**3GPP TSG RAN meeting #93-e RP-21XXXX**

**Electronic Meeting, September 13 - 17, 2021**

## Status Report to TSG

**Agenda item:** 9.3.2.3 UE power saving enhancements for NR [RAN2 WI: NR\_UE\_pow\_sav\_enh]

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| **WI / SI Name** | UE power saving enhancements for NR | | | | |
| included in this status report | Study Item:  - | Core part:  Yes | Performance part:  No | | Testing part:  - |
| **Acronym** | NR\_UE\_pow\_sav\_enh | | | | |
| **Unique ID** | 860047 | | | | |
| **TSG Tdoc of latest approved WI/SI description (if any)** | RP-200938 | | | | |
| **Target Completion Date**  **(indicate if changed)** | Study Item:  - | Core part: 03/2022 | Performance part: 09/2022 | Testing part:  - | |
| **Overall Completion level** | Study Item:  - | Core part:  Overall: 65% | Performance Part: Overall: 0% | Testing part:  - | |

Note: Overall completion level percentage numbers should use one of the colors below:

* xx%: Normal progress, no RAN plenary action needed
* xx%: Progress behind schedule, may need RAN plenary intervention. If so, SR should clearly define requested action
* xx%: Progress critically behind, RAN plenary shall intervene. SR should define requested action

**Source:**

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| **Leading WG** | | RAN2 |
| **Rapporteur** | **Name** | Weide Wu |
| **Company** | MediaTek Inc. |
| **Email** | weide.wu@mediatek.com |

## 1 Work plan related evaluation

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| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

*If you answered No: Then please remove the Excel file from the zip file of this status report.*

*If you answered Yes: Then please fill out the attached Excel template to request a modification of the time budgets for your WI /SI. The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI. The basis are the endorsed time budgets of the last RAN meeting. Please highlight all changes of the values.  
 One time unit (TU) corresponds to ~ 2 hours in the meeting.  
 If this status report covers a WI with Core and Performance part, then please have one line for each in the attached Excel table.  
 Note: If no Excel table is attached, then this means no time budget change.*

**Additional explanations/motivations for the time budget changes in the attached Excel table: N/A**

## 2. Detailed progress in RAN WGs since last TSG meeting (for all involved WGs)

NOTE: Agreements and Open issues impacted cross-TSG aspects shall be explicitly highlighted

