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.  |
| Nokia | Yes | Enough to leave it to NW implementation to ensure enough scheduling opportunity while the UE is monitoring PDCCH. No full alignment needed. |
| Samsung | Yes | We believe the NW is capable to align UE C-DRX patterns with its Cell DTX/DRX pattern(s). |
| Qualcomm | No | If UE is configured with cell DTX and C-DRX, UE behaviour needs to be defined in all possible configurations. Leaving this to NW implementation to configure arbitrary cycles of C-DRX and cell DTX has a few issues in our view:1. MAC spec needs to specify how the UE behaves when ON duration starts during cell DTX OFF period. Does the UE run its inactivity timer? Does it delay its inactivity timer until cell DTX has started? Etc. In our view unless there is a very strong case to be made for completely misaligned C-DRX and cell DTX, we can avoid MAC complexity to specify UE behavior in a case that makes no sense.
2. For cell DTX/DRX activation/deactivation L1 signalling, RAN1 is considering reusing DCI2\_6 format which the UE is already listening to it before C-DRX cycle. If cell DTX and C-DRX become completely arbitrary, how would the UE interpret Cell DTX deactivation indication via L1:
	1. Does the UE still decode WUS PDCCH if it falls into a cell DTX non-active period?
	2. If the periodicity of C-DRX is larger than the periodicity of cell DTX, does the UE “wake up” mid-C-DRX cycle to obtain the latest group L1 activation/deactivation information.
	3. For an L1 activation, how much time is needed between receiving L1 activation/deactivation and applying the new activation/deactivation rules such as canceling SR needs RAN4 input.

