3GPP TSG-RAN WG2 #121-bis-e R2-23XXXXX

Online, 17 – 26 April, 2023

Agenda Item: 8.xx.x

Source: Huawei, HiSilicon

Title: Outcome of [POST121][312][NES] DTX/DRX - Configuration/ activation/ deactivation and alignment (Huawei)

Document for: Discussion and decision

# 1 Introduction

This document is the report of the following discussion:

* [POST121][312][NES] DTX/DRX - Configuration/activation/deactivation and alignment (Huawei)
  + - Scope: Provide and summarize companies' views on:
      * Configuration of Cell DTX/DRX
      * Activation/deactivation of Cell DTX/DRX
      * Alignment between Cell DTX/DRX and UE C-DRX.
    - Intended outcome: Report to the next meeting (with agreeable proposals)

The intention of this document is to invite companies to share their views regarding configuration, activation, deactivation and alignment of Cell DTX/DRX. Taking these into account, the Rapporteur of the discussion provides a set of proposals to be further discussed during RAN2#121-bis-e.

**Deadline for comments: Wednesday, April 5th 2023, 10:00 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:

* Methods of configuring Cell DTX/DRX (not including joint/separate configuration and single/multiple configuration, as they have already been discussed and progressed online)
* Methods of activating and deactivating of Cell DTX/DRX
* Alignment between Cell DTX/DRX and UE C-DRX

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.

The TR 38.864 [2] captured the following with regards to configuration and activation of Cell DTX/DRX, and C-DRX alignment:

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| Cell DTX/DRX is applied to at least UEs in RRC\_CONNECTED state. A periodic Cell DTX/DRX (i.e., active and non-active periods) can be configured by gNB via UE-specific RRC signalling per serving cell. Below examples on Cell DTX/DRX behaviour during non-active periods are assumed to be possible options, and the UE behaviour/impact will be studied:  - Example 1: gNB is expected to turn off all transmission and reception for data traffic and reference signal during Cell DTX/DRX non-active periods.  - Example 2: gNB is expected to turn off its transmission/reception only for data traffic during Cell DTX/DRX non-active periods (i.e., gNB will still transmit/receive reference signals)  - Example 3: gNB is expected to turn off its dynamic data transmission/reception during Cell DTX/DRX non-active periods (i.e., gNB is expected to still perform transmission/reception in periodic resources, including SPS, CG-PUSCH, SR, RACH, and SRS).  - Example 4: gNB is expected to only transmit reference signals (e.g., CSI-RS for measurement).  The study focus on UE behavior when at any point in time the cell activates a single DTX/DRX configuration. It is up to NW whether legacy UEs can access cells with Cell DTX/DRX.  The Cell DTX/DRX mode can be activated/de-activated via dynamic L1/L2 signalling and UE-specific RRC signaling. Both UE specific and common L1/L2 signalling can be considered for activating/deactivating the Cell DTX/DRX mode.  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. At least the following parameters can be configured per Cell DTX/DRX configuration: periodicity, start slot/offset, on duration. Details related to UE behaviour can be discussed during WI phase. Whether to support multiple Cell DTX/DRX configurations can be discussed later in the WI phase.  It is beneficial to align UE DRX with Cell DTX and DRX alignment among multiple UEs. The alignment mechanism can be discussed during the WI phase.  From RAN2 perspective, Cell DTX/DRX is feasible. |

## 2.1 Configuration of Cell DTX/DRX

Are the Cell DTX/DRX parameters signalled to the UEs.

The UE can derive the Cell DTX/DRX configuration from various sources. Based on RAN2#120 contributions and TR 38.864 the Rapporteur identified the following options:

* **Option 1:** Explicit Cell DTX/DRX configuration signalled to the UEs, detailed in questions 2-4.
* **Option 2:** No explicit Cell DTX/DRX configuration, meaning that Cell DTX/DRX has no spec impact [5]

