3GPP TSG-RAN WG2#123 R2-23XXXXX

Toulouse, France, 21 – 25 August, 2023

Agenda Item: x.xx.x

Source: Huawei, HiSilicon

Title: Outcome of [Post122][307][NES] DTX/DRX – alignment, single/multiple configurations, parameter values (Huawei)

Document for: Discussion and decision

# 1 Introduction

This document is the report of the following discussion:

* [Post122][307][NES] DTX/DRX – alignment, single/multiple configurations, parameter values (Huawei)

Scope: Provide and summarize companies' views on:

* Alignment between Cell DTX/DRX and UE C-DRX
* Single/multiple configurations
* Cell DTX/DRX parameter value range

Intended outcome: Report to the next meeting (with agreeable proposals)

Deadline: long email discussion

The intention of this document is to invite companies to share their views regarding alignment, single/multiple configurations and parameter values of Cell DTX/DRX. Taking these into account, the Rapporteur of the discussion provides a set of proposals to be further discussed during RAN2#123.

**Please provide your comments by: Wednesday August 9th, 2023, 1000 UTC**

Companies providing input to this email discussion are requested to leave contact information below.

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# 2 Discussion on open issues

The rapporteur identifies the following open issues to be discussed:

* Alignment between Cell DTX/DRX and UE C-DRX
* Whether there is one or there are multiple cell DTX/DRX configurations
* Cell DTX/DRX parameter value range

The WID [1] captured the following with regards to Cell DTX/DRX and C-DRX alignment:

1. Specify enhancement on cell DTX/DRX mechanism including the alignment of cell DTX/DRX and UE DRX in RRC\_CONNECTED mode, and inter-node information exchange on cell DTX/DRX [RAN2, RAN1, RAN3]

* Note: No change for SSB transmission due to cell DTX/DRX.
* Note: The impact to IDLE/INACTIVE UEs due to the above enhancement should be avoided.

RAN2 achieved the following agreements on Cell DTX/DRX during the RAN2#121 meeting [3]:

**Agreements**

1. There will be no impact to RACH, paging, and SIBs in idle/inactive for both gNB and Rel-18 and legacy UEs
2. Rel-18 NES capable CONNECTED UE(s) can perform RACH and receive SIBs in non-active duration of cell DTX and/or DRX (i.e., same behavior for cell DTX and cell DRX). No further enhancements for CBRA and CFRA will be pursued.
3. Pattern configuration for cell DRX/DTX is common for Rel-18 UEs in the cell. FFS whether we have DTX UE specific inactivity timer. FFS on configuration signaling and stage 3.
4. Confirm study item agreement that we can have separate DTX and DRX configuration. We will focus on designing DTX/DRX for at least single configuration. FFS whether multiple configuration of cell DTX or DRX will be supported.

Further agreements were made during RAN2#121-bis-e [4]:

**Agreements**

1. A periodic cell DTX/DRX configuration is explicitly signalled to the UEs.
2. A periodic cell DTX/DRX pattern is configured by UE specific RRC signalling.
3. The Cell DTX/DRX configuration contains at least: periodicity, start slot/offset, on duration.
4. As a baseline Cell DTX/DRX is activated/deactivated implicitly by RRC signalling, i.e. activated immediately once configured by RRC and deactivated once the RRC configuration is released.
5. From RAN2 point of view, majority companies see a benefit with L1 signalling for Cell DTX/DRX activation/deactivation, send a LS to RAN1 (email 308) with our preference and ask about feasibility and design details. Ask about feasibility and reliability of using L1 signaling. Clarify that the question is about activation/deactivation copy the agreement from last meeting that we are focusing on single configuration. Extract a few key benefits of dynamic signaling from email discussion and online discussions
6. As baseline, UE doesn’t monitor SPS occasions during Cell DTX non-active period. As baseline, gNB is assumed to be not transmitting PDSCH to that UE on such SPS occasions during the Cell DTX non-active period
7. As baseline, UE does not transmit on CG occasions during Cell DRX non-active periods
8. As baseline, UE does not transmit SR occasions overlapping with Cell DRX non-active periods, e.g. SR transmissions are dropped during the non-active period

