. Even if a certain PO is impacted, we have PTW which enables the paging message can be repeated to improve paging reliability. |
| Intel | See comment | If majority of companies support option 3 in previous discussion point 4, there is no need to address this topic (assuming that it could be handled by network configuration). If not, option (1) seems sufficient. |
| Samsung | No | It can be addressed by NW implementation. |
| LGE | No | We think it can be handled by NW. |
| Sequans | No | If it’s an issue, can be addressed by NW implementation assigning longer PTW |
| Nokia | No | Up to NW to take care. |
| ZTE | No | Agree with Qualcomm. For the POs that are not located entirely in PTW, it is up to UE to decide how to handle it. |
| MediaTek | No | We think that this can be handled by the network implementation. |
| CATT | Yes | Multi-beam support is one of the key differences with LTE and should be addressed. We don't necessarily think it requires a new PTW calculation formula though, but instead indicating an additional gNB-specific offset adjusting PTW\_start and/or PTW\_end so that the POs located in the PTW consist of all the PDCCH occasion for paging from all the beams. |
| Apple | No | No need to address. Can be handled by NW implementation. |
| Futurewei | No | It can be addressed by NW implementation. |

## Paging monitoring mechanism in extended DRX

Based on companies’ contributions, considering the configurations discussed in Discussion Point 1, following eDRX combinations could be considered for paging monitoring. The corresponding UE behaviour should be discussed for all cases.

* **Case1** IDLE eDRX cycle <=10.24s, INACTIVE eDRX is not configured
* **Case2** IDLE eDRX cycle > 10.24s, INACTIVE eDRX is not configured
* **Case3** IDLE eDRX cycle <=10.24s, INACTIVE eDRX cycle <=10.24s
* **Case4** IDLE eDRX cycle >10.24s, INACTIVE eDRX cycle <=10.24s
* **Case5**  IDLE eDRX cycle is not configured, INACTIVE eDRX <=10.24s (If configuration 1 in Q1 is allowed.)

**The paging monitoring mechanism for RRC\_IDLE UE will be analyzed firstly.**

When eDRX cycle is longer than 10.24s, according to the agreement in RAN2#113bis-e, PH and PTW will be used and the paging operation in E-UTRAN/5GC can be re-used as baseline:

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| Agreement：  2. eDRX feature, including the related parameters (i.e. PH, PTW. H-SFN) and corresponding paging operation defined for E-UTRA/5GC is used as baseline to enable eDRX >10.24sec for both RRC\_IDLE and RRC\_INACTIVE in NR/5GC |

In LTE, the paging monitoring behaviour in eDRX is as follow:

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| If the UE is configured with a TeDRX cycle of 512 radio frames, it monitors POs as defined in 7.1 with parameter T = 512. Otherwise, a UE configured with eDRX monitors POs as defined in 7.1 (i.e, based on the upper layer configured DRX value and a default DRX value determined in 7.1 or if the UE is in RRC-INACTIVE based on the upper layer configured DRX value, default DRX cycle and RAN paging cycle determined in 7.1), during a periodic Paging Time Window (PTW) configured for the UE or until a paging message including the UE's NAS identity is received for the UE during the PTW, whichever is earlier. |

For Case 1 and Case 3, companies [4][6][8][10][11][13][15] proposed reusing the LTE behaviour, i.e., RRC\_IDLE UE monitors paging based on IDLE eDRX cycle.

For Case 2, Case 4 and Case 5, companies [3][4][6][9][10][11][13][15] proposed UE monitors paging based on the shortest of UE specific DRX cycle, if configured by upper layer and default paging cycle during the CN PTW as LTE.

1. For RRC\_IDLE UE, when IDLE eDRX cycle is configured, companies are invited to provide their views on whether agree the following paging monitoring behaviour:

* When eDRX cycle is no longer than 10.24s, T is determined by IDLE eDRX cycle.
* When eDRX cycle is longer than 10.24s, T is determined by the shortest of UE specific DRX cycle, if configured by upper layer and default paging cycle during the CN PTW.