**Question 1:** *Which option do you support?*

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| **Company** | **Answer** | | **Comments** |
| Apple | Option 1 | | 1. From technique perspective, we are not sure how option 2 can work without spec impact. According to option 2 of P5 of [5], our understanding of the solution is:   1. "Mute" all or some periodic occasions of semi-static/periodic UL/DL transmission (e.g. CG, SPS, SR). 2. Refrain dynamic PDSCH/PUSCH by aligned UE CDRX.   For 1), we are not sure how to efficiently mute periodic occasions only for some time interval without spec impact. If it is done via RRC configuration / reconfiguration of CG/SPS/SR, it will incur extra high gNB power consumption caused by sending UE dedicated RRC signalling for each boundary of the non-active interval.  For 2), we think the key issue is that UE CDRX is per MAC entity, which means the same UE CDRX pattern is applied for all serving cells in CA. So, it will put a restriction on Cell DTX/DRX (i.e. only same DG refraining pattern in all serving cells is allowed). Since different serving cell may have different NES requirement, we think this restriction doesn't make sense.  2. Option 1 is captured in SI conclusion after extensive discussion. However, Option 2 was even not discussed in SI phase. We prefer to respect SI conclusion. |
| vivo | Revised Option 2, see comment | | According to [5], it seems that no explicit cell DTX/DRX configuration does not necessarily imply there is no spec impact. For example, to achieve NES gain, the periodical signals should be deactivated once C-DRX patterns among UEs are aligned, which can also achieve the cell DTX/DRX NES gain. Therefore, for better understanding of all the potential solutions, **we suggest to revise option 2** as:   * Option 2: No explicit Cell DTX/DRX configuration, FFS whether some channels/signals are deactivated when C-DRX patterns among different UEs are aligned.   From our perspective, DRX alignment among UEs is a simple baseline solution to enable the serving cell to achieve a larger window (common C-DRX off duration of the RRC\_CONNECTED UEs) for potential NES occasion. If companies think option 1 provides further benefits, we are open to discuss it. |
| Fraunhofer | Option 1 | | In our understanding one of the main goals of Cell DTX/DRX for Rel-18 is to be able to change quite dynamically between different configurations to serve different loads. Without explicit configuration this goal cannot be achieved, as all that can be done with legacy signalling is reconfiguring C-DRX for each UE separately. Therefore, in the case of no explicit configuration (Option 2) adapting to a lower load or back to a higher load takes a very long time. Thus, option 1 is preferred. |
| Lenovo | Option 1 | | UE needs to know unambiguously when the network is not *receiving* – it needs to be explicitly informed to the UE – otherwise, the UE may attempt transmission at any time, irrespective of CDRX configuration.  UE needs to know unambiguously when the network is not *transmitting* – it needs to be explicitly informed to the UE – otherwise, the UE may expect a response to its transmissions (e.g., SR/ RACH/ CG), absence of which leading to wrong conclusions (RLF or data loss). |
| Huawei | Option 1 | | We support the outcome of the SI phase and think the configuration should be signalled to the UEs by the gNB. |
| Qualcomm | | See comment | Option 2 does not mean no spec. impact: As the rapporteur cites our contribution, we would like to clarify the difference between option 1 and option 2. In both cases, UE shall apply DL/UL restrictions associated with Cell DTX/DRX, respectively.   1. Option 1 means those Cell DTX/DRX restrictions would be applied with a fixed “window”. Outside of this window specific NES DL/UL restrictions do not apply and the UE applies legacy behavior depending on whether it is in inactive or active time. 2. Option 2 means that those NES related DL/UL restrictions apply automatically as long as UE is in inactive time. The spec impact would be the additional behavior expected by the UE on top of CDRX inactive time behavior (i.e., whether to transmit a CG, whether to send an SR, treatment of DL and UL reference signalling, etc.).     In any case, we think the following agreement “Pattern configuration for cell DRX/DTX is common for Rel-18 UEs in the cell.” Somewhat points us towards option 1 so we are fine to pursue that if majority wants, and we are open to further discussion as well now that option 2 should be better understood. |
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How the Cell DTX/DRX parameters are signalled.

**Question 2:** If your answer to Q1 is Option 1, *do you agree to reconfirm the agreement from SI that it is done via RRC dedicated signalling (“periodic cell DTX/DRX pattern is configured by UE-specific RRC”)? If not, please comment on your preferred option.*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | As far as we know, NES gain can be maximized only if the gNB can sleep for a long time (i.e. we should avoid dynamic gNB on-off in short interval). Periodic pattern via RRC configuration is born to serve this purpose. |
| vivo | Yes | 1. It is not necessary to inform IDLE UE about the cell DTX/DRX configuration;  2. SIB update is not that frequent, hence it may not be suitable for handling cell DTX/DRX pattern change as the UE services may change from time to time. |
| Fraunhofer | Yes | Configured by RRC, activated/de-activated by lower layers |
| Lenovo | Yes |  |
| Huawei | Yes | We support configuration by dedicated RRC signalling. |
| Qualcomm | Yes | Agree with Apple |
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Parameters to be configured to the UE.