Again, the issue with leaving it to NW implementation is that both C-DRX and Cell DTX control when the UE monitors PDCCH and for how long, if these mechanisms are arbitrary then UE behaviour needs to be clearly defined for all the many use cases that may result from different configurations (much more than the ones Apple illustrated above). Also to Apple’s point, the NW has to ensure alignment between C-DRX and Cell DTX anyway since the UE only decodes PDCCH when both are in active mode. Another issue, if the cycles are not aligned is that the UE must decode a different number of PDCCH occasions each DRX cycle so there are questions about link adaptation. We suggest sticking to SI agreements on alignment and not introducing new behaviour.  |
| ETRI | No | Even if left to the network implementation, it should be defined that the active time for Cell DTX and On-duration of UE C-DRX should be partially overlapped if not fully aligned for PDCCH monitoring of the UE.If even minimal partial overlap is not allowed, the UE may not be able to perform PDCCH monitoring or may affect current UE C-DRX behaviours. |
| NEC | No | We think there are three cases as followingCase A: a part of UE C-DRX On-duration occasion **fully** falls within Cell DTX on-duration period (e.g., UE A in the below figure) => alignment between Cell DTX and UE C-DRX could be left to NW implementationCase B: a part of UE C-DRX On-duration **partially** falls within Cell DTX on-duration period (e.g., UE B in the below figure)=> it would be better to align Cell DTX and UE C-DRXCase C: no UE C-DRX On-duration falls within Cell DTX on-duration period (e.g., UE C in the below figure)=> it is obviously that UE C-DRX need to be re-configured to align with Cell DTXFor Cases B and C, specifying some principles would be beneficial. |
| LGE | - | The question is not clear. We understand that the alignment of cell DTX/DRX and UE C-DRX mentioned in WID means that active time of UE C-DRX is covered by cell DTX/DRX active period. We think that leaving the alignment mechanism up to NW implementation is a way of how to align cell DTX/DRX and UE C-DRX. When the alignment mechanism is left to NW implementation, the alignment is achieved by NW implementation and no new UE behaviour is needed. |
| vivo | Yes | If at least two cells are activated for a UE with CA capability, and the cell DTX patterns are not aligned, it would be complicated to discuss to which cell DTX pattern the UE C-DRX pattern should be aligned.Therefore, the simplest way out is to define the NW and the UE behavior during the active/non-active overlapping periods, and such principle is applied to each cell independently. Even if the cell DTX pattern and UE C-DRX pattern is not aligned for one cell, the UE can still be scheduled on other Scells for which cell DTX is not activated, or cell DTX is aligned with UE C-DRX.If no SCell or SCG is activated for a UE, then it is up to the NW implementation to reconfigure UE C-DRX to be aligned with cell DTX. |
| Huawei, HiSilicon | No | Offset, periodicity or on-duration of the aligned C-DRX should be determined by NW implementation, but we would like to have some alignment principles to be specified. There should be a time where all UEs are awake to send signalling. The alignment is needed to make the cell DTX/DRX on duration period overlap with the C-DRX on duration period to avoid unnecessary scheduling and maximize energy saving. If there is no alignment principle, the changing of the C-DRX pattern to cater for cell DTX/DRX is left completely up to the gNB. If there is no overlapping between UE C-DRX on-duration and cell DTX/DRX on-duration, the UE cannot be successfully scheduled. Regardless whether it is full alignment or partial alignment, the alignment is needed. |
| OPPO | Yes | C-DRX is configured considering the UE’s QoS requirement, and cell DTX/DRX configuration is mainly for energy saving. A smart network can configure C-DRX and cell DTX/DRX taking both QoS and energy-saving targets into account. As usual, we can rely on gNB implementation to achieve the alignment between C-DRX and cell DTX/DRX as much as possible. Additionally, C-DRX active time is flexible while the on-duration of cell DTX/DRX is fixed (it is still FFS whether to have flexible and extensible cell DTX/DRX active time). Based on the above, it is possible C-DRX active time and cell DTX/DRX active time is not fully aligned. Thus, it is necessary to define UE behaviour as proposed in e.g. [8] proposal 8 or [13] proposals 5 and 6. |
| Fujitsu | No | We think alignment between the Cell DTX/DRX and the UE C-DRX can be done by NW implementation. However, from NW point of view, there is no clear motivation to configure the Cell DTX/DRX and the UE C-DRX without any overlapped period. At least, considering the energy saving efficiency, both of on-duration periods should be overlapped.Therefore, it is reasonable to define some principle for configurations. |
| InterDigital | Yes | We don’t see the need to place configuration restrictions on the network for C-DRX at this point, especially since the network may want to reuse the configuration when Cell DTX is deactivated.That said, we don’t think we need to agree to any additional UE behaviours. We already agreed that “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”, which is sufficient. With this understanding, it is okay if some On durations are not fully overlapped with the cell DTX On duration, since the UE won’t monitor PDCCH anyway when they’re not overlapped, unless there are pending retransmissions. |
| Xiaomi  | No  | In LTE R8, the starting point of DRX on duration of different UE should be different for load balance purpose. However, the alignment requirement between Cell DTX/DRX and UE C-DRX may results in load unbalance. However, from network power saving point of view, the alignment of all UEs’ C-DRX with cell DTX is necessary. RAN2 should discuss whether the UE C-DRX configuration should be changed alone with NES mode change, i.e., from NES mode to non-NES mode and vice versa.If the change is based on network implementation, it may result in frequent RRC signalling (i.e., *RRCReconfiguraiton*) if the NES mode changed frequently. |