## 2.1 RAN1

#### 2.1.1 Agreements

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| **Relating to scope item 1) – a):**   1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]    1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]  * NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting   **The following agreements are achieved:** |
| **RAN1 #106-e meeting**  Conclusion   * For the evaluation of PEI candidate designs (for which observations made in previous RAN1 meetings), it was implicitly assumed by companies that the following processing can also provide synchronization:   + Processing of SSB(s) of each DRX cycle for serving-cell measurement   + Detection of multi-symbol SSS PEI (s)when transmitted   + Detection of TRS/CSI-RS PEI(s) when transmitted   Note: SSS PEI is assumed to reuse the SSS structure as in legacy SSB  Conclusion  To down-select one solution for PEI physical-layer channel/signal in RAN1 #106-e,   * PDCCH-based PEI * SSS-based PEI |
| **Relating to scope item 1) – b):**   1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]    1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]  * NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required   **The following agreements are achieved:** |
| **RAN1 #106-e Meeting**  Agreement  Support at least one of the following alternatives   * Alt1: L1 availability indication at an occasion provides availability/unavailability information only for RS resources with the same QCL reference as the L1 availability indication occasion. * Alt2: L1 availability indication at an occasion can provide availability/unavailability information for RS resources with QCL references not confined to be the same as for the L1 availability indication occasion   Note:  The occasion mentioned above refers to a signal/channel monitoring occasion (e.g. a paging PDCCH or PEI monitoring occasion) to provide the L1 availability indication.  Note: a RS resource is a RS from configured TRS/CSI-RS occasion(s) for idle/inactive UEs., where the configuration for TRS/CSI-RS occasion(s) for idle/inactive UEs is based on periodic TRS only.  Agreement  L1 based availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs is valid for a time duration starting from a reference point, where   * the time duration can be determined based on at least one from the following (to be down-selected):   + Alt-1: configured by higher layer   + Alt-2: a predefined/configured window   + Alt-3: value indicated by the availability indication, where the value is one of multiple configured time duration(s)   + Alt-4: until when the UE receives another availability indication   + A combination of alternatives or other alternatives is not precluded. * the reference point can be determined as at least one from the following (to be down-selected):   + Alt-1: start of next PO or DRX cycle   + Alt-2: time location where UE receives the indication     - Note: the time location is subject to application delay if agreed   + Alt-3: start of current PO or DRX cycle where UE receive the indication   + Alt-4: a time location which is configured by higher layer   + A combination of alternatives or other alternatives is not precluded.   **Agreement**  For a RS resource configured for TRS/CSI-RS occasion(s) for idle/inactive UEs, a quasi co-location type can be determined as   * + ‘typeC’ with an SS/PBCH block and, when applicable, ‘typeD’ with the same SS/PBCH block |
| **Relating to scope item 2) – a):**   1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]    1. Study and specify, if agreed, extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time for an active BWP, including PDCCH monitoring reduction when C-DRX is configured [RAN1]  * NOTE: Rel-15 and Rel-16 available power saving solutions should be supported by the UE and included in the evaluation. RAN1 will ask the confirmation from RAN2 that Rel-15 and Rel-16 available power saving solutions are properly utilized.   **The following agreements are achieved:** |
| **RAN1 #106-e Meeting**  Agreement   * At most 2 bit indication in self-scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) can be specified for triggering the PDCCH monitoring adaptation in a single cell   + FFS: the bit size of the indication is configurable   + FFS: bit mapping to the PDCCH monitoring behaviour   + FFS: details of indication of multiple cells case   Agreement  Select either package 1 or package 2  Package 1         UE behavior after receiving PDCCH indication of monitoring adaptation can be one of the followings,   * + - Working Assumption: Beh 1: PDCCH skipping is not activated     - Beh 1A: PDCCH skipping means stopping PDCCH monitoring for a duration X       * FFS the possible values for X       * FFS: Whether and how to support more than one skipping duration(s)       * FFS: whether to continue monitoring PDCCH scrambled by C-RNTI for Type 0/1/1A/2 CSS or not     - Beh 2: stop monitoring SS sets associated with SSSG#1 and SSSG#2 (if confirmed) and monitoring  of SS sets associated to SSSG#0 (legacy behaviour)     - Beh 2A: stop monitoring SS sets associated with SSSG#0 and SSSG#2 (if confirmed)  and monitoring  of SS sets associated to SSSG#1 (legacy behaviour)     - Working Assumption: Beh 2B(if confirmed): stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring  of SS sets associated to SSSG#2 (if confirmed)          Note: The number of supported SSSG is left to UE feature discussion.         FFS: UE capability of supported UE behaviors         Indication of Beh 1A when SSSG(s) are not configured is supported.         Working assumption: Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported         FFS: Indication of Beh 1A when three SSSG(s) (if supported) are configured         Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating PDCCH schedules data and also PDCCH monitoring adaptation   * + - FFS how the UE behavior(s) defined above mapping to Y bits     Note: at most Y = 2         Working Assumption at most 3 SSSGs is supported to be configured.   * + - FFS: whether or how SSSG can be configured to be monitored conditionally (e.g., depending on HARQ NACK or RTT/ReTx timers)     - FFS: whether or how non-default SSSG to another non-default SSSG          FFS details of timer(s) for switching between SSSG(s)   * + - UE fallbacks to default SSSG (i.e., SSSG#0) after timer expiration.     - R16 timer for SSSG switching and the corresponding behavior is as baseline          FFS whether the timer(s) is configured per SSSG, ~~or~~per BWP or other approaches.         FFS whether the skipping duration(s) is configured per SSSG, per BWP, or other approaches.         FFS PDCCH monitoring adaptation indicated by non-scheduling DCI         PDCCH based monitoring adaptation is ~~limited~~applied to USS and type-3 CSS.    Package 2 (Alt 1 and Alt 2)   * If alt 1 is supported,   + supporting SSSG  switching to emulate PDCCH skipping functionality by an ‘empty’ SSSG (i.e. Alt 1-1)or ‘dormant’ SSSG(i.e. Alt 1-2)     - Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating SSSG index.       * FFS dynamic indication of ~~initial~~ timer value(s)       * FFS details     - At most [3] SSSGs is supported to be configured.       * Note: including‘empty’ SSSG or ‘dormant’ SSSG     - ~~FFS support of single timer to switch to default SSSG#0  or support of multiple timers between SSSGs~~     - FFS whether one or more of the following timer(s) is supported for switching between       * Option 1: Non-default SSSG to default SSSG (i.e., SSSG#0)       * Option 2: Non-default SSSG to another non-default SSSG       * Option 3: Default SSSG (i.e., SSSG#0) to non-default SSSG(s)     - FFS: down selection between ‘empty’ SSSG (i.e. Alt 1-1)or ‘dormant’ SSSG(i.e. Alt 1-2)     - ~~FFS: whether ‘empty’ SSSG and ‘dormant’ SSSG, can be looked as a skipping duration and whether to introduce a SSSG state.~~     - FFS: whether the timer is configured per SSSG, per BWP, or other approaches.     - ~~FFS: whether multiple timer duration(s) can be configured by RRC, and DCI dynamically indicates a timer duration~~     - ~~FFS: do we need to define default SSSGs and for what purpose?~~     - Note: description of ‘empty’ SSSG and ‘dormant’ SSSG has been provided in RAN1#105-E * If alt 2 is supported,   + PDCCH schedules data and also indicates PDCCH monitoring adaptation by PDCCH skipping for a duration is supported.     - Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating PDCCH monitoring adaptation ~~(including  SSSG index, and/or PDCCH skipping duration(s))~~       * ~~Alt 2-1:~~         + FFS: Determination of the duration for PDCCH skipping, e.g.,   One skipping duration configured by RRC signaling,  Multiple candidate values of skipping duration configured by RRC signaling and use DCI to dynamically indicate one of the configured skipping duration  by specification   * + - * + FFS: possible value(s) of the duration         + FFS: joint or separate indication with SSSG switching       * ~~Alt 2-3:~~         + FFS: whether introduce SSS/SSSG specific skipping indication via e.g. bitmap, codepoint, joint indication with a minimum scheduling offset value     - FFS: whether the skipping duration is configured per SSSG, per BWP, or other approaches.     - FFS: PDCCH skipping indicated by non-scheduling DCI     - FFS: interaction with SSSG switching (when configured), e.g. impact to skipping when SSSG timer expires, which SSSG after PDCCH skipping is monitored, etc.   Agreement  package 1 in above agreement is selected. |