**Question 3:** If your answer to Q1 is Option 1, *do you agree to confirm the SI outcome that the Cell DTX/DRX configuration contains at least: periodicity, start slot/offset and on-duration?*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | We think it is straight forward.  Meanwhile, we suggest to confirm we can reuse the formula of UE CDRX to calculate starting time of active duration, i.e. [(SFN × 10) + subframe number] modulo (*Periodicity*) = *StartOffset.* We think it will be helpful to discuss alignment between Cell DTX/DRX and UE CDRX. |
| vivo | Yes |  |
| Fraunhofer | Yes for Cell DTX  No for Cell DRX | Cell-DTX has C-DRX as the UE counterpart, so the design and configuration can be quite close to the C-DRX concept. The goal in Cell-DTX is to align quickly (in low load) and change back to non-alignment (in high load) also swiftly. The 3 mentioned parameters are the basic to move from alignment to non-alignment and vice-versa  Regarding Cell-DRX we think it is premature to define a certain configuration. First we need to discuss what Cell-DRX will look like. As Cell-DRX does not have a UE counterpart the best way to configure it may be quite different than these 3 parameters. |
| Lenovo | Yes |  |
| Huawei | Yes | These parameters are mandatory and need to be signalled. We are OK to reuse the formula of UE C-DRX as indicated by Apple. |
| Qualcomm | Yes | As a baseline, this would make sense. We may need to revisit depending on how much “configurability” companies envision but for now, this is a good starting point. Also agree with Apple on reusing the formula |
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Cell DTX/DRX UE specific inactivity timer was discussed during RAN2#121 and left FFS [3]. The Rapporteur would like to gather companies’ view on this topic.

**Question 4:** *Do you support adding to the list from Question 3 a Cell DTX/DRX inactivity timer (cell active time duration extension mechanism)?*

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| **Company** | **Answer** | **Comments** |
| Apple | No  (leave it to the discussion of FFS of RAN2#121) | As Rapporteur mentioned, we have discussed this issue in RAN2#121 and captured an FFS for it:   1. 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.   During the online discussion, this issue was controversial. Meanwhile we think how DTX UE specific inactivity timer work is not clear. For example:   1. Does it means the cell active time (common to all UEs in the cell) can be extended just because one particular UE has pending traffic? 2. If Yes to 1), does gNB need to reconfigure Cell DTX/DRX pattern to notify all UEs in the cell? 3. If both Cell DTX and UE DRX are configured, how does it work together with inactivity timer of UE CDRX?   Thus, we think it is premature to discuss configuration issue in this email discussion when its mechanism/feature is even not clear. Since an FFS has been captured, we believe companies will bring their solutions/analysis in their contributions. So, we see no necessity to discuss it here in a hurry. |
| vivo | Yes | We think it’s beneficial to keep inactivity timer mechanism in cell DTX/DRX as well if cell DTX is explicitly configured so that the serving cell can timely schedules the UE if necessary. Furthermore, cell DTX inactivityTimer can be smaller than UE DRX inactivityTimer of some UEs to achieve further potential NES gain. For the questions Apple mentions, we have the following opinion:  Q1: Yes. From the serving cell’s perspective, the cell DTX/DRX active time of it is extended even if just one particular UE is scheduled.  Q2: No, the actually extended period can be just kept within the serving cell and the scheduled UE(s). As for the other UEs that are not scheduled (i.e. cell DTX inactivity timer is not started), they do not need to extend the cell DTX pattern, hence the gNB does not need to reconfigure the pattern for therm.  Q3: One way to handle it is that if cell DTX and UE DRX are configured, UE only extend the cell DTX pattern when both cell DTX inactivityTimer and UE DRX inactivityTimer are running. |
| Fraunhofer | No | First and foremost, based on the discussion on RAN2#121, it seems different companies have different views on “cell active time”. The proposal for having an “inactivity timer” seems to come from the understanding that everything is OFF if not on “cell active time”. Other companies seem to regard “cell active time” to be closer to the C-DRX concept of “ON time” which in essence means a fixed time at which PDCCH needs to be decoded. In that case we think it is better to rely on the existing C-DRX inactivity timer – i.e inactivity is individual to each UE, rather than adding another complicated common timer.  Thus the definition of “cell active time” needs to be consolidated and clarified first (see also Q7 for a proposal). That said, we think it is appropriate to let the gNB schedule dynamic PDSCH/PUSCH regardless of “cell inactive time” if the gNB scheduler decides it is appropriate to do so. But the grant (PDCCH) should only start during a fixed phase. (on-duration) |
| Lenovo | Yes | It is indeed inefficient if the network would need to reconfigure Cell DTX/ DRX configuration often since the current configuration does not allow short burst(s) in UL/ DL to be catered to, or at least not respecting QOS. To present such frequent Cell DTX/ DRX reconfigurations, an inactivity timer can be useful. This should only be between the gNB and the concerned UE(s) and other UEs need not know or be informed about it…very similar to Inactivity timer in CDRX context.  The network would be in control and can choose if to extent (start the inactivity timer) or not and would then take appropriate action towards the UE. The details of such mechanism e.g., for which DCI the cell-inactivity timer should be started needs to be further discussed. |
| Huawei | No | We think that introduction of such timer would reduce the benefit of network energy saving, since the non-active time of the gNB would be shortened (gNB would need to run an inactivity timer for every connected UE in the cell). If any follow up transmission for a particular UE is needed it can be scheduled in the next gNB active time.  Furthermore, the complexity of such solution would be increased. As highlighted by Apple the meaning of this active time extension to other UEs would need to be clarified, because by default they would not be aware of such extension and could not benefit from it. |
| Qualcomm | No | We think there is a need to first resolve how the UE is expected to behave when it’s active time (due to inactivity timer running, retransmission in progress, SR transmitted, etc.) overlaps with the start of cell DTX non-active period.  If it is deemed that the UE can extend its active time within the configured cell DTX non-active period, i.e., postponing entering the cell DTX inactive time then there can just be an agreement on that, this does not need a cell inactivity timer.  On the other hand, we have concerns on the UE being required to track a gNB inactivity timer. Just complicates the process with no tangible gains. |
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*[Rapporteur’s summary and proposals]*