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. |
| Nokia | No | See Q1. |
| Samsung | No | See Q1. |
| Qualcomm | Yes | For P6, this is in our view the bare minimum agreeable alignment rule as specified in the WID and the Study Item phase. Suppose P6 is not agreed, is there a realistic reason to configure an ON duration where cell DTX is in non-active duration? This just means the UE is not decoding PDCCH but for some reason running the inactivity timer until it expires or until cell DTX enters active period at which case it is undefined what is the expected behaviour. MAC spec is written with the assumption that UE counts in C-DRX cycles. P6 is consistent with that as the UE can follow well-defined cycles. On the other hand, not having alignment rules means UE has too many rules in the MAC spec to know whether PDCCH should be decoded. For example, we would not want the UE to wake up in the middle of it’s inactive time to receive group L1 cell DTX information then wake up again to receive WUS to derive cycle behaviour. P7 also makes sense. In our view, cell DTX would be the baseline pattern tailored for the UE with highest QoS. Other UEs can vary in periodicity or slot offset if they don’t need to be awake for the full cell DTX cycle. Again no alignment between periodicities means that C-DRX cycles will keep seeing different time occasions of cell DTX and sometimes most or all of the ON duration would align with Cell DTX non-active periods, CG/SPS occasions will behave differently according to which part of the cell DTX pattern they are seeing, same for SR and inactivity timers.  |
| ETRI | Yes (only Proposal 7) | If the active time for Cell DTX and On-duration of UE C-DRX are partially overlapped, the alignment like Proposal 6 is not essential because only partial overlap can achieve NES performance with no impact on the legacy UE C-DRX operation.  |
| NEC | See comments  | P6 with following updates (in red) could be considered as the basic principle. **P6** An aligned UE C-DRX configuration with Cell DTX means that on-duration of C-DRX fully falls within Cell DTX on-duration.With the above basic principle, how to align UE C-DRX (i.e., how to decide on-duration, periodicity, start offset) can be left to NW. |
| LGE | Yes with comment on P6 | For P6, we think that on-duration of UE C-DRX can be replaced with “Active time” of UE C-DRX. On-duration of UE C-DRX falls within cell DTX on-duration by the configuration, and “Active time” of UE C-DRX falls within in cell DTX on-duration by proper gNB scheduling (i.e., network implementation). If an exceptional case such as overlap between UE C-DRX Active time and cell DTX/DRX non-active period happens, it can be handled by the previous agreements. For example, 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 (R2#121bis-e). For retransmissions, when the retransmission timer is running (if C-DRX is configured), the UE is expected to monitor PDCCH, like in legacy (R2#122).For the FFS point (extension of cell DTX active time) of P6, we prefer no extension of cell active time duration for clear cell DTX/DRX operation. |
| vivo | No for P6, Yes for P7 | Based on rapporteur’s precondition, i.e. ‘If alignment principles need to be specified’, then we agree the cycle of cell DTX and UE C-DRX should be aligned for expectable scheduling periods.As for the onDuration alignment, it is enough for UE C-DRX to be partially aligned with cell DTX. P6 is too strong to give the gNB flexibility to adequately shorten the cell DTX onDuration. A smart gNB is expected to seek a balance between energy saving and guaranteeing UE performance. |
| Huawei, HiSilicon | Yes, but can modify | This gives some flexibility for the NW and maximises the overlap between gNB active-time and UE monitoring PDCCH. At the same time the NW can do load balancing between UEs by setting different offset values. We would be open to modify P6 to include at least some cases of partial alignment. Some previous agreements on DG assignment/retx timer running during Cell DTX non-active time are in fact cases of partial alignment. |
| OPPO | No | See Q1. |
| Fujitsu | Yes, with comments | For P6, based on the agreements, it is intended that the on-duration of UE C-DRX may not fully fall within the Cell DTX active period. In addition, it is preferred to remove FFS part from P6, because it is not directly related to alignment manner, this part should be discussed separately. |
| InterDigital | No | Per our answer to Q1.In order for P7 to work, we also need to agree first that all serving cells have the same Cell DTX parameter values (e.g. periodicity, and slot offset) configured. |
| Xioami  | Yes  |  |

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.  |
| Nokia | - | Up to NW implementation. Reconfiguration not necessarily needed since we agreed the behaviour that if the UE active time does not fall into the Cell active time, then the UE does not need to monitor. |
| Samsung | - | Not sure this enhancement is within the scope of NES WI. If needed, we prefer to leave it up to NW implementation using legacy signalling.  |
| Qualcomm | Option 1 | If NW intends to configure a cell DTX cycle, it can do so after it has ensured all UEs C-DRX patterns are well aligned with cell DTX using legacy signalling. No issues identified and no need to do option 2 optimizations neither is it in scope.  |
| ETRI | Option 1 | If a network node with an intention to apply the Cell DTX/DRX function determines that C-DRX parameter adjustment of some UEs is necessary, a legacy C-DRX reconfiguration message can be transmitted to the corresponding UE. |
| NEC | See comments | Option 1 is simpler and safer. When Cell DTX/DRX is activated/deactivated implicitly by RRC signalling, Option 1 is our preference.Addition to activated/deactivated implicitly by RRC signalling, RAN1#113 agreed to support the group common L1 signalling using PDCCH for cell DTX/DRX activation and deactivation without HARQ feedback.AgreementRAN1 supports the group common L1 signalling using PDCCH for cell DTX/DRX activation and deactivation without HARQ feedback* Send an LS to RAN2 to consider the additional support of a MAC CE based indication
* Subject to UE capability

