**3GPP TSG-RAN WG2 Meeting #109bis R2-200xxxx**

**Online, April 2020**

**Agenda Item: 6.11.1**

**Source: MediaTek Inc. (Rapporteur)**

**Title: [Post109e#43][PowSav] UE Assistance and RRC open issues**

**Document for: Discussion and decision**

1 Introduction

This document discusses the various open issues on UE assistance and with the Rel-16 version of the RRC specification for power savings. The aim of this discussion is to provide recommendations to resolve them.

2 Known open issues

The open issues discussed in this section are from those listed in [1]. Please note that those issues raised in email discussion Post109e#44 are not listed here.

### Issue#1: Range of reported UAI

We have the following open issue from R2#109e:

*The reported values of UE assistance on reduced bandwidth, cells and MIMO layers for power savings can range up to at least the corresponding value in the current active configuration. FFS if it can be up to UE capability.*

The issue was debated over email discussions 108#39 and AT109e#505 [2][3], with 10 companies indicating that they would prefer a reporting range up to the UE’s capability while 3 companies indicated that they would prefer to limit the reporting range to the current active configuration.

To have a more robust and free-form technical discussion, companies are recommended to provide their input to the table below. In the column on the left, companies can describe scenarios that need to be addressed on this open issue. Companies are encouraged to then provide solutions/arguments in the column on the right to address the corresponding scenario raised.

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| **Scenario to be addressed** | **Discussion on the scenario (indicate your company with your comments)** |
| [CATT] Scenario #1: Blind SCell setup by NW upon new DRB.  A UE has on-going traffic with small data rate and is configured accordingly with e.g. a small bandwidth on a single Serving Cell on FR1. Then the UE requests a new DRB setup to serve a new application. NR is expected to provide a significant improvement in the user experience in terms of throughput and latency. As a result, a typical network implementation of early NR deployments will, upon setting-up a new DRB, activate all configured SCells to serve the associated new application with maximum performance. However, in most cases only a subset of all SCells would be needed and this will consume unnecessary large power, especially from the RF side, considering FR2 SCells involving power-hungry multi-beam antenna systems. | [CATT] In Scenario #1, if the UE cannot indicate its bandwidth and SCell needs associated with the new application, which would necessarily be larger than the current ones, the NW will behave as described in the left column, i.e. activate right away arbitrarily the highest performance, although overkill, bandwidth and SCell configuration. Reporting early the desired absolute configuration upon new DRB setup prevents the NW to allocate a maximum configuration first and then the UE to report a preferred reduced configuration afterwards. This allows saving all UE power spent unnecessarily in the meantime in tracking and measuring FR2 SCells (and associated beams) it does not need. |
| [CATT] Scenario #2: An opposite network implementation to scenario #1 could wait for getting the full picture of the buffer status in DL and/or UL before making a decision to activate appropriate SCells. This incurs some unavoidable delay before making such decision. During this delay, UE still needs to consume power, e.g. PDCCH monitoring, measurements and so on while not taking profit of the appropriate SCells setup for the requesting application e.g. file download or upload. | [CATT] Same as for scenario #1, if the UE cannot indicate its bandwidth and SCell needs associated with the new application, which would necessarily be larger than the current ones, the NW will behave as described in the left column incurring unnecessarily delay in setting up the appropriate configuration, and thus power consumption. |
| [CATT] Scenario #3: A UE is configured with both FR1 and FR2 SCells for a given application. The UE gets into a power limited mode (e.g. low battery) and would therefore prefer to abandon FR2 power-hungry SCells in favor of an augmented configuration in FR1 SCells. | [CATT] This scenario can be addressed only if the UE can report a preferred configuration in FR1 which is “augmented” compared with current configuration and a reduced configuration on FR2 SCells.  [QCM] We agree with CATT that this scenario can happen but can’t be addressed if UE is only allowed to request up to its current configuration. |
| [QCM] Scenario #4: Suppose UE has been running on battery and operating in low-power mode. After it is plugged in an outlet, it wants to switch out of low power mode and adjust its radio resource configuration for higher throughput. | [QCM] In this scenario, there is no easy way for network to learn that UE has changed its power source and wants to increase its bandwidth etc. If UE is restricted to request only up to its current configuration, currently there is no other way for UE to signal this change in its power saving preference.  On network side, if a network implementation can’t handle UE requests beyong its current configuration, it can simply not accept such requests. |

### Issue#2: Reporting UAI for a frequency range for which no cells are configured

*A UE can report a preferred aggregated bandwidth for a frequency range on the configured serving cell. FFS if it is allowed even if it is not configured with serving cells on that frequency range*

Similar to Issue#1, this issue was debated over email discussions 108#39 and AT109e#505 [2][3], with 10 companies indicating that they would prefer a reporting range up to the UE’s capability while 3 companies indicated that they would prefer to limit the reporting range to the current active configuration.