FFS: whether we will allow to configure the UE per SR configuration with whether SR can be transmitted during Cell DRX non-active period to to support high priority traffic

1. (for the SRs that will be dropped) If SR is not to be transmitted on an PUCCH occasion during Cell DRX non-active time, the UE keep the SR pending, i.e., the UE delays the SR transmission till the Cell DRX active period without triggering RACH. For the FFS case there may be some exceptions.
2. The understanding for the gNB scheduling behaviour for new transmissions during Cell DTX non-active period is that the gNB does not schedule UE-specific dynamic grants/assignments, even if the UE is in C-DRX Active Time. UE doesn’t monitor PDCCH for dynamic grants/assignments for new transmissions during Cell DTX non-active period, even if the UE is in C-DRX Active time. FFS how to deal with any exceptions (e.g. SR if agreed and RACH).

FFS how to deal with retransmissions

## 2.1 Alignment between Cell DTX/DRX and UE C-DRX

The alignment of UE C-DRX with Cell DTX and DRX was deemed beneficial in the TR 38.864 [2]. The mechanism will be discussed during the WI phase. The alignment needs to be specified as per WID [1] objective 2. Alignment was also discussed over email [6] but the Rapporteur’s proposals were not treated online.

Whether the alignment is left to network implementation.

A group of companies would like to leave the alignment up to NW implementation. The Rapporteur understands that in this scenario RAN2 defines gNB and UE behaviours during Cell DTX/DRX active and non-active time and it is up to the NW how the alignment is performed.

**Question 1:** *Do you agree to leave the alignment mechanism up to NW implementation (i.e. it is up to NW implementation to choose appropriate configurations of UE C-DRX and Cell DTX)?*

* *Yes, only define UE behaviour as proposed in e.g. [8] proposal 8 or [13] proposals 5 and 6 (i.e. there is no mandate of any alignment from the spec perspective)*
* *No, some principles are needed (as in e.g. [6] Proposals 6 and 7, or other if only partial alignment is mandated)*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | 1. In RAN2, we typically don't specify NW requirement unless it will result in bad consequence. For our specific issue on Cell DTX, we think system can still work (i.e. no serious issue is foreseen) even if Cell DTX is not aligned with UE CDRX. 2. If such requirement is agreed, one followed issue is that the NW may be forced to immediately reconfigure multiple UE CDRX upon Cell DTX is activated, to ensure the requirement to be satisfied. Such reconfiguration of UE CDRX requires the NW to send multiple RRC messages immediately, which is unnecessarily complex and incurs high signalling overhead.   Thus, we prefer to just specify UE behaviour in all possible overlapping duration. As discussed in our contribution, RAN2 has agreed UE behaviour in T2 in RAN2#121b-e, and only behaviours in T1 and T3 need further discussion.  A picture containing screenshot, line, diagram, text  Description automatically generated |
| Fraunhofer | No | If the alignment is left for NW implementation, without any signalling enhancement, there would be a trade off in optimizing the network settings for low load and high load. Basically, in that case a single C-DRX configuration can be optimized for low load or for high load but not both. Thus, without any change, alignment would mean sacrificing high load performance and/or a lot of signalling overhead. The final effect could be that most operators would be very conservative in activating Cell DTX/DRX or disable it, in order not to affect QoS at high load. Therefore, energy savings would be very limited.  Basic principles and enhanced signalling would allow having reduced energy consumption at low load and proper performance at high load without sacrificing one for the other. |
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If alignment principles need to be specified, the following proposals were made in [6]:

**Proposal 6:** An aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX falls within Cell DTX on-duration. FFS extension of Cell DTX active time beyond Cell DTX on-duration. (15/25)

**Proposal 7:** The periodicity of UE C-DRX configurations in a cell should be the same or a multiple of the serving Cell’s DTX periodicity.

**Question 2:** Do you agree with proposals 6 and 7 from [6]? If not, please comment on your proposed alignment specification, if any.