How to reconfigure UE C-DRX patterns when activating/deactivating cell DTX by the group common L1 signalling (and/or potential MAC CE based indication) needs further considerations. |
| LGE | Option 3 | Two different UE C-DRX configuration can be configured. One is used during cell DTX being deactivated, the other is used during cell DTX being activated.Based on the recent RAN1 discussion, RAN1 agreed to adopt L1 signalling for activation/deactivation. Cell DTX activation and deactivation can be performed swiftly for multiple UEs by the L1 signalling. At the transition between activation and deactivation, we see issues such as misalignment of cell DTX pattern and UE C-DRX pattern, and signalling overhead fixing the misalignment. Therefore, one solution can be considered where two UE C-DRX patterns are configured and one of them is activated according to cell DTX activation or deactivation. |
| vivo | Option 3 | Agree with Frauhofer that a C-DRX configuration used upon cell DTX activation is needed. Otherwise, C-DRX may be reconfigured every time when cell DTX is activated/deactivated.Option 2 only mentions about the pattern parameters that are different from the original one. However, the gNB may also reconfigure C-DRX inactivityTimer/retransmissionTimer parameters. Therefore, we propose an option as follows:* **Option 3:** The NW configures a second UE C-DRX configuration, which is activated/deactivated when cell DTX is activated/deactivated.
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| Huawei, HiSilicon | Option 1/2 | We can keep the legacy mechanism for simplicity, but a new simple one can also be OK for us. |
| OPPO | Option 1 | If the gNB would like to reconfigure the C-DRX pattern when activating/deactivating cell DTX, the legacy mechanism can be used for simplicity. |
| Fujitsu | Option 1 | It is assumed Cell DTX is activated after the alignment with UE C-DRX by RRC reconfiguration (or configures and activates Cell DTX and UE C-DRX simultaneously). Therefore, it is enough to reuse the legacy C-DRX reconfiguration procedure.  |
| InterDigital | -  | Option 1 can be used, but it is not necessary before every cell DTX activation. It’s up to the network, e.g. depending on whether some C-DRX on durations overlap with cell DTX. As explained in our answer for Q1, we already agreed that “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”, and thus there is no need to reconfigure C-DRX before every cell DTX activation. |
| Xiaomi  | Option 3 | One separate C-DRX configuration can be configured for NES mode and non-NES mode and the UE can choose the corresponding C-DRX due to NES mode change. It is similar mechanism like CHO configuration agreed in last RAN2 meeting. |

*[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.



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

**Question 4:** Separate DTX and DRX configuration means (Rapporteur clarification – choosing option 1 does not exclude support for joint DTX/DRX configuration. Question 5 asks about the preference for joint configuration and question 4 is about the meaning of “separate” from the current RAN2 agreement.):