To have a more robust and free-form technical discussion, companies are recommended to provide their input to the table below similar to Issue#1 above.

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| **Scenario to be addressed** | **Discussion on the scenario (indicate your company with your comments)** |
| [CATT] Scenario #1: same as for issue #1 | [CATT] If the UE is not configured with FR2 SCell (not needed for current on-going traffic) it cannot indicate a preferred FR2 SCell configuration, and the NW will behave as described in the left column, i.e. activate right away arbitrarily the highest performance, although overkill, FR2 SCell configuration. Reporting early the desired absolute configuration upon new DRB setup prevents the NW to allocate a maximum configuration first and then the UE to report a preferred reduced configuration afterwards. This allows saving all UE power spent unnecessarily in the meantime in tracking and measuring FR2 SCells (and associated beams) it does not need |
| [CATT] Scenario #2: same as for issue #1 | [CATT] Same as for scenario #1, if the UE cannot indicate its FR2 bandwidth and SCell needs associated with the new application, the NW will behave as described in the left column incurring unnecessarily delay in setting up the appropriate configuration, and thus power consumption |
| [QCM] Scenario #3: same as Scenario #4 that we described in Issue #1 | [QCM] Please see our comment on Scenario #4 in Issue #1. |
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### Issue#3: Intepretation of fields when not reported

*All fields in the minSchedulingOffsetPreference and DRX-Preference IEs in the UE assistance information message are optional fields. FFS what it means when the UE omits the values.*

With regards to the interpretation of omitted IEs (e.g. drx-preference, maxBW-preference etc.) within a UAI report, the current implementation for power savings is aligned with the agreements from the main session in R2#108 on UAI reporting (see approved CR R2-1916632).

The open issue is the NW’s interpretation of the UAI report, when fields within an IE are omitted from the report (preferredDRX-ShortCycle is omitted from the drx-preference IE, or preferredK0/2 is omitted from the minSchedulingOffsetPreference IE). In [2], one company pointed out that it is dependent on whether this is the first instance that a UAI is sent or one that follows an earlier report. Accordingly the discussion below is split to consider how the NW interprets a UAI in each of these scenarios.

**Interpretation when fields within an IE (e.g. preferredDRX-ShortCycle in a drx-Preference IE, or preferredK0/2 in a minSchedulingOffsetPreference IE) are omitted from a UAI report**

***Scenario A: The UE has not provided a preference for the field since UAI was configured***

*How does the NW intepret the UAI received, when it does not include the field?*

*Option 1. UE does not have a preference for this field  
Option 2. Other (please specify)*

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| --- | --- | --- |
| **Company** | **Preference** | **Comments (if any)** |
| Qualcomm | Option 1 |  |
| CATT | Option 1 |  |
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***Scenario B: The UE has previously provided a preference for the field in a UAI***

*How does the NW intepret the UAI received, when it does not include the field?*

*Option 1. UE does not have a preference for this field  
Option 2. UE does not want to change its preference from the previously reported preference  
Option 3. Other (please specify)*

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| **Company** | **Preference** | **Comments (if any)** |
| Qualcomm | Option 2 |  |
| CATT | Option 1 | It is aligned with the behavior in Scenario A (i.e. when the UE has not provided a preference for the field since UAI was configured.) |
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### Issue#4: Release Preference IE structure

As per the current implementation of release preference reporting in RRC, once the UE is configured with UAI for release preference, the UE reports a *releasePreference* **only** when it prefers to leave RRC connected mode. Thereafter, it can report *releasePreference* again in case of a change of its preference (i.e. back to connected).

During email discussion 108#39, two options for the release preference IE structure had most support and are listed out below:

*Option 1: Preferred state is always reported, and indicates idle, inactive, connected and out of connected, i.e.*

preferredRRC-State-r16 ENUMERATED {idle, inactive, connected, out of connected}

*Option 2: Release indication and preferred RRC state are separately indicated, i.e.*

releaseIndication-r16 ENUMERATED {connected, out-of-connected} OPTIONAL,

preferredRRC-State-r16 ENUMERATED {idle, inactive} OPTIONAL

Option 1 is aligned with the current implementation described above. Option 2 raises a new open issue on the interpretation of a *releasePreference* IE that only includes *preferredRRC-State*. Companies are asked to provide their preference between the two options above. If Option 2 is preferred, please also include your interpretation of a *releasePreference* IE that only includes *preferredRRC-State*.