#### 2.1.2 Remaining open issues

RAN1 continues discussing and deciding the physical layer details for idle/inactive-mode and connected-mode power saving enhancements. In particular, the following are the remaining open issues:

* For scope item 1) - a):
  + Decision on PEI physical-layer channel/signal, taking into account the chair’s note of RAN1#106-e below. Rapporteur suggests RAN Plenary decision to facilitate RAN1 progress for this scope item.

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| Proposed Working Assumption   * PDCCH-based PEI   Supported by 20 companies, but can not be accepted by 3 companies, i.e., Intel, CATT, Sony. |

* + Specify details for subgroups indication with PEI and/or paging DCI
  + Specify PEI monitoring occasion (MO) determination and UE paging monitoring behaviour with PEI (Behv-A and/or Behv-B), taking into account multi-beam operation and whether and how to support multiple PEI MOs per PO and/or unlicensed operation with LBT
  + Specify remaining details for the PEI physical-layer channel/signal if decided
* For scope item 1) - b):
  + Specify how gNodeB indicates the availability of configured TRS/CSI-RS occasion(s) for idle/inactive UEs based on at least physical layer signaling
  + Specify configuration structure of RS resources in TRS/CSI-RS occasion(s) for idle/inactive UEs
* For scope item 2) - a):
  + Specify details for Package 1 selected in RAN1#106-e.
  + Discuss and decide
    - Remaining issues for scheduling DCI based PDCCH monitoring adaptation
    - Whether and how to minimize impact to data scheduling (for new transmissions and retransmissions)
    - Application delay
    - Other mechanism (if support), e.g., non-scheduling DCI, implicit indication, etc.