* ***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.  |
| Nokia | Option 2 | Not sure we understood the question. It was never intended to disallow configurating both. It only means the parameters can be configured separately.  |
| Samsung | both | Network can configure either or both of them. If both are configured, parameter values can be same or different. |
| Qualcomm | Option 1+ | We think cell DTX/DRX should be aligned for exactly the reasons the rapporteur has outlined. Furthermore, we reiterate our earlier opinion that a standalone cell DRX or cell DTX do not work due to HARQ feedback, CG timers, SR, etc. We can clarify in the next question. Take the green box in case a above: technically UE can transmit an SR/CG but there is no PDCCH to monitor for feedback. For SR this almost certainly mean the UE will keep retransmitting SR until SR-RACH is triggered which is both higher UE power and Network energy than not having cell DTX/DRX to begin with.  |
| ETRI | Both | Agree with Samsung |
| NEC | See comments | Option 1 should be supported.We have sympathy on Option 2 when both Cell DTX and Cell DRX are configured by the NW. Considering there is a gap between UL grant and PUSCH transmission, at least configuring Cell DTX and Cell DRX with different start offset (assuming the same on-duration, periodicity) would be beneficial. |
| LGE | Option 1 with comment | We think that Option 1 can be supported by separate cell DTX and cell DRX configuration. In addition, both cell DTX and cell DRX are also configured simultaneously. For the case that both cell DTX and cell DRX are configured, we prefer configuring cell DTX and cell DRX with the same parameters (e.g., same periodicity, same on-duration, and same offset). |
| Vivo | Option 1 as baseline | We think at least Option 1 is aligned with SI conclusion.As for Option 2, if no proponents observe obvious need for unaligned pattern between cell DTX and cell DRX, we prefer not to pursue option 2 for simplicity. |
| Huawei, HiSilicon | Option 1 | It was shown during the SI phase that cell DTX can bring larger NW energy saving gains than cell DRX therefore we would like to allow a cell DTX only configuration. Option 2 is not needed as explained in the answer for the next question. |
| OPPO | Option 1 | Option 1 is aligned with the SI conclusion.  |
| Fujitsu | Option 1 | Option 1 is already supported in SI phase. For simplicity and energy saving efforts, the same parameter values are applied to both Cell DTX and Cell DRX.  |
| InterDigital | Option 1 | It is fine to leave proper configuration up to the network, but Option 1 may simplify assumptions for the UE behaviour. No strong opinion. |
| Xiaomi  | Both option 1 and option 2 | If I understand the question correctly, the cell DTX configuration and cell DRX configuration can be:Case 1: cell DTX configuration onlyCase 2: cell DRX configuration onlyCase 3: both cell DRX configuration and cell DTX configuration. |

**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)*

|  |  |  |
| --- | --- | --- |
| **Company** | **Answer** | **Comments** |
| Apple | Yes | ProponentOur 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.  |
| Nokia | No  | We agreed separate configurations then the rest could be left to NW implementation, e.g. possibly with certain offset considering the CSI reporting based on DL measurement, etc. |
| Samsung | No | Leave it to NW implementation |
| Qualcomm  | Yes | We do not support standalone Cell DTX or DRX.To take a simple example of cell DTX only. UE technically can transmit SR and CG since cell DRX is not configured, so the NW \*really\* wants to preserve those operations for supposedly NES or QoS reasons. * SR: UE can send it but cannot monitor PDCCH. UE will keep retransmitting SR until SR-RACH is triggered which is both higher UE power and Network energy than not having cell DTX/DRX to begin with and higher latency, so this is actually a configuration that makes everything worse for the system. Would we want to preserve “leaving this to NW implementation” even though no company has demonstrated a need for this capability, or will we again realize that this causes a problem for SR and patch the SR behavior to avoid a RACH.
* CG: UE transmits a CG and starts a CG timer to receive feedback before flushing HARQ. In this case, the only useful portion of the CG timer is either when the RTT timer is running or when cell DTX is active. At which case, the CG timer has to be configured with very long duration to avoid premature HARQ flushing which can cause overuse of HARQ buffers for holding TBs. This is a less severe problem than SR but again it is very questionable what NES benefits come from such a configuration.