## 2.2 Activating and deactivating of Cell DTX/DRX

A following issue is how to activate/deactivate the Cell DTX/DRX configuration. The SI phase identified the following options: dynamic L1/L2 signalling and UE-specific RRC signalling [2].

In our understanding, the “RRC signalling” in the TR 38.864 means that the Cell DTX/DRX is activated/deactivated implicitly for single configuration, i.e. activated once configured, and deactivated once de-configured. If there are multiple configurations configured by RRC, there is a need of explicit activation/deactivation of one of the parameter sets.

We see the following options for Cell DTX/DRX activation/deactivation:

* **Option 1:** Activated/deactivated by dynamic L1 or L2 signalling (in this option please state which one do you prefer)
* **Option 2:** Activated/deactivated implicitly, i.e. activated immediately once configured by RRC and deactivated once the RRC configuration is released
* **Option 3:** Both
* Option 4: Cell DTX/DRX activation/deactivation is aligned to modification period boundary

**Question 5:** Please indicate your preference on how the Cell DTX/DRX configuration is activated/deactivated. If you see a need you can propose other options.

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| **Company** | **Answer** | **Comments** |
| Apple | Option 3 | For Option 2 (RRC only), as we replied in Q2, it should be baseline because a periodic pattern with long non-active duration can maximize NES gain.  For Option 1:   * We see some benefit of cell common or UE group common L1 signalling. Our consideration is that it can reduce the signalling overhead of sending UE dedicated RRC message to reconfigure Cell DTX/DRX. * For UE dedicated L1 or L2 signaling, we think it doesn't make sense because the dynamic switch of gNB ON-OFF pattern can't help save gNB power consumption. |
| vivo | Option 2/3 | If cell DTX/DRX is already activated, then it should also be activated for the UEs that just enter RRC\_CONNECTED mode and configured with cell DTX/DRX configuration(s). Therefore, option 2 is necessary.  If there is a need to configure multiple cell DTX/DRX configurations, option 1 may be necessary to dynamically change cell DTX/DRX pattern. Otherwise, option 2 is enough as we do not observe the need to activate cell DTX faster with L1/L2 signalling. |
| Fraunhofer | Option 1 with L1 | If the activation and de-activation is left only for RRC (assuming UE-specific RRC), the configuration will not be dynamic enough (like legacy). Being able to adapt more dynamically to the load is the best enhancement which Cell DTX/DRX can provide. For this reason we prefer Option 1. We prefer it on L1, as it is more suited to a single cell indication (see Q6). Or L1/L2 with L2 saving some bits of L1. |
| Lenovo | Option 4 (1st preference)  Option 2 (2nd preference) | We think the network energy saving will be based on statistical data available in the network and therefore network has reasonable/ stable assumptions about when and for how long it wants to (or can) save power. So, we think really dynamic signalling (unlike e.g., type-2 based CG configurations) do not bring in additional value.  Option 4 enables that Cell DTX/DRX activation/deactivation is aligned to modification period boundary and thereby provides a good sync point for gNB/ UEs, without requiring further activation signalling. |
| Huawei | Option 3 | At least one kind of UE-specific signalling for (de)activating Cell DTX/DRX should be supported. For that purpose, UE-specific RRC signalling can be used in the case of initial configuration and new UEs entering the cell.  In our view cell-level L1/DCI activation/deactivation is also useful as it would provide a fast and efficient way to dynamically control Cell DTX/DRX. |