## 2.2 RAN2

#### 2.2.1 Agreements

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| **Relating to scope item 1) - a)**   1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]    1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]  * NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting   **The following agreements are achieved:** |
| RAN2 #115-e Meeting   * When AMF has assigned a UE with a Paging subgroup, some NAS signaling should be supported between AMF and UE to convey the related information to the UE. Exact information is FFS. The design and procedure are up to SA2/CT1. * When AMF has assigned a UE with a Paging subgroup, some signaling should be supported between AMF and gNB(s) to inform gNB(s) about the related subgroup information for paging a UE in RRC\_IDLE/RRC\_INACTIVE. Exact information is FFS. The message(s) and associated design are up to RAN3. * It is FFS when a UE in RRC\_INACTIVE has been assigned by CN a Paging subgroup, whether some signaling should be introduced between gNBs to inform each other about the UE’s subgroup for RAN paging. * If RAN2 agrees to support UE assistance information to CN in support of Paging subgroup assignment, RAN2 will focus on the paging probability and power profile attributes. * UEID-based subgroup method requires, in addition to the already available information for legacy UEID-based grouping in PO, the total number of supported UEID-based subgroups by the network. * At least for UEID-based subgroup method the total number, Nsg, of supported subgroups by the network is decided by RAN and broadcasted in System Information. * At least for UEID-based subgroup method the total number, Nsg, of supported subgroups is controlled on a cell basis and can be different in different cells. * We go with Option 1 (CN assigns subgroup ID) * R2 assumes that All the cells within the registration area supports the same number of CN assigned subgroups, i.e. no remapping of CN assigned group ID to RAN subgroup ID (will revisit only if serious issues are found). * For the purpose of continued discussions, R2 assumes that UE has separate UE caps for CN assigned and UEID based subgrouping, the actual decision to be taken later. * RAN capability is known based on broadcast information. FFS with explicit indication or implicitly based configuration. * [Post115-e][067][ePowSav] LS out (MediaTek)   Scope: LS out to inform about progress to other concerned groups and ask the relevant groups to take this into account and align.  Intended outcome: Approved LS out (**R2-2108917**)  Deadline: Short (not for RP) |
| **Relating to scope item 1) – b):**   1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]    1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]  * NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required |
| RAN2 #115-e Meeting   * The TRS/CSI-RS configuration is provided in a new SIB. * RAN2 assumes that TRS/CSI-RS configurations are broadcasted. Potential addition of dedicated signalling can be discussed in a later meeting based on company contributions. * The legacy SI update procedure is used for changing TRS/CSI-RS configurations. * Postpone the topic about TRS/CSI-RS availability until a later meeting when RAN1 also has progressed. * On demand SI should be possible for the SIB with TRS/CSI-RS information. * Postpone the discussion on segmentation of the new SIB until RAN1 has sent the list of the parameters and a potential structure. * Postpone the discussion on splitting the TRS/CSI-RS information to a common and RS-specific part until RAN1 has sent the list of the parameters and a potential structure. |

#### 2.2.2 Remaining open issues

With the above, the following are remaining issues for idle-mode power saving enhancements in RAN2:

* For scope item 1) – a):
  + Discuss and decide how to handle the use of CN-assigned and UEID-based UE paging subgrouping in RAN
  + Specify configurations and procedures for UE subgrouping as well as paging early indication and/or paging DCI based on RAN1 design
* For scope item 1) – b):
  + Discuss and decide SIB content for TRS/CSI-RS information, based on RAN1 input
  + Discuss and decide, if needed, remaining details, including availability indication, segmentation of SIB, splitting the TRS/CSI-RS information (to a common and RS-specific part), and dedicated signalling, based on RAN1 input

## 2.3 RAN3

#### 2.3.1 Agreements:

Agree that some subgroup information should be sent over NG and F1.

#### 2.3.2 Remaining Open issues: N/A

From RAN2 LS to RAN3 (R2-2108917), the following is the identified open issue related to UE sub-grouping enhancement:

* Whether to use a one-step or two-steps mapping approach
* Whether synchronization is needed between DU and AMF
* Whether some subgroup information should be sent over Xn (e.g. RAN Paging message)
* Whether there is RAN3 impact due to using randomization by UE IDs
* Whether to restrict to last serving cell (e.g. like was for CIOT GWUS)
* Whether we need assistance information from RAN to CN (e.g. RRC Inactive statistics to be combined with idle statistics in AMF).