For standalone cell DRX, the 38.864 SI has demonstrated that cell DRX benefits is less than cell DTX by quite the significant margin, so this is already not well motivated. For this case realistically given last meeting agreements (DG, retx & HARQ are unchanged), we have a full UL/DL operation except for SR, which is configurable by the NW and the NW can simply avoid configuring PUCCH resources rather than the roundabout way of configuring a standalone cell DRX configuration that is effectively only suspending SR resources (some or all) periodically. We don’t think simply modifying SR occasions merits a standalone Cell DRX operation |
| ETRI | No | Agree with Nokia’s comments, and separate configurations should be considered for RA reception of network node. |
| NEC | Partially Yes | Refer to our answer for Question 4.Yes for on-duration, periodicityNo for start offset  |
| LGE | Yes | Configuring cell DTX and cell DRX with the same parameters (e.g., same periodicity, same on-duration, and same offset) is preferred for simple and clear cell DTX/DRX operation. |
| Vivo | Yes with comment | For UE behavior simplicity, we prefer cell DTX and cell DRX to be aligned. Although this kind of alignment does not mean they should be necessarily configured with the exact same pattern parameters due to DL/UL transmission timing offset, we support them to be the same for standardization and implementation simplicity. |
| Huawei, HiSilicon | Yes | Configuring separate sets of parameters for cell DTX and DRX has no clear benefit (in comparison to fully aligned configuration) and furthermore complicates the implementation on the UE side. Having only one set of parameters also reduces the signalling load because there is no need to send two parameter sets (for DTX and DRX) via RRC. In this case one set of parameters can be sent for cell DTX plus an additional indication whether cell DRX is also enabled. |
| OPPO | Yes | To simplify the UE behaviour and standardization effort. In addition, the benefit of having different parameters for cell DTX/DRX is not clear. |
| Fujitsu | Yes  | Configuring different parameters for Cell DTX/DRX are not needed. There are no clear power saving gains, and it makes the UE implementation more complicated. |
| InterDigital | Yes | Per our answer for Q4 |
| Xiaomi  | No  | The strict restriction is not needed in the spec and it can be up to network configuration.  |

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?

|  |  |  |
| --- | --- | --- |
| **Company** | **Answer** | **Comments** |
| Apple | Single is baselineMultiple 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. |
| Nokia | multiple | It could be beneficial to configure multiple and decide which one to activate based on the load, services requirements of the UEs etc. RAN1 agreed to define new DCI for activation/deactivation, it would not be a bottleneck to indicate one of the multiple being activated. |
| Samsung | Multiple | With the multiple configuration, RRC signalling overhead can be reduced.  |
| Qualcomm | Single | Realistically, L1 change of DRX parameters is not favourable since MAC state changes on the MAC time scale which is slower than the L1 time scale. We have concerns that an abrupt L1 modification of cell DTX/DRX configuration can make the timing after configuration change ambiguous for MAC, especially with the reliability issue for group signalling the UE can miss this change in configuration and fall out of sync with gNB.  |
| ETRI | Multiple |  |
| NEC | Single is baseline | In terms of overhead, we are not sure how often Cell DTX/DRX will require changing. Also, pre-configured cycles may not be perfectly adapted to a change in traffic, a single configuration that is dynamically adjusted to the traffic situation may be more optimised in terms of NES gains. |
| LGE | Single | If traffic load of a cell is changed very dynamically, multiple configurations may have benefit. Considering that traffic load of a cell is aggregation of multiple UE’s traffic in the cell, we think that traffic load of a cell does not change dynamically. So, single cell DTX/DRX configuration may be sufficient. |
| Vivo | Single | Since it is likely that only one cell DTX/DRX pattern can be activated at a time, and the NW load variation rate is low, the need for dynamic cell DTX/DRX pattern changing is not convincing. Moreover, with the change of the load and UE services, the pre-configured cell DTX/DRX configurations may not be adequate any more. In sum, only single configuration should be configured when cell DTX/DRX is about to be activated. |
| Huawei, HiSilicon | single | Single configuration is far simpler from the implementation perspective than having several sets configured. RAN2 should specify a fully functional single-configuration solution before considering adding multiple configuration options. |
| OPPO | Single as a baseline, Open to multiple | If the cell load or the energy-saving state would be changed dynamically, it is beneficial of having multiple cell DTX/DRX configuration sets configured in RRC and one of which is activated at one time by DCI. If companies are convinced with this scenario, we are also fine to support multiple sets of parameters. |
| Fujitsu | Multiple | RAN1 supports group common L1 signalling for activation/deactivation. In our understanding, this L1 activation/deactivation signalling is beneficial to reduce the overhead for dynamic switching of the multiple Cell DTX/DRX configurations. Then if the L1 activation/deactivation signalling is adopted, the multiple configurations would be also supported. |
| InterDigital | Single as baseline | Single configuration is simpler, and the network can always reconfigure it if needed. Multiple can be further discussed after L1/L2 signalling discussion is finalized. If supported, only one configuration per serving cell should be active  |
| Xiaomi  | One or two based on UE C-DRX configuration | First, we should make it clear the question is from UE’s perspective or from cell’s perspective that the cell DTX configuration is one or more.We assume it is from UE’s perspective.In R16, dual DRX are introduced for FR1 and FR2, i.e. shorter C-DRX parameter values in FR2 can improve the power consumption in FR2. However, only *drx-onDurationTimer* and *drx-InactivityTimer* parameters are configured separated and other DRX parameters are same in the two DRX.If dual DRX is configured, two cell DTX/DRX patterns are allowed to configure for FR1 serving cells and FR2 serving cell respectively from UE perspective. Otherwise, only one cell DTX/DRX configuration is allowed. |