| Qualcomm | Option 2 as a baseline.  FFS Option 3 For **single configuration only.** | First of all, the rapporteurs sentence above “If there are multiple configurations configured by RRC, there is a need of explicit activation/deactivation of one of the parameter sets” is not in line with last meeting agreement “We will focus on designing DTX/DRX for at least single configuration”, so we actually do not agree with discussing switching between multiple configurations now based on RAN2 agreements, and we don’t agree with neither that multiple configurations will be needed nor with using L1 to switch between them. To summarize why L1 switching is an implementation challenge: It requires UEs to decode a common L1 DCI and subsequently modify the MAC state machine which is maintained in MAC with many inputs that affect the state such as DL/UL traffic, re-Tx, MAC CE commands, etc.. When the new config is signalled, the CDRX state becomes ambiguous with sensitive timing.  As mentioned by other companies (and discussed during SI). It should be straightforward to allow the gNB to configure and/or activate Cell DTX/DRX via unicast RRC signalling, i.e., option 2.  For option 3 **for activating/deactivating single cell DTX/DRX configuration only**, we understand that L1 or group signalling is proposed to save the time and overhead of RRC signalling, however feasibility and details are RAN1 scope. Thus, we prefer to agree on option 2 to move things forward for now, and check with RAN1 on the following:   1. Whether it is feasible to use a group DCI to control CDRX (or cell DTX/DRX) state 2. What timelines would make sense for the UE to have time to adapt and whether in the end complexity would be prohibitive to the expected NES gain. 3. The exact L1 signalling design.   Based on that, L2 signalling can also be explored for activation/deactivation of DRX since it was already discussed in XR. |
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If L1/L2 signalling is to be pursued, another issue is whether the L1 signalling can be UE specific or cell common, as indicated in the TR [2]. Note that we have already agreed in RAN2 #121 that pattern configuration for cell DRX/DTX is common for Rel-18 UEs in the cell. Also, in the rapporteur’s understanding, the cell common signalling is only for L1, not for L2.

**Question 6:** *Do you see a need of cell level common L1 signalling for activating/deactivating the cell DTX/DRX pattern in addition to UE specific signalling?*

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| **Company** | **Answer** | **Comments** |
| Apple | Yes with wording change.. | As we mentioned in Q5, We see some benefit of cell common L1 signaling. Our consideration is that it can reduce the signalling overhead of sending UE dedicated RRC message to reconfigure Cell DTX/DRX to each UE. And the saving of overhead/message number towards UE) will also transform to NES gain.  We think the question may be confusing what is "*in addition to UE specific signalling*": is it RRC signaling or UE dedicated L1 signaling? We believe it should be RRC signaling. So, we suggest below change:  *Do you see a need of cell level common L1 signalling for activating/deactivating the cell DTX/DRX pattern in addition to ~~UE specific signalling~~RRC signaling?* |
| vivo | Yes | If the A/D signalling is UE specific, then a simpler solution is to just reconfigure DRX pattern for different UEs for UE DRX alignment, and potentially restrict some channels/signals transmission/reception. Therefore, using common L1 signalling is more reasonable.  We agree with Apple on the revision for the question. |
| Fraunhofer | Yes | Cell-DTX and Cell-DRX are cell concepts. So if the network wants to indicate a certain state (load state), that is on a cell level and we agree to rapporteur that L1 is more suited to cell common signalling. The individual interpretation of what to do on certain load state can still be configured specifically to each UE. |
| Lenovo | No | The proposed Option 4 to Q5 (Cell DTX/DRX activation/deactivation is aligned to modification period boundary) applies to all UEs and therefore no separate common or UE-specific signalling is necessary. |
| Huawei | Yes | As described above it can be useful if the need of activation/deactivation is more dynamic.  We agree with Apple’s proposal and we also think UE specific L1/L2 signalling does not bring much gains. In our view the L1 signalling should be used for cell level changes. |
| Qualcomm | Leave to RAN1 in single configuration case only | Assuming we are talking about activating/deactivating a single cell DTX/DRX configuration only:  As mentioned in the previous question, there are a lot of difficulties in aligning timing this way between gNB and UE that are not being thoroughly discussed here, and would probably make much more sense to discuss in RAN1. RAN2 cannot design a new group common DCI to control CDRX cycles. |
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*[Rapporteur’s summary and proposals]*