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| **Company** | **Option 1/2** | **Comments (if any)** |
| Qualcomm | Option 2 | Option 1 only allows UE to indicate its preference for Idle/Inactive state when it requests connection release. UE has no way to indicates its state preference when its connection release is initiated by network.  This limitation of Option 1 can be avoided if preferred RRC state and connection can be indicated independently (i.e. Option 2). More specifically,   * If both ReleaseIndication and PreferredRRC-state are present, it means UE is requesting a connection release and a preferred RRC state after the release; * If only ReleaseIndication is present, UE is not asking for a connection release at the moment and the indicated preference is only for later when network releases UE’s connection; * If only ReleaseIndication is present, it means UE is requesting a connection release without any preference for its RRC state after the release. |
| CATT | Option 1 | It’s simple and clear. There is no agreement that UE can indicate its preference on RRC non-connected state only without a connection release request. |
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### Issue#5: NR SCG release preference

*UE implicitly can indicate a preference for NR SCG release by indicating zero number of carriers or zero aggregated maximum bandwidth in both FR1 and FR2.*

The agreement above is currently captured in TS 37.340 [4]. A suggestion was made at R2-109e to also capture the text above as a Note in the RRC specification as a clarification to the reader. Example text is provided below:

***NOTE: If the UE is in (NG)EN-DC, it can indicate a preference for NR SCG release by indicating zero maximum number of secondary component carriers, or zero maximum aggregated bandwidth in both FR1 and FR2.***

*Do companies support the inclusion of a Note as above into the RRC specification?*

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| **Company** | **Yes/No** | **Comments (or text modification suggestions, if any)** |
| Qualcomm | Yes | We think this note is both necessary and useful to have, especially for developers who may read only 38.331 for their work (developers typically do not read stage-2 specs, or at least not as carefully as they would read 38.331). As simple and a bit redundant as it may seem, it can help developers who are not aware of this agreement know how UE can request SCG release, without potential misinterpretation or second guessing.  Ps. A number of notes in 331 are added for the same reason (e.g. Note 1 on RRC reconfiguration with sync). So there is precedence for adding such a note. |
| CATT | Yes | Agree with Qualcomm. |
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### Issue#6: Whether flags *ps-TransmitPeriodicL1-RSRP/CSI* are defined per cell group or per CSI report configuration

An open issue from the last meeting was whether the *ps-TransmitPeriodicL1-RSRP* and *ps-TransmitPeriodicCSI* flags were to be defined per cell group or per CSI report configuration. The updated parameter list from R1 [5] does not provide a recommendation. It is therefore recommended that we conclude on this open issue in R2.

*Which option do companies support regarding the definition of the ps-TransmitPeriodicL1-RSRP/CSI flags?*

*Option 1: Defined per cell group (no change to the RRC CR)  
 Option 2: Defined per CSI configuration*

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| **Company** | **Option 1/2** | **Comments (if any)** |
| Qualcomm | Option 2 | Our view is that we need only a single flag configured per CSI-reportConfig and that can help avoid unnecessary CSI reports when UE has no data. The reason behind our preference is that  - The need for CSI report (L1-RSRP in particular) is different between active traffic and no traffic. When there is active traffic, narrow beams with high gains are used to maximize throughput. So frequent CSI reporting is needed to maintain not-so reliable narrow beams. On the other hand, when there is no traffic, UE only needs to maintain its PDCCH beam, which typically is more robust and requires less frequent beam management. So CSI reporting can be much less frequent.  - To support different CSI reporting frequencies based on traffic, we can either introduce sparse reporting when UE has no data (unfortunately it was not agreed in the last meeting), or configure CSI reporting per CSI, e.g. set CSI reporting flag to TRUE for low frequent CSIs intended for PDCCH beams but set CSI reporting flag to FALSE for high frequent CSIs intended for PDSCH beams. Obviously, we can’t achieve such behavior if CSI reporting flag is configured per UE. |
| CATT | Option 1 | Option 1 is simple. Option 2 can be achieved via network implementation, e.g. the network can configure frequent CSIs as SPS CSI reporting and infrequent CSIs as periodic CSI reporting to reduce UE power consumption. |
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3 Known open issues related to SCG specific UAI

In this section we discuss the open issues related to the agreements on SCG specific UAI.