*[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?*

|  |  |  |
| --- | --- | --- |
| **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 |
| Nokia | UE DRX values as starting point | UE DRX value range could be a good starting point. |
| Samsung | UE DRX values as starting point | Proponent of the proposal. |
| Qualcomm | UE DRX values as a starting point |  |
| ETRI | UE DRX values as a starting point |  |
| NEC | UE DRX values as a starting point |  |
| LGE | Longer cell DTX on-duration timer value is needed. | Considering the alignment of UE C-DRX and cell DTX in Q2, at lease multiple UE’s on-duration of UE C-DRX needs to fall within cell DTX on-duration. Therefore, it needs to be discussed that cell DTX on-duration timer value needs to be longer than UE C-DRX on-duration timer value.  |
| Vivo | UE DRX values as a starting point |  |
| Huawei, HiSilicon | All C-DRX values up to cellDTX-cycle | The C-DRX values can be supported. The maximum value should be no longer than the max cycle. |
| OPPO | UE DRX values as a starting point |  |
| Fujitsu | UE DRX values as a starting point |  |
| InterDigital | UE DRX values as starting point |  |
| Xiaomi  | UE DRX values as starting point |  |

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?*

|  |  |  |
| --- | --- | --- |
| **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 |
| Nokia | UE DRX values as starting point |  |
| Samsung | UE DRX values as starting point | Proponent of the proposal. |
| Qualcomm | UE DRX values as a starting point |  |
| ETRI | UE DRX values as a starting point |  |
| NEC | UE DRX values as a starting point |  |
| LGE | UE DRX values as starting point | We think that cellDTX-Cycle can be equal to or shorter than UE C-DRX periodicity considering that the periodicity of UE C-DRX is the same or a multiple of the periodicity of cell DTX in Q2. |
| Vivo | UE DRX values as a starting point |  |
| Huawei, HiSilicon | Up to 1280 ms. | Ues in connected mode can’t wait too long for a transmission as the impression might be that the connection was lost. 1 second seems a reasonable max value, considering the delay would be also for uplink transmission (including voice call establishment). |
| OPPO | UE DRX values as a starting point |  |
| Fujitsu | UE DRX values as a starting point |  |
| InterDigital | UE DRX values as starting point |  |
| Xiaomi  | UE DRX values as starting point |  |

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 |  |
| Nokia | Yes |  |
| Samsung | Yes | Same as Q7/Q8 |
| Qualcomm | Yes |  |
| ETRI | Yes |  |
| NEC | Yes |  |
| LGE | Yes |  |
| vivo | Yes |  |
| Huawei, HiSilicon | yes | Similarly to C-DRX. |
| OPPO | Yes |  |
| Fujitsu | Yes |  |
| InterDigital | Yes | For alignment with C-DRX, there is also a “slot offset” parameter to define the delay after the beginning of the subframe to when the UE starts the on duration timer. |
| Xiaomi  | Yes  |  |

*[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