## 2.3 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:

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| 2. 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. |

In order to specify the alignment RAN2 needs to have a common understanding of what the alignment of Cell DTX/DRX and UE C-DRX means.

In the rapporteur’s understanding, an aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX falls within Cell DTX active time. As highlighted in [4] the active duration of UE C-DRX can be extended by the UE DRX inactivity timer, therefore it is impossible to ensure that active duration of Cell DTX is always overlapping with UE C-DRX active time (T2 in the figure below). But it is possible to ensure that the on-duration of UE C-DRX is within the Cell DTX active time and this is proposed by the rapporteur.



Fig. 1. Illustration of issue scenarios of Cell DTX and UE CDRX alignment [4]

**Question 7:** *Do companies agree to the following statement:*

“An aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX falls within Cell DTX active time.” This definition includes all cases regardless if the periodicity and on-duration are the same or different across the cell, and starting time of UE C-DRX on-duration is the same as cell DTX active duration or not.

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| **Company** | **Answer** | **Comments** |
| Apple | Yes | We think Rapporteur suggested statement is reasonable. |
| vivo | No | We think Rapporteur’s statement involves several issues and would like further clarification:  1. cell DTX active time definition?  It’s a little bit early to define cell DTX active time as the cell DTX pattern may be extended.  2. How to understand ‘alignment’?  We think ‘UE C-DRX pattern aligns with cell DTX pattern’ means that the on-duration of UE C-DRX is at least partially overlapped with cell DTX on-duration, and the wording ‘within’ is just part of all the cases.  If rapporteur’s statement is intending to clarify this issue, then we suggest to revise the statement as:  An aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX ~~falls within~~ is at least partially overlapped with Cell DTX ~~active time~~ on-duration.  3. Whether the UE C-DRX active time regarding UE C-DRX onDurationTimer is submissive to cell DTX active time regarding cell DTX onDurationTimer？  If rapporteur’s statement is intending to clarify this issue, then we agree that the cell DTX active time includes the UE C-DRX on-duration within the cell DTX on-duration. |
| Fraunhofer | Partially | We agree to the general direction of the statement, but as we already discussed Q4 we think that “Cell DTX active time” needs to be more accurately defined. Using C-DRX concept as basis, TS 38.300 on section 11 distinguishes “active time” from “on-duration”. Basically, “on-duration” is fixed whereas “active time” varies and includes the “on-duration” . We would suggest to define “Cell-DTX active time” and “Cell-DTX on-duration” in a similar way:  “Cell-DTX on-duration is the time when a cell may transmit PDCCH” (fixed per cycle)  “Cell-DTX active time is the time a cell stays active within Cell-DTX cycle”  We don’t think UEs need to track Cell-DTX active time. A UE should only track its own active time. If a UE is not scheduled during “Cell-DTX on-duration” it should sleep regardless of other UEs and Cell actitivity.  So the statement could be revised to “An aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX falls within Cell DTX on-duration.” We would agree with this revised version. |
| Lenovo |  | While the intention of the statement from Rapp is not wrong in our view, we need to focus on necessary UE behaviour for Cell DTX/ Cell DRX. As long as it is clear what UE does when the cell is not receiving and/ or when the cell is not transmitting, we can do away with such definition…at least for now. |
| Huawei | Yes | To answer Vivo’s questions:   1. Even if Cell DTX active time is extended by the inactivity timer, this definition would still hold (i.e. UE on-duration would fall within Cell active time). 2. The partially overlapping case would bring complexity to the solution. If the overlap would be short, the opportunity for the UE to receive PDCCH might be limited. RAN2 would need to specify behaviours and timer values for this case, which is not needed if we agree on the initially proposed statement. Furthermore, the UE would waste power in the time when UE on-duration fall outside of Cell active time. 3. We use the term “Cell DTX active time” on purpose, not knowing if it will be only on-duration or on-duration + inactivity timer. We would be fine to change the wording to “(…)on-duration of C-DRX falls within Cell DTX on-duration ~~active time~~”. |
| Qualcomm | No | First of all: Rapporteurs proposal is not very clear to us, “on-duration of C-DRX falling within Cell DTX active time.” On-duration is not the issue here as this is easily done by configuration. The issue is the active time of CDRX which may conflict with cell DTX non-active period (T2 in the figure), so we will answer the question assuming both cases here until there is clarity on the exact proposal.  **Active time**  We prefer that when the UE needs to extend UE CDRX (T2 in the figure), gNB does not go into Cell DTX non-active period (as per this specific UE understanding). Thus, we propose a more straightforward proposal like this: **“Cell DTX non-active period can only occur when the UE is already during CDRX inactive time”.** We think this is the proper order of things with respect to MAC spec. UE goes to inactive time using legacy CDRX procedure then starts applying cell DTX/DRX non-active time restrictions.  The issue with the proposal “An aligned UE C-DRX configuration with Cell DTX means that the on-duration of C-DRX falls within Cell DTX active time”, assuming the same logic applies for active time would be:   1. Forces UE into a fixed duty cycle, i.e., extending UE active time for a transmission or a retransmission becomes impossible. This not acceptable for most type of traffic to have zero flexibility in timelines for retransmissions or HARQ ACK/NACKs etc. as those events are pretty important that’s why we define HARQ-specific retransmission and RTT-timers. We cannot simply cancel this whole mechanism for NES purposes. 2. Cell DTX/DRX is maintained per serving cell, so it will not even be possible to align individual serving cells cell DTX cycles with the MAC entity CDRX operation. Recall that the SI phase agreement “Cell DTX/DRX can be configured per serving cell and can be applicable for different cells in CA. No additional RAN2 impacts or enhancements are foreseen.” 3. Requires modification of existing DRX timers to consider cases when cell DTX non-active timer overlap with a running timer (Case T2 above) 4. May have RAN1 impact: Requires modifications for PHY timelines (K0,K1,K2) to consider cases where Cell DTX overlaps with any transmission/reception event.   **On-Duration**  If we are discussing on-duration here then it would be easy to align on-duration with cell DTX non-active time by configuration, but that wouldn’t answer the more important issue of active time overlap with Cell DTX non-active time (our understanding of T2 duration) |
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**Question 8:** *Which option of NW-UE alignment do you prefer:*