## 2.4 RAN4

#### 2.4.1 Agreements

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| **Relating to scope item 2) - b)**   1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]    1. Study the feasibility and performance impact of relaxing UE measurements for RLM and/or BFD, particularly for low mobility UE with short DRX periodicity/cycle, and specify, if agreed, relaxation in the corresponding requirements [RAN4]  * NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS   **The following agreements are achieved:** |
| **RAN4 #100-e Meeting**  **Approved: WF on RLM/BFD relaxation for UE Power Saving enhancements (R4-2115348):** **Sub-topic 1 Relaxation applicability** Issue 1-1: Relaxation when neither serving cell quality criteria nor low mobility criteria is configured  When neither serving cell quality criteria nor low mobility criteria is configured, the existing RLM/BFD requirements shall apply.   * Note: It can be revisited if   + dedicated or broadcast signalling to indicate the UE when it is allowed to relax the RLM/BFD measurements is agreed, or   + good serving cell criteria is agreed to be predefined.   Issue 1-2: Whether low mobility criteria is necessary to be configured?   * Option 1: No. It is up to network. * Option 2: Yes.   Issue 1-3: Whether good serving cell criteria is necessary to be configured?   * Option 1: No. It is up to network. * Option 2: Yes.   Issue 1-6: When DRX cycles > 80ms  If the UE applies a DRX cycle longer than 80ms, the UE is assumed not to perform relaxed RLM/BFD measurements and the existing RLM/BFD requirements would apply. **Sub-topic 2 Low mobility criteria**  Issue 2-1: Low mobility criteria   * Agreements:   + Low mobility criteria     - Reuse Rel-16 low mobility criterion based on L3 RSRP measurement variation.       * FFS the RSs for L3 RSRP measurement  **Sub-topic 3 Good serving cell quality criteria** Issue 3-1: SINR definition for good serving cell quality criteria   * + Option 1: reuse the legacy definition of the SINR for radio link quality evaluation of RLM/BFD.   + Option 2: L3-SINR. RSRQ and RSRP can also be used as serving cell quality metric for UE that does not support the optional L3-SINR measurement.   Issue 3-2: predefined or configured threshold   * Option 1: The thresholds are configured to the UE by the network. * Option 2: The thresholds is predefined. * Option 3: The offset values X to UE for deriving the threshold   + Option 3a: The offset values are configured to the UE by the network.   + Option 3b: The offset value(s) are predefined   Note: Values of X are discussed in issue 3-3-1/3-3-2  Issue 3-3-1: good serving cell quality criteria for RLM  The good serving cell quality criteria for RLM is   * Option 1: radio link quality > Qout + X (dB).   + Value of X is FFS.     - Option a: X may depend on TSSB and TDRX     - Option b: X may depend on scenarios, i.e., RS types (SSB/CSI-RS), frequency range     - Other options are not precluded * Option 2: radio link quality > Qin + X (dB).   + Value of X is FFS.     - Option a: X may depend on TSSB and TDRX     - Option b: X may depend on scenarios, i.e., RS types (SSB/CSI-RS), frequency range     - Other options are not precluded * Other options are not precluded   Issue 3-3-2: good serving cell quality criteria for BFD  The good serving cell quality criteria for BFD is   * Option 1: radio link quality > Qout\_LR + Y (dB).   + Value of Y is FFS.     - Option a: Y may depend on TSSB and TDRX     - Option b: Y may depend on scenarios, i.e., RS types (SSB/CSI-RS), frequency range     - Other options are not precluded * Option 2: radio link quality > Qin\_LR + Y (dB).   + Value of Y is FFS.     - Option a: Y may depend on TSSB and TDRX     - Option b: Y may depend on scenarios, i.e., RS types (SSB/CSI-RS), frequency range     - Other options are not precluded * Other options are not precluded   Issue 3-4-1: same thresholds for RLM and BFD   * Option 1: the same thresholds used for good serving cell quality and low mobility criteria are applied for both RLM relaxation and BFD relaxation * Option 2: different threshold should be allowed.  **Sub-topic 4 Exiting Relaxation criteria** Issue 4-1: Exit criteria based regarding the radio link quality   * Background: * Agreement in RAN4 98-e-Bis meeting:   + *The UE while performing relaxed RLM upon detecting certain number of out-of-sync indications or upon triggering T310 or upon observed link quality degradation or mobility state change reverts to the normal RLM operation (i.e. without relaxation).* * Agreement in RAN4 99-e-Bis meeting:   + *If the UE fulfills any of serving cell quality exit condition or low mobility exit condition, or DRX cycle length is NOT allowed for relaxation, UE will exit relaxation mode.*     - *Note1: Whether the exit condition for serving cell quality is explicitly specified or not is up to issue 2-3-2.*     - *Note2: FFS the details of the exit condition of low mobility’*   Additional criteria are discussed below.   * Option 1: Exit RLM relaxation mode when any relaxation criterion is not met, or when N310 starts to count. No additional exit criterion needs to be defined. * Option 2: Reuse Qout as the radio link quality threshold. Exit relaxation mode when the radio link quality is worse than Qout * Option 3: Introduce a radio link quality threshold higher than Qout. Exit relaxation mode when the radio link quality is worse than a SINR threshold (Thexit ).   + Option 3a: Thexit = SINRenter with a hysteresis value   + Option 3b: Thexit = SINRenter – 3dB   + Option 3c: Thexit > Qout   + Option 3d: Thexit = Qout+7dB or Qin * Option 4: No additional criteria are needed, previous agreement from 98-e-bis and 99-e-bis are sufficient.   