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Agenda Item: 8.3.2

Source: InterDigital

Title: Report of [301][NES] Summary of DTX/DRX – 8.3.2

Document for: Discussion, Decision

# Introduction

This is summary document for agenda 8.3.2. This document summarizes proposals in the referenced papers and related offline discussion:

[301][NES] Summary of DTX/DRX – 8.3.2 (InterDigital)

Questions are to be answered only during the [AT] phase of the offline discussion.

# Discussion on open issues

During the post meeting email discussion [3], the following open issues were identified:

* Whether L1/L2 signalling can be used to configure the DTX/DRX pattern, or only used to activate the RRC-configured DTX/DRX pattern.
* Whether L1/L2 signalling for DTX/DRX activation is UE specific or can also be group common
* Whether multiple sets of DTX/DRX configurations/modes are allowed to be configured by RRC, and what are the benefits compared with only one configuration at a time?
* DRX/DRX alignment
* Joint or separate configuration of DTX and DRX mode/operation
* DTX definition assumptions and related UE behaviour
* Whether there are valid scenarios to keep CA in Cell DTX/DRX

## DTX/DRX configuration and related L1/L2 signalling

**Whether L1/L2 signalling can be used to activate or also configure a DTX/DRX pattern**

In R2#119bis-e, it was agreed that “*Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signalling*”. The following options were proposed for understanding the agreement:

* Alt-1: Allow both periodic pattern (configured by RRC) and one-shot pattern –(re)-configured by L1/L2 signalling- [4, 10]
* Alt-2: Allow periodic pattern, configured by RRC; L1/L2 signalling can be used to activate it [4, 5, 8, 11, 12, 14, 16, 19, 20]
* Alt-3: Allow both periodic pattern (configured by RRC) and one-shot pattern (A “non-active” period is activated dynamically by L1/L2 signalling, where the period is configured by RRC) [7]

Alt-1 provides configuration by L1/L2 signalling, while Alt-3 describes dynamic triggering of aperiodic non-active period by L1/L2 signalling. It seems like a majority of companies have the understanding of the agreement more aligned with Alt-2. The following proposal is made:

**Proposal 1** Clarify previous agreement to: periodic cell DTX/DRX pattern is configured by RRC and can be activated by L1/L2 signalling.

**Whether L1/L2 signalling for DTX/DRX activation is UE specific or can also be group common**

Per the agreement “*Dynamic L1/L2 group signalling from NW to provide NW DTX mode/configuration is also considered in RAN2*”, some companies would like to clarify that both UE-dedicated and group common signalling can be used for indicating a DTX/DRX mode, as apposed FFS as captured in the TP [2]. Group common can be used for signalling overhead reduction but also to align DRX among multiple UEs in the cell. In [4, 5, 7, 12, 15, 20], it is proposed that both UE specific and group common L1 or L2 signalling can be considered for indicating a DTX/DRX pattern. [14] proposes to consider activation by group signalling later once further details on cell DTX/DRX are understood.

**Proposal 2** Capture in TR 38.864 that both UE specific and group common signalling can be considered for activating the DTX/DRX pattern, per the agreement in 119b-e.

**Whether multiple sets of DTX/DRX configurations/modes are allowed to be configured by RRC**

One FFS is whether multiple sets of DTX/DRX mode configurations are allowed to be configured by RRC, which is captured as an editor’s note in the baseline DTX/DRX TP in [2]. The following options are proposed:

* Option 1: Multiple sets of Cell DTX/DRX configurations can be configured in RRC, and L1/L2 signalling is used to activate the applicable configuration set. [7, 8, 10, 13, 15, 19, 20]
* Option 2: Only a single cell DTX and DRX configuration is configured at a time [4, 11].
* Option 3: In addition to pattern activation, L1/L2 indication is also be considered to deactivate/stop applying a Cell DTX/DRX pattern (without releasing the RRC configured Cell DTX/DRX) [4, 12]
* Option 4: Support for multiple configurations can be left for work item phase, e.g. after single cell DTX/DRX is defined and further R1 details [5, 12, 14]