* **Option 1:** As long as the on-duration of C-DRX falls within Cell DTX active time, the aligned C-DRX of different UEs can vary in offset, periodicity or on-duration [9] as in Fig. 2.



Fig. 2. Different UE DRX patterns aligned with a certain Cell DTX (if Cell DTX is activated).

* **Option 2:** In addition to the on-duration of C-DRX falling within Cell DTX active time, the alignment between cell DTX/DRX and UE C-DRX also requires the starting time of UE C-DRX active duration to be the same as cell DTX active duration (i.e. there is a NES specific start offset).



Fig. 3: C-DRX start offset alignment among multiple UEs [23]

* **Option 3:** There is only a single UE C-DRX pattern in a cell which is fully aligned with cell DTX (i.e. exactly the same on/off configurations for the cell and all UEs in this cell).

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| **Company** | **Answer** | **Comments** |
| Apple | Option 2 | We believe Option 2 can maximize NES gain because the same starting time of active duration can make the UEs to finish their transmissions as early as possible, so that gNB can enter non-active duration early.  For option 1, the distributed on-durations of different UEs will make gNB have to keep waking up to wait the last UE's ON-duration finished, and correspondingly gNB has to configure a long active duration of Cell DTX. It is bad for gNB power saving. As example, in below figure, if UE1 and UE2's on-duration are distributed, the active duration of Cell DTX has to be configured to end in T2 to wait UE 2's on-duration finished. However, if UE2's on-duration starts from T0, the Cell DTX active duration can be reduced to end in T1.    For option 3, we don't see the point to make this strong restriction on alignment:   * Different UE may have different traffic requirements. It doesn't make sense to mandate all UEs to have same ON-OFF pattern. * Because we have inactivity timer for UE CDRX anyway, the totally equal on/off duration may also result in the situation of Figure.1. |
| vivo | Option 1 | This question is related to how we understand question 7, which we suggest the wording ‘within’ needs to be further clarified. It is not necessary to assume the cell DTX onDurationTimer in cell DTX configuration is definitely larger than the UE C-DRX onDurationTimer in UE DRX configuration. From our understanding, UE monitors some PDCCH within the overlapping part of cell DTX on-duration and UE C-DRX on-duration.  We think Option 1 is beneficial for the gNB to balance the location of scheduling occasions among UEs within cell DTX on-duration. It is up to gNB implementation to realize option 2 with the support of option 1.  As for Option 3, we share similar view with Apple. |
| Fraunhofer | Option 1 | We prefer Option 1 - Assuming it is actually aligned to “Cell-DTX on” duration (as in Fig 2) and not to “Cell-DTX active time” (see our answer to Q7 for the distinction).  Option 2 is too inflexible for non-zero load. For example, if Cell-DTX on time is 5 ms and cycle is 20 ms , why would all UEs need to align to the beginning of the 5 ms? It would be better to distribute the load over those 5 ms  Option 3 does not consider the UE needs. Why a UE with C-DRX cycle of 320 ms would be forced to a Cell-DTX cycle of 20 ms? That would drain UE battery. |
| Lenovo | Option 2 | Option 1 does not allow use of a more optimized separate CDRXs for UE when cell is saving power and when it is not.  Option 2 provides the maximum power saving opportunity for the network.  Option 3 is sub-optimal as the network then would need to conservatively configure same UE CDRX to all UEs in the cell and this would be then according to most strict/ demanding QoS.  Another point that is not yet discussed here concerns Cell DRX specifically. Today, the UE can transmit at any point i.e., even when in CDRX sleep time e.g., perform a RACH procedure if need be. However, this will not necessary be the case when the Cell is not receiving. Discussion around the current question does not address this. |