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| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes | Agree with the monitoring behavior described above |
| OPPO | Yes | The PO monitoring mechanism in LTE can be reused. |
| Huawei, HiSilicon | Yes | Reuse the LTE principle |
| Xiaomi | Yes |  |
| Intel | Yes |  |
| Samsung | Yes |  |
| LGE | Yes |  |
| Sequans | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes | Reuse the LTE mechanism. |
| CATT | Yes |  |
| Apple | Yes | Same as LTE. |
| Futurewei | Yes |  |

**Then, the paging monitoring mechanism for RRC\_INACTIVE UE will be analyzed.**

For RRC\_INACTIVE UE, there may be state mismatch issue between UE and Network, then the UE in RRC\_INACTIVE also needs to monitor CN paging to avoid paging miss. When eDRX cycle for RRC\_INACTIVE is configured, the paging monitoring mechanism should ensure the RRC\_INACTIVE UE can be reached by RAN paging and CN paging. In the following, the paging monitoring mechanism for different cases will be discussed.

**For case1, IDLE eDRX cycle <=10.24s and INACTIVE eDRX is not configured:**

UE monitors CN paging based on IDLE eDRX cycle, and UE monitors RAN paging based on RAN paging cycle.

Companies proposed the following paging monitoring methods:

* Option 1: T is determined by the shortest of IDLE eDRX cycle, RAN paging cycle, and default paging cycle [4][5].
* Option 2: T is determined by the shortest of RAN paging cycle and IDLE eDRX cycle [7][10].
* Option 3: T is determined by RAN paging cycle [6][12][13].

For option 1, company [4] proposed default paging cycle should be involved for SI change notification to calculate T.

Here, RAN paging cycle means RAN DRX cycle, as there is no INACTIVE eDRX configuration.

It should be noted that the RAN paging cycle is mandatory in NR, and IDLE eDRX cycle is always not shorter than RAN paging cycle, hence, the Option 2 and Option 3 is same from Rapporteur point of view. Companies are also invited to provide opinions on which option/expression is preferred. For example, using option 2 could have a unified formula to determine T for case 1 and case 4 below, while using option 3 is simpler.

1. When IDLE eDRX cycle is no longer than 10.24s and INACTIVE eDRX cycle is not configured, companies are invited to provide their preference among the following options on the paging monitoring calculation used for RRC\_INACTIVE UE:
   * Option 1: T is determined by the shortest of IDLE eDRX cycle, RAN paging cycle, and default paging cycle.
   * Option 2: T is determined by the shortest of RAN paging cycle and IDLE eDRX cycle.
   * Option 3: T is determined by RAN paging cycle.
   * Option 4: Others, please specify.