**Question 1: which of the above options do you prefer for whether to configure multiple sets of DTX/DRX?** *multple options can be indicated (for example options 2 and 3 can imply single configuration that can activated/deactivated by L1/L2 signalling).*

|  |  |  |
| --- | --- | --- |
| Company | Preferred option(s) | Additional comments |
| CATT | 2 as baseline | But we think it also depends on how many different NES designs are defined by RAN1 for DTX/DRX. |
| BT | 1 as baseline | Option 2 is a subcase of option 1. With option 2, NW can set a single configuration where L1/L2 signalling is not needed.  If L1/L2 is defined to activate the DTX/DRX configuration, we do not envision the problem to use the same mechanism to deactivate the configuration. |

**Joint or separate configuration of DTX and DRX mode/operation**

One open issue discussed in [3] is whether DTX and DRX should be defined jointly or separately for the DL and UL traffic. TX power consumption tends to be higher, as UL traffic demand is usually smaller than DL. The following options are proposed

* Option 1: Cell DTX and Cell DRX modes can be configured and operated separately (e.g. one RRC configuration set for DL and the other set for UL). [5, 7, 8, 14, 15, 20]
* Option 2: Cell DTX and Cell DRX are configured jointly: Common periodicity and on-duration are used if both cell DTX and DRX are activated. [4, 11]
* Option 3: Only cell DRX configuration is informed to a UE and is separate from DTX. UE is unaware of DTX [19]

**Proposal 3:** Cell DTX and Cell DRX modes can be configured and operated separately (e.g. one RRC configuration set for DL and the other set for UL).

## DRX/DRX alignment

Overprovisioning DRX even when the cell is in DTX can lead to increased battery consumption, while under-provisioning it can impact QoS. In the post-meeting email discussion [3], whether/how to align UE DRX with network DTX and whether/how to align DRX alignment among multiple UEs were discussed. The following options are proposed to address it:

* Option 1: NW implementation to ensure alignment/overlapping durations between cell DTX and DRX, e.g. to maximize energy savings and align multiple UEs in the cell. [5, 6, 7, 14, 15, 20].
* Option 2: all NES UEs in a cell have the same cell DTX/DRX pattern, though the configuration may be UE-specific [11]
* Option 3: Cell DTX/DRX pattern configured by SIB signalling for all UEs [13]
* Option 4: Cell DTX overrides the UE behaviour on UE DRX (UE DRX active time is only possible in the Cell DTX active period, and similarly for the non-active time) [10]

**Proposal 4:** Proper network configuration of cell DTX and UE DRX can ensure the alignment between cell DTX and UE DRX, with the aim to maximize energy savings and align DRX for multiple UEs in the cell. No additional RAN2 impacts or enhancements are foreseen.

## DTX/DRX definition assumptions and related NES UE behaviour

**NES-capable UEs:**

One open issue listed in [3] is on DTX definition assumptions and related UE behaviour during non-active durations. The following examples on cell DTX/DRX are captured in the baseline TP [2] for assumptions on the UE behaviour during non-active DTX periods:

* 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).

[4, 7, 14] mention that those examples are sufficient to conclude the SI, and further details/prioritization can be done in the normative phase after RAN1 has progressed with more details. However, some companies have proposed additional prioritization to be captured in the SI:

1. Capture in TR 38.864 that Example 1 is prioritized, i.e. assume that gNB turns off all the transmissions and reception during the DTX/DRX non-active period. Resources in non-active periods are not used by the UE [12]
2. Capture in TR 38.864 that Example 3 is prioritized [19]
3. SSBs assumed to be transmitted per legacy assumptions during DTX, including during non-active periods [5, 11], i.e. deprioritize Example 1.

**Question 2: Do you think any of the above prioritization options need to be captured in TR 38.864 in addition to the already captured examples on DTX/DRX definition?**

|  |  |  |
| --- | --- | --- |
| Company | Answer | Additional comments *if yes, which option* |
| CATT | No | Agree with Rapporteur to leave the examples in the TR and wait for RAN1 for finalizing the design. |
| BT | No | Leave prioritization to normative phase |

With regards the gNB/UE behaviour during DTX/DRX, the following assumptions are further proposed:

1. UE-specific configured DL and UL resources and signals (e.g. PDCCH, PDSCH, PUSCH, PRACH, PUCCH, CSI/SRS) are assumed as deactivated/suspended during cell DTX and DRX, respectively [8, 11, 13, 15].
2. UE to stop monitoring PDCCH and suspend UL grant/RACH transmissions during DTX [20]
3. There can be some exceptions to DTX/DRX assumptions, e.g. to suspend DTX/DRX, e.g. when UE is performing RA. [8, 15]
4. UE suspends CSI measurements and beam management during DTX if SSBs are not transmitted (e.g. per Example 1) [20]
5. Impact on the timers in MAC (e.g. DRX, BFD) during DTX is to be considered during the normative phase [8]

The following impacts/assumptions can thus be listed for the impact of DTX/DRX on the UE behaviour:

* Impact 1: Which configured DL and UL resources can be assumed as deactivated/suspended during DTX and DRX, respectively, including: PDCCH, PDSCH, PUSCH, PRACH, PUCCH
* Impact 2: Which UE-specific DL and UL signals can be assumed as deactivated/suspended during DTX and DRX, including CSI-RS and SRS.
* Impact 3: Whether there can be some exceptions to DTX/DRX assumptions, e.g. to suspend DTX/DRX during RA
* Impact 4: Suspension of CSI measurements and beam management during DTX if SSBs are not transmitted per legacy assumptions
* Impact 5: Impact on the timers in MAC (e.g. DRX, BFD) during DTX

It is thus possible to capture some of the above assumptions on the UE behaviour in TR 38.864 as impacts that can be addressed during the normative phase, or leave some time for RAN1 to progress a bit.

**Question 3: Which of the above DTX/DRX assumptions, if any, should be captured in TR 38.864 to be addressed during the normative phase for the UE behaviour assumptions during DTX/DRX?**

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| --- | --- | --- |
| Company | Possible impact(s) | Additional comments |
| CATT | All | But impacts 1-2 are to be addressed by RAN1. |
| BT | All |  |

**Legacy UE access to cells with DTX/DRX**

The following options were proposed regarding whether legacy UE are allowed on cells with DTX/DRX:

* Option 1: up to NW implementation whether to allow or bar legacy UEs to access cells with NW DTX/DRX mode. [4, 7, 8, 11, 15, 20]
* Option 2: DTX should apply to legacy and NES-capable UEs alike [5]
* Option 3: legacy UEs are barred by the cells with DTX/DRX modes [16]

Given there is a majority for option 1, the following is proposed:

**Proposal 5**: It is up to NW implementation whether to allow or bar legacy UEs to access cells with Cell DTX/DRX.

## Whether there are valid scenarios to keep CA in Cell DTX/DRX

Cell DTX/DRX is configurable per serving cell, as the name suggests. An open issue discussed though is whether DTX/DRX can be applicable in the case of carrier aggregation (CA), if configured by the network. The following options are proposed:

* Option 1: Cell DTX/DRX configuration can be configured per serving cell and can be applicable for different cells in CA, but without any optimizations for CA. [4, 7, 14, 15, 19]
* Option 2: Cell DTX is not considered in CA [20]
* Option 3: DTX/DRX pattern is either cell-level or BWP-level in CA [11]

Given there is a majority for option 1, the following is proposed:

**Proposal 6a**: From network perspective, 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.

From a UE perspective, [7, 19] discusses whether DTX/DRX can be configured and operated per MAC entity (i.e. for all serving cells) or per serving cell. In legacy UE DRX, DRX is modelled and maintained per MAC entity configured. With the number of serving cells going up to 16, having DTX/DRX maintained by the UE requires multiple simultaneous DRX cycles. The two following options are thus possible:

* Option 1: From a UE perspective, Cell DTX/DRX is maintained per MAC entity (i.e. for all serving cells), as in legacy [7]
* Option 2: From a UE perspective, Cell DTX/DRX is maintained per serving cell and multiple UE DRX cycles/confgurations can be active at the same time in CA operation [19]

**Proposal 6b**: From a UE perspective, RAN2 discuss the following options for DRX maintenance:

* Option 1: Cell DTX/DRX is maintained per MAC entity (i.e. for all serving cells), as in legacy.
* Option 2: Cell DTX/DRX is maintained per serving cell and multiple UE DRX cycles/confgurations can be active at the same time in CA operation.