| Huawei | Option 1 | In our view there is no need to restrict the starting time of UE C-DRX on-duration if the network can achieve the alignment as defined in Question 7 without it. This should be left up to the network to configure for connected UE load balancing in the Cell DTX active time.  From our perspective the periodicity of C-DRX should be same or a multiple of Cell-DTX's periodicity, and the on-duration cannot exceed the Cell-DTX's on-duration but can be different for various UEs. |
| Qualcomm | Option 1 | Option 3 should not be considered since it forces all UEs to have the same active time, which naturally would be configured conservatively according to the UE with most stringent QoS needs. This is bad for UE power, since almost all UEs are forced into larger than needed ON duration.  Option 2 unnecessarily limits both the capacity and the NES gains of the gNB while also requiring the UE to have larger than needed active time. Since it does not properly distribute PDCCH occasions over time (like option 1 does) it needs to keep some UEs awake (and the gNB itself) until enough PDCCH occasions are there to accommodate all UEs. |
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**Question 9:** *Do you agree to leave the alignment mechanism up to NW implementation? If not please state the possible spec impact in the comments.*

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| **Company** | **Answer** | **Comments** |
| Apple | No | 1) It is too early to conclude no spec impact. We think we should first make the alignment mechanism clear, and then discuss whether it has spec impacts or not.  2) In Rapporteur's Figure 1, the UE behaviour in duration T1 and T2 are not clear. For the moment, it is hard to say whether the UE will always follow legacy UE CDRX behaviour (i.e. without spec change) because we don't even conclude UE behaviour in Cell DTX (and whether the restriction on UE reception in Cell DTX is more strict than UE CDRX). |
| vivo | Maybe yes | We agree with Apple that it is too early to discuss this. Maybe we can come back to this issue later. |
| Fraunhofer | No | If we leave it fully to NW implementation the adaptation will not be dynamic enough and the network will not save more energy than a Rel-17 network.  The main spec need is explicit parameters to align the cycle quickly. The simplest solution to achieve dynamic adaptation is: When Cell-DTX is not activated, the existing C-DRX parameters apply. When Cell-DTX is activated a new set of parameters apply. On top of that it is worth to consider more than 2 configurations, in order to adapt to different loads more quickly, e.g. 5%, 10%, 15% and 20% load. |
| Lenovo | No | We think there will need to be specific UE behaviour and any reasonable solution (unlike Option 3 of Q8) will find it difficult to keep this only up to network implementation.” |
| Huawei | Maybe Yes | The alignment should be decided and executed by the NW. There might be a need of a "start offset" signalling but it should be a part of the signalling from Q5-Q6, so if a start offset is agreed it is enough for the network to be able to align the UEs. We are fine to postpone this to a later stage. |
| Qualcomm | No | Agree with Apple |
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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

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