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| --- | --- | --- |
| **Company** | **Option (s)** | **Comments / arguments** |
| Qualcomm | Option 2 |  |
| OPPO | Option 2 | Since UEs in RRC INACTIVE should monitor both CN paging and RAN paging, both RAN paging cycle and IDLE eDRX cycle are need to be taken into account. |
| Huawei, HiSilicon | Option1 | With option 2/3, the UE can miss SI change notification if the modification period is shorter.  We understand the discussion point is whether to consider the default paging cycle, as the rapporteur’s understanding is that option 2 and 3 have no significant difference if the RAN paging cycle cannot be longer than the IDLE DRX cycle.  As to the default paging cycle, option 2/3 is more like LTE manner, while option 1 is more like NR principle. |
| Xiaomi | Option 2 |  |
| Intel | Option 1 (legacy) | If UE in INACTIVE is not configured with eDRX, there is no need to change legacy operation (as shown below in the reference from 38.034) which we understand to be the same as option 1.  *“T: DRX cycle of the UE (****T is determined by the shortest of the UE specific DRX value(s), if configured by RRC and/or upper layers, and a default DRX value*** *broadcast in system information.”* |
| Samsung | Option 1 or 2/3 | If default DRX cycle is included to support SI change notification, we think RAN2 needs to also include it to all the other cases for UEs in RRC\_INACTIVE, which will be discussed below. We still have no strong preference, but we want to have consistent decision for all the cases. (i.e., Include default DRX cycle in all the cases vs. Not include default DRX cycle in all the cases) |
| LGE | Option 1 |  |
| Sequans | Option 1 | Agree with Intel |
| Nokia | Option 1 |  |
| ZTE | Option 2 |  |
| MediaTek | Option 3 | Because RAN paging cycle is always shorter than CN eDRX cycle, option 3 can be used instead of option 2. |
| CATT | Option 4 | Take LTE as baseline, i.e. T is determined by the IDLE eDRX cycle = 2.56 or 5.12 or 10.24 seconds, irrespective of Idle or Inactive state (we are not sure if Option 1’s intention is like legacy).  In LTE 36.304 7.1 Discontinuous reception for paging is specified as follows  “- T: DRX cycle of the UE.  If a UE specific extended DRX value of 512 radio frames is configured by upper layers according to 7.3, T =512.”  And in 36.304 7.3 Paging in extended DRX is specified as follows:  “If the UE is configured with a TeDRX cycle of 512 radio frames, it monitors POs as defined in 7.1 with parameter T = 512.”  According to the 36.304, when eDRX= 5.12s is configured for the UE, the UE will monitor the PO according to T=5.12s no matter it is in inactive or idle.  We think it is better to reuse the LTE mechanism. |
| Apple | Option 2 |  |
| Futurewei | Option 1 |  |

**For case 2, IDLE eDRX cycle > 10.24s and INACTIVE is eDRX not configured:**

In this case, the CN PTW will be configured, and the paging monitoring mechanism for RRC\_INACTIVE UE has been introduced in LTE:

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| --- |
| In RRC\_INACTIVE state if extended DRX is configured by upper layers according to 7.3:  - If a UE specific extended DRX value other than 512 radio frames is configured:  - During the PTW, T is determined by the shortest of the RAN paging cycle, if configured, the UE specific paging cycle, if allocated by upper layers, and the default paging cycle. Outside the PTW, T is determined by the RAN paging cycle, if configured. |

Companies [4][5][6][10][12][13][15] supported reusing the LTE behaviour **during CN PTW**, i.e. UE monitors paging based on the shortest of UE specific DRX cycle, if configured by upper layer, RAN paging cycle, and default paging cycle.

1. Companies are invited to provide their views on whether agree: when IDLE eDRX cycle is longer than 10.24s and RAN eDRX cycle is not configured, RRC\_INACTIVE UE monitors paging based on the shortest of UE specific DRX cycle, if configured by upper layer, RAN paging cycle, and default paging cycle **during CN PTW**? If No, please provide your preferred solution(s).

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes |  |
| OPPO | Yes | The PO monitoring mechanism in LTE can be reused. |
| Huawei, HiSilicon | Yes | Reuse LTE |
| Xiaomi | Yes |  |
| Intel | Legacy operation | Response to discussion point 7) also applies here, we understand that legacy operation is sufficient. In our understanding, there is no need for a UE in INACTIVE to monitor differently during the CN PTW understanding that currently UE in INACTIVE always monitors the shortest of all the configured values (including the one provided by upper layers) as shown in reference included in previous discussion point 7). |
| Samsung | Yes |  |
| LGE | Yes |  |
| Sequans | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Futurewei | Yes |  |

**Outside CN PTW**, T=RAN paging cycle in LTE.

Companies have different views on UE monitors paging **outside CN PTW**:

* Option 1: T is determined by the shortest of RAN paging cycle and default paging cycle [4][5].
* Option 2: T is determined by RAN paging cycle [6][10][12][13][15].

For option 1, similar as case1, company [4] proposed that default paging cycle should be involved for SI change notification to calculate T.

1. When IDLE eDRX cycle is longer than 10.24s and INACTIVE eDRX cycle is not configured, for RRC\_INACTIVE UE, companies are invited to provide their views on the paging monitoring mechanism **outside CN PTW** among the following options?
   * Option 1: T is determined by the shortest of RAN paging cycle and default paging cycle.
   * Option 2: T is determined by RAN paging cycle.
   * Option 3: others, please specify.