## Detailed information configured per DTX/DRX pattern

The following information details are proposed to be configured per cell DTX/DRX pattern:

1. periodicity [4, 10, 11, 16, 18, 20]
2. start slot/offset [4, 10, 11, 16, 18, 20]
3. active period (e.g. on duration) [4, 10, 11, 16, 18, 20]
4. A flag that indicates which example of cell DTX is used [20]
5. Related information of WUS signal -if supported- [20]

It is possible to capture some of the configuration details in TR 38.864 or leave them for the normative phase/stage-3 after some further progress is made.

**Question 4: Which of the above DTX/DRX configuration details, if any, should be captured in TR 38.864 or they can be left for the normative phase?**

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| --- | --- | --- |
| Company | Preferred option(s) | Additional comments |
| CATT | 1, 2, 3 | We think these are the minimum information that is safe to capture. More, if any can be addressed in the WI phase. |
| BT | 1, 2, 3, 4 | 1 – 3 is the minimum data  4 is desirable from neighbour NES cells. |

## UE assistance information related to DTX-DRX

The following info is proposed to be added as UE assistance information for DTX/DRX:

1. Indication of UE’s buffer status for UL channel transmissions [15]
2. UE traffic information such as service priority, delay tolerance, data rate, data volume, traffic type, time criticality, and packet size [15]
3. the preferred NW DTX/DRX pattern (i.e., DTX periodicity and DRX periodicity) [17]

It is possible to capture some of the relevant UE assistance information in TR 38.864 or leave them for after some further progress is made.

**Question 5: Which of the above DTX/DRX configuration details, if any, should be captured in TR 38.864 or they can be left for the normative phase?**

|  |  |  |
| --- | --- | --- |
| Company | Preferred option | Additional comments |
| CATT | FFS | It’s too early. It does’nt mean we do not support UAI, but we think it is better to be addressed in the WI. |
| BT | 2, 3 | Options 2 and 3 may be used by NW to adjust its DTX/DRX patterns  Option 1 FFS  For SI phase, perhaps it is enough to say that UAI may be beneficial |

It is proposed in [9] to extend support of DTX/DRX to group UEs in inactive/idle states for paging. Per the agreement last meeting, “Let’s start with understanding solution in the context of connected”, that impact on Idle/Inactive UEs can be considered later once further details are understood for DTX/DRX in connected mode. Further paging related enhancements can be discussed in AI 8.3.3.

# Conclusion

This is summary document for agenda 8.3.2. This document summarizes proposals in the referenced papers and related offline discussion.

During the [PRE] phase of the meeting, the following is proposed based on the summarized proposals:

**Proposal 1** Clarify previous agreement to: periodic cell DTX/DRX pattern is configured by RRC and can be activated by L1/L2 signalling.

**Proposal 2** Capture in TR 38.864 that both UE specific and group common signalling can be considered for activating the DTX/DRX pattern, per the agreement in 119b-e.

**Proposal 3:** Cell DTX and Cell DRX modes can be configured and operated separately (e.g. one RRC configuration set for DL and the other set for UL).

**Proposal 4:** Proper network configuration of cell DTX and UE DRX can ensure the alignment between cell DTX and UE DRX, with the aim to maximize energy savings and align DRX for multiple UEs in the cell. No additional RAN2 impacts or enhancements are foreseen.

**Proposal 5**: It is up to NW implementation whether to allow or bar legacy UEs to access cells with Cell DTX/DRX.

**Proposal 6a**: From network perspective, 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.

**Proposal 6b**: From a UE perspective, RAN2 discuss the following options for DRX maintenance:

* Option 1: Cell DTX/DRX is maintained per MAC entity (i.e. for all serving cells), as in legacy.
* Option 2: Cell DTX/DRX is maintained per serving cell and multiple UE DRX cycles/confgurations can be active at the same time in CA operation.

The draft TP in Appendix B captures the above proposals.