Issue 4-2: Whether to additionally specify the exit criterion for low mobility criteria  No additional exit criterion for low mobility, i.e. UE exit low mobility state as long as the entering condition is not met. **Sub-topic 5 During Relaxation mode** Issue 5-1: Whether to specify UE behavior in the relaxation mode   * RAN4 does not specify UE RLM/BFD relaxation behaviour in the spec but to specify the evaluation period during for relaxation   Issue 5-2-1: the formula of relaxed evaluation period  Previous agreement:  Scaling factor defining the relaxed RLM/BFD evaluation period is defined based on max(TDRX, TSSB) [R4-2105797].   * RAN4 specify the new evaluation period based on Max(T, Ceil([Y] x P x N) x Max(TDRX, TRLM-RS/BFD-RS))   + where Y is K \* current Rel-15 samples, and K is the predefined relaxation factor.   + where T is the lower bound of relaxed evaluation period. FFS whether the relaxation factor K to be applied on T.   + Scaling factor K is defining the relaxed RLM/BFD evaluation period is defined based on max(TDRX, TSSB).   + Note: 1.5 scaling factor is considered in current Rel-15 samples.   Issue 5-2-2: whether to apply relaxation factor on lower bound of relaxed evaluation period   * Option 1: Yes, also lower bound of relaxed evaluation period is also relaxed. * Option 2: No.   Issue 5-3: relaxation factors  Previous agreement:  Scaling factor defining the relaxed RLM/BFD evaluation period is defined based on max(TDRX, TSSB) [R4-2105797].   * + The following aspects can be considered when specify the relaxation factor:     - different relaxation factors for FR1 and FR2     - different relaxation factors for SSB and CSI-RS     - FFS different relaxation factors for different SINR regions   + FFS the exact value of relaxation factors     - Option 1:       * K=1 for 80 ms < TSSB ≤ 160 ms       * K=4 for MAX(TDRX, TSSB) ≤ 80 ms     - Option 2:       * K=2 for MAX(TDRX, TSSB) ≤ 40 ms in FR1       * K=1.5 for 40ms < MAX(TDRX, TSSB) ≤ 80 ms in FR1       * FFS K for FR2.     - Option 3:       * K=4 for MAX(TDRX, TSSB) ≤ 80 ms in FR1       * K=2 for MAX(TDRX, TSSB) ≤ 80 ms in FR2     - Option 4: Relaxation factors are different for FR1 and FR2, for the different SINR regions.     - Other options are not precluded   Issue 5-4: OOS indication during relaxation mode   * Option 1: UE indicates OOS during relaxation mode. * Option 2: UE is not required to send the first OOS indication to higher layers during relaxation mode. * Option 2a: UE indicate OOS right at exiting relaxation mode * Option 3: Left to UE implementation. * Option 4: the UE shall continue evaluate the serving cell quality and send out-of-sync indications when the measured SINR becomes worse than Qout threshold and follow the associated procedures (including N310 counters.), i.e. same as in legacy RLM procedure  **Sub-topic 6 Other Aspects** Issue 6-1: Specification structure   * Option 1: Relaxed RLM/BFD requirements are introduced in new subsections within the existing RLM/BFD sections TS 38.133. * Option 2: introduce new table for relaxation evaluation period into the current subsections.   Issue 6-2-1: Relaxation criteria in intra-band CA   * When BFD measurements are configured on SCell   + For intra-band CA with CSI-RS based RLM on SpCell and CSI-RS based BFD in SCell, the UE is allowed the operate in relaxed mode for RLM and/or BFD if UE has fulfilled the relaxation criteria for both RLM and BFD.   + For intra-band CA with CSI-RS based RLM on SpCell and CSI-RS based BFD in SCell, if UE has failed to fulfil the relaxation criteria for any of RLM and BFD, then the UE is not allowed to operate in relaxed mode in RLM and BFD in any of the cells.   + Note: This can be revisited upon clarification on the SCell BFD requirements in R16 eMIMO maintenance. * When BFD measurements are configured on SpCell   + For intra-band CA, whether to allow RLM/BFD relaxation depends upon whether both RLM and BFD measurements on SpCell fulfil the relaxation criterion.   Issue 6-2-2: Relaxation criteria for multiple RLM-RS/BFD-RS   * Option 1   + The relaxation condition of RLM/BFD relaxation for multiple RS resources can be defined as when the radio link quality is better than the entering threshold for any RLM/BFD RS resource.   + The exiting condition of RLM/BFD relaxation for multiple RS resources can be defined as when the radio link quality is worse than the exiting threshold for all the RLM/BFD RS resources. * Option 2   + The UE is allowed to operate RLM/BFD in relaxed mode for a certain cell (SpCell or SCell) when the radio link quality is better than the entering threshold for all RLM/BFD-RS resource.   + The UE shall exit the RLM/BFD relaxed mode when the radio link quality is worse than the exiting threshold for any the RLM/BFD-RS resources. * Option 3   + revisit after exiting criteria. * Option 4: The UE behaviour on checking the entering/exiting condition of cell quality criterion regarding multiple RLM-RSs/BFD-RSs is not specified.   Issue 6-2-3: Relaxation criteria in NR-DC and inter-band CA  FFS:   * For the case of NR-DC and inter-band CA, whether UE needs to evaluate the entering/exiting conditions for each serving cell configured for either RLM and/or BFD evaluation. * For the case of NR-DC and inter-band CA, whether UE is allowed to relax RLM/BFD if it meets the relaxation criterion in other serving cells   **LS to RAN2 on criteria for RLM/BFD relaxation (R4-2115349)** |