*In MR-DC with NR SN, support SCG specific UAI for power saving, which includes drx-Preference, maxBW-Preference, maxCC-Preference, maxMIMO-LayerPreference, and minSchedulingOffsetPreference.*

*UE transmits SCG specific UAI for power saving in a transparent container to the MN and the MN then forwards the received container to the NR SN. FFS if UAI can also be reported for power saving directly via SRB3 if configured. FFS on the signalling details.*

### Issue#7: Reporting SCG specific UAI for power saving via SRB3

*Do companies support the reporting of SCG specific UAI for power saving via SRB3?*

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| **Company** | **Yes/No** | **Comments (if any)** |
| Qualcomm | Yes | If SRB3 is configured and supported by UE. |
| CATT | Yes | The MN does not need to be aware of SCG specific UAI for power saving. Hence, if SRB3 is configured, the UE can report SCG specific UAI for power saving via SRB3 directly. |
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### Issue#8: SCG specific UAI for power saving in (NG)EN-DC

*How does the network configure the UE to report SCG specific UAI for power savings in case of (NG)EN-DC?*

*Option 1: Include the NR UAI configuration in RRCConnectionReconfiguration on the LTE leg, (i.e. otherConfig is included in nr-SecondaryCellGroupConfig)  
Option 2: Include the NR UAI configuration in RRCReconfiguration on the NR leg using SRB3  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 1 | Option 2 can also be used if SBR3 is configured |
| CATT | Option 1&Option2 | If SRB3 is configured, the network can include the NR UAI configuration in *RRCReconfiguration* via SRB3 directly.  If SRB3 is not configured, the NR SN generate *RRCReconfiguration* message which includes the NR UAI configuration. Then the LTE MN transfers the received RRC message for SCG configuration transparently to the UE via RRCConnectionReconfiguration message (i.e. *otherConfig* is contained in *mrdc-SecondaryCellGroup* in *RRCConnectionReconfiguration* message.) Actually, in option 1, the NR UAI configuration is also included in *RRCReconfiguration* but transferred on the LTE leg. |
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*How does the UE report the SCG specific UAI for power savings in case of (NG)EN-DC?*

*Option 1: Include the NR UEAssistanceInformation in ULInformationTransferMRDC on the LTE leg  
Option 2: Transmit UEAssistanceInformation on the NR leg using SRB3  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 1 | Option 2 can also be used too if SBR3 is configured |
| CATT | Option 1&Option 2 | If SRB3 is configured, the UE can transmit *UEAssistanceInformation* via SRB3 directly.  If SRB3 is not configured, the UE transmits the *UEAssistanceInformation* message via the E-UTRA MCG embedded in E-UTRA RRC message *ULInformationTransferMRDC*. The MCG forwards the received info transparently to the SCG. |
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### Issue#9: SCG specific UAI alongside NR-DC

As our agreement was for MR-DC with NR SN, the implication is that SCG specific UAI for power saving is supported in NR-DC as well. However, the UAI report in NR-DC (for all cases, including power saving) is across both cell groups, i.e. it is for NR cells across both the MCG and the SCG. We therefore need to discuss the configuration, reporting and interpretation of the UAI in NR-DC.

*Do companies support the reporting of SCG specific UAI for power saving for NR-DC?*

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| **Company** | **Yes/No** | **Comments (if any)** |
| Qualcomm | Yes |  |
| CATT | Yes | Some UE assistance info, e.g. *maxBW-Preference, maxCC-Preference, maxMIMO-LayerPreference*, can be CG specific or across both cell groups. However, some UE assistance info (i.e. *drx-Preference* and *minSchedulingOffsetPreference*) is CG specific reporting. For example: DRX configuration is CG specific configuration. The MCG and the SCG may serve totally different traffic types. Then the preferred DRX configurations are different the MCG and the SCG. If the UE only reports preferred DRX configurations across both cell groups, inappropriate DRX configurations may be configured by the network. E.g. short DRX configurations are suitable for traffics on the SCG. If the UE reports preferred short DRX configurations across both cell groups, inappropriate short DRX configurations may be configured by the MCG. If the UE doesn’t report preferred short DRX configurations, short DRX configurations may not be configured by the SCG. Considering all UE assistance info can be CG specific, we propose the UE to report CG specific UAI (not across both cell groups) for power saving for NR-DC. |
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If the answer to the above question is yes, then the following questions need to be addressed.