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (s)** | **Comments / arguments** |
| Qualcomm | Option 2 |  |
| OPPO | Option 2 | The PO monitoring mechanism in LTE can be reused. |
| Huawei, HiSilicon | Option 1 | Same reason as discussion point 7 |
| Xiaomi | Option 2 |  |
| Intel | Legacy operation | See response to discussion point 9) |
| Samsung | Option 1 or 2 | Please see our previous response in Discussion point 7 |
| LGE | Option 1 |  |
| Sequans | Option 1 |  |
| Nokia | Option 1 |  |
| ZTE | Option 2 |  |
| MediaTek | Option 2 |  |
| CATT | Option 2 |  |
| Apple | Option 2 |  |
| Futurewei | Option 1 |  |

**For case 3, IDLE eDRX cycle <=10.24s and INACTIVE eDRX cycle <=10.24s**:

Similar to case1, companies [2] [4] [5] [6] [7] [10] [12] [13] [15] proposed UE monitors paging based on the shortest of IDLE eDRX cycle and INACTIVE eDRX cycle.

If IDLE eDRX is always no shorter than INACTIVE eDRX (i.e. configuration 2 in Q1 is not allowed), then, the proposed solution, i.e. UE monitors paging based on the shortest of IDLE eDRX cycle and INACTIVE eDRX cycle, is equal to UE monitors paging based on the INACTIVE eDRX cycle. Companies are also invited to provide opinions on which description is preferred.

1. Companies are invited to provide their views on whether agree: when both IDLE eDRX cycle and INACTIVE eDRX cycle are no longer than 10.24s, RRC\_INACTIVE UE monitors paging based on the shortest of IDLE eDRX cycle and INACTIVE eDRX cycle. (Or if you do not agree the configuration 2 in Q1, RRC\_INACTIVE UE monitors paging based on the INACTIVE eDRX cycle).

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Xiaomi | Yes |  |
| Intel | No | The objective with eDRX feature is to save UE’s power consumption. There are two approaches proposed by companies:   * Approach 1) with burden in UE side. For this, UE monitors both or the shorted of RAN configured eDRX cycle and CN configured eDRX cycle. This approach 1) seems preferable by majority of companies but UE power consumption will suffer (as UE will wake up more frequently) which is not the intended objective of the feature. * Approach 2) with burden in network side. If UE in INACTIVE monitors only RAN POs, UE’s intended power saving is achieved but then network has to coordinate to ensure NAS paging is not missed.   In our understanding UE should ideally monitor PF/PO based on the eDRX cycle that was configured based on its RRC state. Therefore a UE in INACTIVE and configured with eDRX cycle to be used in INACTIVE (i.e. RAN configured eDRX), monitors paging based on the RAN configured eDRX (independently of the paging DRX cycle configured in IDLE). However, this UE in RRC\_INACTIVE monitors both RAN assigned UE ID and CN assigned UE ID (as in legacy operation).  As previously explained, we understand that the coordination between the eDRX values provided by RAN and CN should be left up to network instead of making the UE to monitor more frequently that would increase UE’s power consumption. We understand that this adds some burden on network side but should be acceptable in order to achieved UE’s intended power consumption (understanding that network could also choose to configure the UE with a different eDRX cycle in RAN and/or CN). |
| Samsung | Yes | BTW, there is no need to discuss whether to include default DRX cycle? |
| LGE | Yes |  |
| Sequans | Yes | Default DRX cycle seems to be considered here too |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes |  |
| CATT | Yes but | We do not agree configuration 2 in Q1 should be allowed but think it could even be simplified further by mandating that, like in LTE, when both IDLE eDRX cycle and INACTIVE eDRX cycle are ≤ 10.24s, then the same eDRX cycle value should be set for both Idle and Inactive. |
| Apple | No | Same view as Intel. The UE only needs to monitors the INACTIVE POs. |
| Futurewei | Yes |  |

**For case 4, IDLE eDRX cycle >10.24s and INACTIVE eDRX cycle <=10.24s**

For RRC\_INACTIVE UE, **during CN PTW**, companies proposed the following paging monitoring methods:

* Option 1.1: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer, INACTIVE eDRX cycle and default paging cycle [4][5][7][10].
* Option 1.2: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer and default paging cycle [6][13].
* Option 2: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer, RAN paging cycle and default paging cycle[2][12].