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| **Company** | **Answer** | **Comments** |
| Apple | No | We have provided 2 reasons in Q1 on NW alignment requirement is not needed. In addition, we also think this requirement seems to be not quite useful because UE CDRX may extend its active time (e.g. inactivity time) out of Cell DTX on-duration. Then, we still need to face unaligned scenario. So, even if these two requirements are agreed, we think it can't help much on NES gain. |
| Fraunhofer | Yes (with review and addition) | P6 is fine as it is.  We propose P7 is revised to “The periodicity of aligned UE C-DRX configurations in a cell should be the same or a multiple of the serving Cell’s DTX periodicity” . Meaning that non-aligned configurations (for high load) could still take any value.  And the main need to complement P6 and P7 is that a UE can be configured with an “aligned UE C-DRX configuration” and a “non-aligned UE C-DRX configuration”. This is what would allow the network to operate smoothly in both low and high load without a lot of signalling overhead. |
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How to align Cell DTX/DRX with UE C-DRX by reconfiguration of multiple UE C-DRX

When cell DTX is activated, UEs should adopt an aligned C-DRX that may differ from the current C-DRX pattern (at least in terms of offset). The existing mechanism is to reconfigure C-DRX of UEs by UE-specific RRC messages. This procedure may cause high signalling overhead when cell DTX is activated/deactivated. The Rapporteur would like to establish a baseline how to efficiently change the C-DRX of multiple UEs to align the C-DRX when cell DTX is activated/deactivated without increasing signalling overhead.

**Question 3:** What is your preferred solution to reconfigure multiple UE C-DRX patterns when activating/deactivating cell DTX. Possible options include:

* ***Option 1:*** *Send legacy C-DRX reconfiguration with all parameters*
* ***Option 2:*** *New mechanism to send only parameters that differ from the current C-DRX pattern, e.g. offset (details in comments)*
* ***Option 3:*** *Other (answer in comments)*

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| **Company** | **Answer** | **Comments** |
| Apple | Option 1 | If no NW alignment requirement is introduced, we think NW don't need to **immediately** reconfigure multiple UE CDRX to ensure the requirement to be satisfied. Then, the legacy solution (i.e. reconfigure C-DRX with all parameters) can be performed in a long time duration (i.e. distribute different UE's RRC messages in time). So, we don't see issue to reuse legacy solution. Option 2 needs further justification on its benefit. |
| Fraunhofer | Option 2 | Due to traffic variations a network will need to change often between states where the C-DRX patterns are aligned (for low load / cell DTX) and a state where the C-DRX patterns are not aligned (for high load / best QoS achieved via traffic distribution over time).  The legacy mechanism would be prohibitive here as RRC reconfigurations would be performed too often. A new mechanism where 2 C-DRX configurations (for low and high load) are set in advance is needed. When Cell DTX/DRX is activated, the low load configuration is used. When Cell DTX/DRX is de-activated the other configuration is used. |
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*[Rapporteur’s summary and proposals]*

## 2.2 Single or multiple Cell DTX/DRX configurations

Understanding of “separate” Cell DTX and Cell DRX configurations.

During the RAN2#121 meeting we have confirmed the possibility of separate DTX and DRX configuration. The Rapporteur would like to establish the understanding of separate configurations and whether different parameter values for cell DTX and DRX should be allowed. Some contributions have highlighted [8] that when Cell DTX and Cell DRX are jointly operated, allowing different patterns brings no clear NES gain, but will significantly complicate UE behaviours and introduce extra standard work.

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Fig.1. Different understandings of joint Cell DTX and cell DRX operation [8]

**Question 4:** Separate DTX and DRX configuration means:

* ***Option 1:*** *The gNB can configure only Cell DTX (i.e. without Cell DRX) or only Cell DRX (i.e. without Cell DTX)*
* ***Option 2:*** *The gNB can configure both Cell DTX and Cell DRX with different parameter values (e.g. different offset, on-duration, periodicity) as in Fig.1 case a).*

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| **Company** | **Answer** | **Comments** |
| Apple | Option 1 | Option 1 is aligned with TR 38.864 (especially below highlighted part):  " **Cell DTX and Cell DRX modes can be configured and operated separately (e.g., *one RRC configuration set for DL and another for UL*)**. Cell DTX/DRX can also be configured and operated together. " |
| Fraunhofer | Option 1 | During study phase the main argument for separate DTX and DRX configuration was highly asymmetric load. That is covered in Option 1 without complicating UE behaviour and standardization work. |
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**Question 5:** Do you agree that when Cell DRX is configured together with Cell DTX it must be fully aligned with Cell DTX (i.e. exactly the same periodicity, offset and on-duration) for one serving cell?