*In NR-DC, what does the UE report on the MCG, when UAI for power saving is configured on the MCG as well as on the SCG?*

*Option 1: The UAI includes assistance information across MCG and SCG  
Option 2: The UAI includes assistance information specific to MCG only  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 3 | The UAI includes assistance information specific to either MCG or SCG.  In our view, in many scenarios power saving is a procedure more specific to a MAC entity than UE. Therefore, UE should have the flexibility to indicate its preference specific to a cell group. |
| CATT | Option 3 | The UAI reporting is CG specific. The MCG doesn’t need to be aware of UAI for the SCG. Thus:  - For UAI for MCG, the UE reports it to the MCG directly.  - For UAI for SCG, the UE reports it to the SCG via SRB3 directly if SRB3 is configured while the UE reports it to the MCG via SRB1 (i.e. the *UEAssistanceInformation* message is embedded in NR RRC message *ULInformationTransferMRDC*) which is forwarded to the SCG via the MCG transparently if SRB3 is not configured. |
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*In NR-DC, what does the UE report on the MCG, when UAI for power saving is configured on the MCG only?*

*Option 1: The UAI includes assistance information across MCG and SCG  
Option 2: The UAI includes assistance information specific to MCG only  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 2 |  |
| CATT | Option 2 | As mentioned above, UAI is CG specific. If UAI for power saving is configured on the MCG only, it means the network wants to know the UE preference configurations on the MCG only. |
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*How does the network configure the UE to report SCG specific UAI for power savings in case of NR-DC?*

*Option 1: Include the NR UAI configuration in RRCReconfiguration on SRB1, (i.e. otherConfig is included in mrdc-SecondaryCellGroup)  
Option 2: Include the NR UAI configuration in RRCReconfiguration on SRB3  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 1 |  |
| CATT | Option 1&Option 2 | If SRB3 is configured, the network can send *RRCReconfiguration* message which includes *otherConfig* via SRB3 directly.  If SRB3 is not configured, similar to the case of (NG)EN-DC, the NR UAI configuration is included in *RRCReconfiguration* generated by the SCG. Then the message is contained as *mrdc-SecondaryCellGroup* in *RRCReconfiguration* of the MCG and sent via SRB1, i.e. *otherConfig* is included in *mrdc-SecondaryCellGroup*. |
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*How does the UE report the SCG specific UAI for power savings in case of (NG)EN-DC?*

*Option 1: Include the NR UEAssistanceInformation in ULInformationTransferMRDC on SRB1  
Option 2: Transmit UEAssistanceInformation on the NR leg using SRB3  
Option 3: Other (please specify)*

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| **Company** | **Preference(s)** | **Comments (if any)** |
| Qualcomm | Option 1 |  |
| CATT | Option 1&Option 2 | It is similar to the case of (NG)EN-DC.  If SRB3 is configured, the UE can transmit *UEAssistanceInformation* via SRB3 directly.  If SRB3 is not configured, the UE transmits the *UEAssistanceInformation* message via the NR MCG embedded in NR RRC message *ULInformationTransferMRDC*. The MCG forwards the received info transparently to the SCG. |
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4 Other open issues

Please use the table below to list out other issues that companies would like to raise for further discussion

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| **Issue ID (e.g. M#1)** | **Description** |
| M#1 | The intention of per-BWP DL MIMO layers configuration is that UE adaptation of the number of Rx antennas provides power saving gains. For example, if per-BWP DL MIMO layers are re-configured to 2 layers from 4 layers, the power consumption is reduced if UE switches to 2 Rx antennas from 4 Rx antennas. Thus, there is an underlying relationship between maximum DL MIMO layers and Rx antennas. UE should be allowed to turn on the same number of Rx antenna(s) in a DL BWP as the maximum number of DL MIMO layers indicated per BWP, and this is expected to be captured in the spec to provide an instruction for UE implementation.  So the following NOTE is preferred to be added in the field description for *maxMIMO-Layers*.  NOTE: When the maximum MIMO layers configured for a DL BWP is N, the UE may use N antenna connector(s) for the reception of PDSCH on the DL BWP.  [QCM] For any given DL MIMO configuration, It has always been up to UE implementation how many Rx antenna to use. There is no need to add such a note to define coupling between them.  [CATT] We have the same understanding as Qualcomm. |
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5 Conclusion

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6 References

1. R2-2002383 - RAN2#109e agreements and remaining Issues for Power Saving (CATT)
2. R2-2001914 - [AT109e][505][Pow] Email discussion on open issues on UE assistance (Qualcomm)
3. R2-2001912 - Email discussion summary on running 38.331 CR for Power Saving (Mediatek)
4. R2-2002387 - CR for supporting UE Power Saving in TS 37.340 (Oppo)
5. R1-2001478 - Updated consolidated parameter list for Rel-16 NR (Qualcomm)