In LTE, RAN paging cycle initially means RAN DRX cycle. After introducing eDRX for RRC\_INACTIVE, the IE *ran-PagingCycle* was extended to include RAN eDRX cycle. Thus, if the *ran-pagingCycle* field in NR is also extended to include the INACTIVE eDRX cycle as LTE, the RAN paging cycle also means INAXCTIVE eDRX. In this way, option 2 is the same as option 1.1. Otherwise, option 2 is different from option 1.1.

1. Companies are invited to provide their views on which option do you prefer on the configuration of INACTIVE eDRX cycle when it is not longer than 10.24s:

* Option 1: Extend the existing *ran-pagingCycle* field as LTE.
* Option 2: Introduce an additional IE for INACTIVE eDRX to contain all values of INACTIVE eDRX cycles (also include values >10.24, if agreed in future).
* Option 3: Others, please specify.

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (s)** | **Comments / arguments** |
| Qualcomm | Option 1 |  |
| OPPO | Option 1 |  |
| Huawei, HiSilicon | Option 2 | In option 1, UE cannot differentiate between the legacy 2.56 RAN paging cycle and the 2.56 INACTIVE eDRX cycle. |
| Xiaomi | Option 1 |  |
| Intel | 1 | By going with LTE, legacy definition of T could easily be reused when monitoring paging during the applicable PTW (reference below from 38.034):  “*“T: DRX cycle of the UE (****T is determined by the shortest of the UE specific DRX value(s), if configured by RRC and/or upper layers, and a default DRX value*** *broadcast in system information.”*” |
| Samsung | Option 2 | We prefer option 2 for clear distinction. |
| LGE | Prefer Option 1 Option 2 is also fine | We think Option 1 is the simplest, so prefer Option 1.  Option 2 is also acceptable. |
| Sequans | Option 2 |  |
| Nokia | Option 1 or 2 | Both seem feasible. |
| ZTE | Option 2 | Option 2 is more future proof. And separating eDRX cycle and RAN paging cycle is clearer in specification. |
| MediaTek | Option 2 | We think that option 2 is more future proof and clearly separates the I-DRX and eDRX configurations. |
| CATT | Option 1 or 2 | If eDRX cycle>10.24s is not supported for inactive, option 1 is fine.  Otherwise option 2. |
| Apple | Option 1 |  |
| Futurewei | Option 2 |  |

From rapporteur point of view, option 1.1 and 1.2 are the same, as INACTIVE eDRX cycle is not shorter than UE specific DRX cycle and default paging cycle. But they are different expressions for future extension or unified formula for different cases. Companies are also invited to provide opinions on which option/expression is preferred.

1. When INACTIVE eDRX cycle is not longer than 10.24s and IDLE eDRX cycle is longer than 10.24s, for RRC\_INACTIVE UE, companies are invited to provide their views on the paging monitoring mechanism **during CN PTW**, among the options described below.
   * Option1.1: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer, INACTIVE eDRX cycle and default paging cycle.
   * Option 1.2: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer and default paging cycle.
   * Option 2: T is determined by the shortest of UE specific DRX cycle, if configured by upper layer, RAN paging cycle and default paging cycle.
   * Option 3: Others, please specify.