#### 2.4.2 Remaining open issues

With the above, the following are remaining open issues for RLM/BFD relaxation in RAN4:

* Low mobility criteria
* Good serving cell quality criteria
  + SINR definition for good serving cell quality criteria
  + Predefined or configured threshold
  + Good serving cell quality criteria for RLM
  + Good serving cell quality criteria for BFD
  + Same thresholds for RLM and BFD
* Exit criteria based regarding the radio link quality
* Relaxed evaluation period of RLM/BFD
* OOS indication during relaxation mode

## 2.5 RAN5

#### 2.5.1 Agreements: N/A (RAN5 is not involved in the WI)

#### 2.5.2 Remaining Open issues: N/A

#### 2.5.3 Remaining Open issues with cross-WG dependencies: N/A

## 2.6 RAN6

#### 2.6.1 Agreements: N/A (RAN6 is not involved in the WI)

#### 2.6.2 Remaining Open issues: N/A

## 3. Detailed progress in SA/CT WGs since last TSG meeting (for all involved WGs)

NOTE: This section only needs to be filled in for WI/SIs where there is a corresponding relevant WI/SI in SA/CT.

## 3.1 SAx/CTs

#### 3.1.1 Agreements with cross-TSG impacts: N/A

#### 3.1.2 Remaining Open issues with cross-TSG impacts: N/A

## 4. References

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| * **Previous status report(s)**   RP-211452 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek)  RP-210733 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek)  RP-202685 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek)  RP-201701 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek) |
| **RAN1 Contributions** |
| **RAN1 #106-e Meeting**   * **Potential paging enhancements:**   R1-2103848 Summary of paging enhancements Moderator (MediaTek)  R1-2102316 Paging enhancements for UE power saving in IDLE/inactive mode Huawei, HiSilicon  R1-2102405 Further discussion on Paging enhancements for power saving OPPO  R1-2102463 Discussion on potential paging enhancements Spreadtrum Communications  R1-2102532 Paging enhancements for idle/inactive mode UE power saving vivo  R1-2102565 Discussion on power saving enhancements for paging ZTE,Sanechips  R1-2102641 Paging enhancement for UE power saving CATT  R1-2102681 On paging enhancements for idle/inactive mode UE power saving MediaTek Inc.  R1-2102805 On paging enhancement Panasonic  R1-2102892 Discussion on paging early indication design CMCC  R1-2102991 Paging enhancement for power saving Xiaomi  R1-2103041 On Paging Enhancements for UE Power Saving Intel Corporation  R1-2103115 Paging early indication for idle/inactive-mode UE Apple  R1-2103177 Paging enhancements for idle/inactive UE power saving Qualcomm Incorporated  R1-2103249 Discussion on paging enhancements Samsung  R1-2103310 Discussion on potential paging enhancements Sony  R1-2103355 Discussion on potential paging enhancements LG Electronics  R1-2103405 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell  R1-2103424 Paging enhancements for UE power saving InterDigital, Inc.  R1-2103586 Discussion on paging enhancements NTT DOCOMO, INC.  R1-2103614 Paging enhancement for UE power saving Lenovo, Motorola Mobility  R1-2103642 Design of Paging Enhancements Ericsson  R1-2103653 On paging early indication Nordic Semiconductor ASA  R1-2103768 Paging enhancement for power saving Xiaomi  R1-2102407 Paging and TRS indication in idle/inactive modes OPPO  R1-2102534 Discussion on paging grouping vivo  R1-2102643 Details of PEI configuration CATT  R1-2103426 Paging indication based on sub-time units InterDigital, Inc.   * **TRS/CSI-RS occasion(s) for idle/inactive UEs**   R1-2104115 Final summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)  R1-2102317 Assistance RS occasions for IDLE/inactive mode Huawei, HiSilicon  R1-2102406 Further discussion on RS occasion for idle/inactive UEs OPPO  R1-2102464 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum Communications  R1-2102478 TRS/CSI-RS occasions for idle/inactive UE TCL Communication Ltd.  R1-2102533 TRS/CSI-RS occasion(s) for idle/inactive UEs vivo  R1-2102566 TRS for RRC idle and inactive UEs ZTE,Sanechips  R1-2102642 Configuration of TRS/CSI-RS for paging enhancement CATT  R1-2102682 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.  