* *Yes, must be fully aligned together as in Fig.1 case b).*
* *No, Cell DTX and Cell DRX can be configured with different parameter values (e.g. different offset, on-duration, periodicity) as in Fig.1 case a)*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | Proponent  Our intention is just to make UE behaviour simple, and avoid unnecessary complex specification work on alignment between Cell DTX and Cell DRX.   * The NES gain of case a) over case b) is not clear because the power consumption of DL is much higher than UL according to TR38.864 . * DL and UL are sometimes tightly coupled (e.g. DL transmission and its UL HARQ feedback). Allowing case a) will significantly complicate UE behaviors and introduce extra standard work (e.g. alignment mechanism between Cell DTX and Cell DRX, UE behaviors in 4 combinations of Cell DTX active/non-active and Cell DRX active/non-active). |
| Fraunhofer | Yes | That will simplify UE behaviour and standardization. |
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Single vs multiple configurations.

RAN2 agreed to support at least single configuration, with an FFS whether multiple configurations of cell DTX or DRX will be supported. The Rapporteur would like to gather companies views on this topic. According to the agreements from RAN2#121 there can be only one configuration active at a time, so the question is regarding whether:

* The NW can configure multiple sets of parameters and then switch between them (multiple configurations),
* There can be only one pattern configured at a time (single configuration).

**Question 6:** Do you support single or multiple Cell DTX/DRX parameter sets to be configured?

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| **Company** | **Answer** | **Comments** |
| Apple | Single is baseline  Multiple can be further discussed after L1/L2 signalling discussion is finalized | First, we want to clarify our understanding that irrespective of whether multiple configuration introduced, only one configuration can be activated at one time. It doesn't make sense that multiple parallel Cell DTX running in one UE.  Secondly, we think single vs multiple only matters in L1/L2 signalling (i.e. multiple configurations can be configured in RRC, and L1/L2 signaling to change). Please note that if RRC signalling is used to activate/change Cell DTX pattern, RRC reconfigures different Cell DTX configuration. Then, there will be no difference between single and multiple configurations.  Because RAN2 has not discussed RAN1 reply LS on L1 signalling (and potential MAC-CE as indicated in the LS), we think such discussion can be discussed after the signalling is finalized. |
| Fraunhofer | multiple | We should strive for dynamic adaptation to the load, without excessive signalling overhead. If only a single Cell DTX/DRX parameter set is supported the network needs to do a lot of RRC re-configuration if the load changes e.g. from 0% to 20% or from 15% to 5%. Thus, we should support multiple configurations set in advance and dynamically switch among them with the L1 signaling.  A few configurations (e.g. 2 – 3) should be enough for most purposes. We can also optimize the L1 overhead by signaling on L2/L3 how many bits are used for configuration IDs, or selecting subsets of configurations which can be currently considered. |
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*[Rapporteur’s summary and proposals]*

## 2.3 Cell DTX/DRX parameter value range

As part of offline discussion [AT122][305] some companies commented that the value range of cell DTX/DRX parameters is not decided yet and it is needed to be able to estimate the maximum delay a connected mode UE can have when the gNB has configured cell DTX/DRX. Parameters were also mentioned in [12]. The previously agreed parameters being: periodicity, start slot/offset, on duration. The Rapporteur invites companies to state their preferred value range for the corresponding cell DTX/DRX parameters, UE C-DRX value range is given for reference.

cellDTX-onDurationTimer (and cellDRX-onDurationTimer if applicable)

UE C-DRX has on-duration values from 1/32 ms to 1600 ms.