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (s)** | **Comments / arguments** |
| Qualcomm | Option 1.1 |  |
| OPPO | Option 2 | With the assumption that *ran-pagingCycle* field in NR is extended to include INACTIVE eDRX cycle as LTE, Option 2 should be adopted. |
| Huawei, HiSilicon | Option 1.1 | It seems the key point is whether to consider the INACTIVE eDRX cycle. If INACTIVE eDRX cycle is never smaller than the default paging cycle, it seem no big difference among options. To make it simple and to reduce extra restriction to NW configuration, option 1.1 can be the more general formulation. If to agree option 1.1, NW implementation can also achieve the same configuration and UE behavior as other options.  We need some clarifications on what is exactly “RAN paging cycle” in option 2 (somehow related the discussion point 11). |
| Xiaomi | Option 1.1 |  |
| Intel | 3 | As explained in previous discussion point 10, UE in INACTIVE should monitor eDRX cycle values <=10.24 sec regardless of CN PTW in order to minimise UE’s power consumption. We understand that this mis-match case address corner case scenarios (e.g. when RAN loses all UE’s context). Therefore in those cases, CN should be use the RAN configured eDRX information if required based on its CN configured (e)DRX cycle instead of enabling a solution that will always make the UE to consume more power (understanding that most of the time, CN will not need to page a UE in INACTIVE). |
| Samsung | Option 1.1 or 1.2 |  |
| LGE | Option 1.1 |  |
| Sequans | Option 1.1 |  |
| Nokia | Option 1.1 |  |
| ZTE | Option 1.1 |  |
| MediaTek | Option 1.1 | The question seems to be whether the RAN I-DRX cycle or RAN (Inactive) eDRX cycle should be taken into account for the shortest value evaluation. In LTE, eDRX cycle would be indicated in the *ran-pagingCycle* field when eDRX is configured in Inactive and this would be used in the shortest value evaluation. Assuming Option 2 in DP 11 above (separate I-DRX and eDRX RAN configurations in Inactive), perhaps it is more sensible to use the Inactive (RAN) eDRX cycle in the shortest evaluation in NR as well. |
| CATT | Option 1.1 | Equivalence of 1.1 & 2 depends on the outcome of discussion point 11). |
| Apple | Option 1.1 |  |
| Futurewei | Option 1.1 |  |

As for the paging monitoring **outside CN PTW**, companies[2][4][5][6][7][10][12][13] proposed UE monitors paging based on the INACTIVE eDRX cycle as LTE.

1. When IDLE eDRX cycle is longer than 10.24s and INACTIVE eDRX cycle is not longer than 10.24s, companies are invited to provide their view on whether agree that RRC\_INACTIVE UE monitors paging based on the INACTIVE eDRX cycle **outside CN PTW**?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
| Qualcomm | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Xiaomi | Yes |  |
| Intel | Depends | As explained in previous discussion points, UE in INACTIVE should monitor paging based on RAN configured eDRX cycle regardless of the CN configured (e)DRX cycle. |
| Samsung | Yes |  |
| LGE | Yes |  |
| Sequans | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes |  |
| MediaTek | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Futurewei | Yes |  |

**For Case 5, IDLE eDRX cycle is not configured and INACTIVE eDRX <=10.24s**

If you agreed configuration 1 in Q1 and case 5 existed, paging monitoring methods should be determined.

Company [8] proposed to ask SA2/CT1 whether RAN needs to provide to CN any related information, such as, option (1) when a UE in INACTIVE supports eDRX, option (2) when a UE in INACTIVE is configured with eDRX or option (3) when a UE in INACTIVE is configured with eDRX with its corresponding eDRX configuration.