During the [AT] phase of the meeting, the following is proposed:

TBD

# References

1. [RP-213554](http://ftp.3gpp.org/tsg_ran/TSG_RAN/TSGR_94e/Docs/RP-213554.zip), “Study on network energy savings for NR”, Huawei.
2. R2-2211067, “TP on Cell DTX DRX to TR 38.864”, Huawei/Apple.
3. R2-2211066, “Report of [POST119bis][303][NES] TP on NW DTX/DRX”, Huawei/Apple.
4. R2-2211443, “Remaining issues on Cell DTX/DRX”, CATT
5. R2-2211586, “NES Network DTX and DRX Mechanism”, Qualcomm
6. R2-2211664, “discussion on cell DTX/DRX”, vivo
7. R2-2211679, “Further discussion on Cell DTX / DRX”, Apple
8. R2-2211774, “Further details on Cell DTX/DRX”, Nokia, Nokia Shanghai Bell
9. R2-2211920, “Discussion on idle and inactive state UE grouping for NES gNB DTX”, Sony
10. R2-2211953, “Discussion on DTX/DRX mechanism”, OPPO
11. R2-2212058, “Discussion on DTX/DRX for NES”, Samsung
12. R2-2212113, “Considerations of Cell DTX and DRX”, Intel Corporation
13. R2-2212182, “Supporting multiple DTX configuration”, ZTE Corporation, Sanechips
14. R2-2212314, “Further aspects on Cell DTX/DRX”, Ericsson
15. R2-2212324, “Cell DTX/DRX”, InterDigital
16. R2-2212569, “Cell DTX/DRX related issues”, ETRI
17. R2-2212792, “Assistance information for NW DTX/DRX”, NTT DOCOMO INC.
18. R2-2212840, “Recommendations for DTX/DRX mechanism”, MediaTek Inc.
19. R2-2212851, “Discussion on DTX/DRX mechanism”, LG Electronics Inc.
20. R2-2212869, “Discussion on cell DTX Huawei”, HiSilicon Late

# Appendix A: R2#119bis-e Agreements on DTX/DRX

=> Let’s start with understanding solution in the context of connected

• Example 1: gNB is expected to turn off all transmission and reception for data traffic and reference signal during Cell DTX / DRX OFF duration.

• Example 2: gNB is expected to turn off its transmission / reception only for data traffic during Cell DTX / DRX OFF duration (i.e. gNB will still transmit / receive reference signals).

• Example 3: gNB is expected to turn off its dynamic transmission / reception during Cell DTX / DRX OFF duration (i.e. gNB is expected to still perform periodic transmission / reception, including SPS, CG-PUSCH, SR, RACH, and SRS).

• Example 4: gNB is expected to only transmit reference signals (e.g. CSI-RS for measurement).

=> RAN2 assumes that the options above are possible for gNB DTX/DRX behavior and discuss UE RAN2 behavior/impact during the DTX/DRX.

=> For the purpose of our discussion we will focus on a single UE behavior at any point in time. FFS if we allow multiple configuration of NW DRX/DTX behaviors.

=> Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling.

=> Dynamic L1/L2 group signalling from NW to provide NW DTX mode/configuration is also considered in RAN2

=> It is beneficial to align UE DRX with network DTX and DRX alignment among multiple UEs. Details are FFS, including UE transmission/reception behavior during DTX. RAN2 to study the alignment.

# Appendix B: Draft TP for Cell DTX/DRX

6 Techniques to improve network energy savings

*Editor's note: simulation results to be captured under this section.*

*Editor's note: RAN2 and RAN3 related aspect to be provided by using separate sections like 6.X when applicable.*

6.1 Techniques in time domain

6.1.1 Cell DTX/DRX

6.1.1.x Higher layer procedures

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 RRC signalling. 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 will focus on UE behavior when at any point in time the cell activates a single DTX/DRX configuration. It is up to network implementation whether to allow or bar legacy UEs to access cells with Cell DTX/DRX.

*Editor's note: FFS if multiple sets of Cell DRX/DTX configuration are allowed.*

The Cell DTX mode activation can be indicated to the UE via dynamic L1/L2 signalling. Both UE specific and group common signalling can be considered for activating the 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).

It is beneficial to align UE DRX with Cell DTX and DRX alignment among multiple UEs. Proper network configuration of cell DTX and UE DRX can ensure the alignment between Cell DTX and UE DRX, with the aim to maximize energy savings and align DRX for multiple UEs in the cell. No additional RAN2 impacts or enhancements are foreseen.

6.1.1.y Assistance information from UE side

*Editor's note: will be updated once more agreements are made.*

6.1.1.z Impacts on network interfaces

*Editor's note: will be updated once more agreements are made.*