**Question 7:** *What is your preferred value range for cellDTX-onDurationTimer?*

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| **Company** | **Answer** | **Comments** |
| Apple | Same as UE CDRX | At this stage, we see no reason to define any different value range from UE CDRX. If different value range is introduced, it implies that RAN2 need to consider extra requirement between UE CDRX and Cell DTX. 3GPP has discussed value range of UE CDRX a lot in past several releases and the current value range should work in all important scenarios and traffic types. We think such extra specification work is not needed.  To make Cell DTX more backward compatible to UE CDRX, we prefer to reuse the same value range of all configurations of UE CDRX (including on-duration, periodicity and offset), and same start time formula in TS 38.321. |
| Fraunhofer | 1/32 ms to 90% of *cellDTX-Cycle* | The exact values however should also depend whether P7 (on Q1) is adopted or not. If yes, it is more important that the values align easily to C-DRX than having too many possibilities |
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cellDTX-Cycle (and cellDRX-Cycle if applicable)

UE C-DRX has Long cycle values from 10 ms to 10240 ms.

**Question 8:** *What is your preferred value range for cellDTX-Cycle?*

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| **Company** | **Answer** | **Comments** |
| Apple | Same as UE CDRX | Same comment in Q7.  To make Cell DTX more backward compatible to UE CDRX, we prefer to reuse the same value range of all configurations of UE CDRX (including on-duration, periodicity and offset), and same start time formula in TS 38.321. |
| Fraunhofer | 5 ms to 1280 ms | In our view, it is fundamental that *cellDTX-Cycle* can be aligned to SSB periods easily. Anything else would cap energy savings.  A cell DTX cycle should not be smaller than a SSB cycle (minimum 5 ms), to facilitate alignment to SSB bursts. It also does not need to be larger than largest SSB period (160 ms), as in that case SSBs would be the limiting factor for NES, but allowing setting it up to 1280 ms would improve forward compatibility with larger SSB periods.  If P7 (on Q1) is adopted it is more important that the values align easily to C-DRX than having too many possibilities |
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cellDTX-StartOffset

RAN2 needs to define timers for cell DTX/DRX, e.g. cellDTX-onDurationTimer and cellDRX-onDurationTimer. It was proposed [8] [9] to reuse the start timer formula of the onDurationTimer from UE C-DRX:

[(SFN \* 10) + subframe number] modulo (cellDTX-Cycle) = cellDTX-StartOffset

**Question 9:** *Do you agree with the start timer formula proposed above?*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | Same comment as Q7/Q8.  To make Cell DTX more backward compatible to UE CDRX, we prefer to reuse the same value range of all configurations of UE CDRX (including on-duration, periodicity and offset), and same start time formula in TS 38.321. |
| Fraunhofer | Yes |  |
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*[Rapporteur’s summary and proposals]*

# 3 Conclusion

Based on the discussion in the previous sections we propose the following:

**Proposal 1** abc.

**Proposal 2** def.

# 4 References

1. RP-223540, “New WID: Network energy savings for NR”, Huawei
2. 3GPP TR 38.864 V1.0.0, “Study on network energy savings for NR (Release 18)”
3. R2-2301903, “Report from Session on NES, UAV, Small Data, Rel-15-17 UP, Rel-17 Small Data, IIoT/URLLC, and RACH partitioning”, Session Chair (InterDigital)
4. R2-2304203, “Report from Session on NES, UAV, Rel-15-17 UP, Rel-17 Small Data, IIoT/URLLC, and RACH partitioning”, Session Chair (InterDigital)
5. R2-2306543, “Report from Session on NES, UAV, Rel-15-17 UP, Rel-17 Small Data, IIoT/URLLC, and RACH partitioning”, Session Chair (InterDigital)
6. R2-2302796, “Outcome of [POST121][312][NES] DTX/DRX - Configuration/ activation/ deactivation and alignment (Huawei)”, Huawei, HiSilicon
7. R2-2305120, “Cell DTX-DRX Mechanism”, Qualcomm Incorporated
8. R2-2305082, “Discussion on key open issues of Cell DTX / DRX”, Apple
9. R2-2305389, “Discussion on cell DTX and DRX”, Huawei, HiSilicon
10. R2-2305840, “Further aspects on cell DTX/DRX”, Ericsson
11. R2-2305651, “Remaining issues on DTX/DRX”, Nokia, Nokia Shanghai Bell
12. R2-2305013, “Remaining issues for Cell DTX\_DRX”, Samsung Electronics
13. R2-2305529, “Discussion on DTX/DRX mechanism”, OPPO