1. When IDLE eDRX cycle is not configured and INACTIVE eDRX <=10.24s, companies are invited to provide their view on what the paging cycle should be used for RRC\_INACTIVE UE to monitor paging or other requirements for this case?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
| Qualcomm |  | We think the same principle still applies, i.e. UE’s monitoring periodicity = min(INACTIVE eDRX, monitoring periodicity for CN paging) = min(INACTIVE eDRX, default paging cycle, UE-specific DRX cycle) |
| OPPO |  | In our understanding, RAN eDRX can be configured only if CN eDRX is configured, so we don’t think this is a valid case. |
| Huawei, HiSilicon |  | We think this case would not be possible.  We think we should confirm the principle that INACTIVE eDRX cannot be configured If IDLE eDRX is not configured. |
| Xiaomi |  | We think case 5 is invalid. UE in RRC\_INACTIVE cannot be configured with e-DRX for RRC\_INACTIVE when e-DRX for RRC \_IDLE is not configured |
| Intel |  | As explained in previous discussion points, UE in INACTIVE should monitor paging based on RAN configured eDRX cycle regardless of the CN configured (e)DRX cycle. |
| Samsung |  | We don't see the necessity to consider this case. |
| LGE | - | We think INACTIVE eDRX can be configured only if IDLE eDRX is configured. |
| Nokia |  | If config 1 allowed, agree with Qualcomm |
| ZTE |  | Agree with Qualcomm if configuration 1 in Q1 is agreed. |
| MediaTek | N/A | Should not be a valid case. |
| CATT |  | We don't support this configuration. |
| Apple | UE follows INACTIVE eDRX config. | UE follows INACTIVE config and monitor based on INACTIVE eDRX config. |
| Futurewei |  | We don’t think such case should be supported. |

## Others

1. Any other relevant issues need to be discussed?

|  |  |
| --- | --- |
| **Company** | **Issue description** |
| Huawei, HiSilicon | We can also discuss whether support of eDRX is optional at the gNB, when it supports RedCap. |
| Apple | In our view, eDRX operation in RAN (gNB) is fundamental feature of RedCap, and so do not see a need for making eDRX operation optional at the gNB that support RedCap. In other words, we do not see the need for a eDRX support when RedCap support is already present in the gNB. This is different from LTE, as in LTE, eDRX was added as a feature for power-saving, while in NR, RedCap feature carries eDRX along with it. |
|  |  |

# Summary

TBD

# References

1. R2-2106905 Reply LS on introducing extended DRX for RedCap UEs (C1-213966; contact: Qualcomm) CT1 LS in Rel-17 NR\_redcap-Core To:RAN2 Cc:SA2, RAN3
2. R2-2107073 Discussion on eDRX for RedCap UEs OPPO discussion Rel-17 NR\_redcap-Core
3. R2-2107096 CN PTW and RAN PTW for RedCap eDRX Samsung discussion Rel-17
4. R2-2107210 eDRX for RedCap UE Huawei, HiSilicon discussion Rel-17 NR\_redcap-Core
5. R2-2107217 eDRX configurations for RedCap UEs Qualcomm Incorporated discussion Rel-17 FS\_NR\_redcap
6. R2-2107412 Discussion on eDRX for RedCap UEs vivo, Guangdong Genius discussion Rel-17 FS\_NR\_redcap
7. R2-2107534 Discussion on e-DRX for Redcap Devices Xiaomi Communications discussion
8. R2-2107675 Leftover issues for eDRX Intel Corporation discussion Rel-17 NR\_redcap
9. R2-2107706 Discussion on eDRX for RRC\_IDLE and RRC\_INACTIVE LG Electronics UK discussion Rel-17
10. R2-2107751 eDRX for RedCap UEs ZTE Corporation, Sanechips discussion Rel-17 NR\_redcap-Core
11. R2-2107905 Consideration on eDRX for RedCap UE Lenovo, Motorola Mobility discussion Rel-17
12. R2-2108230 Remaining issues for eDRX MediaTek Inc. discussion Rel-17 NR\_redcap-Core R2-2105671
13. R2-2108280 Details of eDRX and PTW in RRC\_IDLE and RRC\_INACTIVE Ericsson discussion NR\_redcap-Core
14. R2-2108525 Discussion on eDRX for RRC\_Idle and RRC\_Inactive CMCC discussion Rel-17 NR\_redcap-Core
15. R2-2108699 Discussion on eDRX for NR RRC Inactive and Idle CATT discussion Rel-17 NR\_redcap-Core
16. R2-2108778 Open issues on eDRX for UE in RRC\_INACTIVE DENSO CORPORATION discussion Rel-17 NR\_redcap-Core