R1-2102806 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs Panasonic  R1-2102893 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCC  R1-2102992 On TRS/CSI-RS configuration and indication for idle/inactive UEs Xiaomi  R1-2103042 TRS/CSI-RS functionality during idle/inactive mode Intel Corporation  R1-2103116 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving Apple  R1-2103178 TRS/CSI-RS for idle/inactive UE power saving Qualcomm Incorporated  R1-2103250 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs Samsung  R1-2103251 Moderator summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)  R1-2103311 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs Sony  R1-2103356 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG Electronics  R1-2103406 On RS information to IDLE/Inactive mode UEs Nokia, Nokia Shanghai Bell  R1-2103425 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.  R1-2103479 On TRS/CSI-RS occasions for idle/inactive UEs Sharp  R1-2103587 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.  R1-2103615 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola Mobility  R1-2103643 Provisioning of TRS occasions to Idle/Inactive UEs Ericsson  R1-2103654 On TRS design for idle/inactive UEs Nordic Semiconductor ASA   * **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**   R1-2103634 Discussion on DCI-based power saving adaptation ITRI   * **Others**   R1-2102567 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE,Sanechips  R1-2103389 Analysis on power consumption for IDLE mode and RedCap Huawei, HiSilicon  R1-2103644 Modeling of Network Power Consumption Ericsson |
| **RAN2 Contributions** |
| **RAN2 #115-e Meeting** **Idle/inactive-mode UE power saving:** R2-2106552 LS on Paging Subgrouping RAN2  R2-2106666 Report of [AT114-e][025][ePowSav] Subgrouping network architecture MediaTek Inc.  R2-2104773 Paging subgroup assignment Qualcomm Incorporated  R2-2104783 Paging Enhancements\_UE Grouping Samsung Electronics Co., Ltd  R2-2104807 Discussion on grouping-based paging OPPO  R2-2104909 UE sub-grouping for paging enhancement vivo  R2-2105021 Further considerations of network assigned subgrouping Intel Corporation  R2-2105087 NR UE Power Save IDLE/INACTIVE Paging Grouping Schemes Apple  R2-2105283 UE subgrouping schemes with paging enhancement CATT  R2-2105293 UE Paging Subgroup Assignment for Power Saving MediaTek Inc.  R2-2105295 Discussion on idle\_inactive\_mode UE power saving Xiaomi Communications  R2-2105411 Details on paging subgrouping determination and indication Nokia, Nokia Shanghai Bell  R2-2105656 Grouping methods for Paging Ericsson  R2-2105718 Discussion on the control node for UE grouping Huawei, HiSilicon  R2-2105736 PEI monitoring in NR: CN and System level impacts VODAFONE Group Plc  R2-2105809 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility  R2-2105855 Further Consideration on UE Grouping ZTE, Sanechips  R2-2105956 Discussion on UE grouping control entity Futurewei Technologies  R2-2106257 Considerations on paging subgrouping CMCC  R2-2106349 UE subgrouping for paging enhancement LG Electronics Inc.   * Other aspects RAN2 impacts   R2-2105088 NR UE Power Save TRS/CSI-RS Signaling for IDLE/INACTIVE UEs Apple |
| **RAN4 Contributions** |
| **RAN4 #100-e Meeting**   * **General and work plan [NR\_UE\_pow\_sav\_enh]:**   R4-2111266 Discussion on work split between RAN2 and RAN4 on R17 RLM and BFD relaxation for NR vivo   * **UE measurements relaxation for RLM and/or BFD [NR\_UE\_pow\_sav\_enh-Core]**   R4-2108351 WF on RLM/BFD relaxation for UE Power Saving enhancements MediaTek  R4-2108764 On RLM and RLF relaxation for UE power saving ZTE Corporation  R4-2109067 Further discussion on RLM/BFD relaxation measurement CATT  R4-2109242 Discussion on UE power saving for RLM and BM Intel Corporation  R4-2109246 Further discussion on UE measurements relaxation for RLM and/or BFD Xiaomi  R4-2109364 UE measurements relaxation for RLM and/or BFD Apple  R4-2109494 Discussion on RLM/BFD relaxation for NR power saving enhancement CMCC  R4-2109550 Discussion about RLM/BFD measurement relaxation Nokia, Nokia Shanghai Bell  R4-2109551 Simulation results for UE power saving enhancements Nokia, Nokia Shanghai Bell  R4-2109561 On Power Saving RRM Requirement Qualcomm, Inc.  R4-2109886 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc.  R4-2110303 Further discussion on RLM/BFD measurement relaxation Huawei, HiSilicon  R4-2111248 Simulation results on UE power saving for RLM and BM Ericsson  R4-2111249 Discussions on UE power saving for RLM and BM Ericsson  R4-2111267 Discussion on R17 RLM and BFD relaxation for NR vivo |