**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]

|  |  |
| --- | --- |
| **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: 70%  | 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:**

|  |  |
| --- | --- |
| **Leading WG** | RAN2 |
| **Rapporteur** | **Name** | Weide Wu |
| **Company** | MediaTek Inc. |
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## 1 Work plan related evaluation

|  |  |
| --- | --- |
| **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 SSBConclusionTo down-select one solution for PEI physical-layer channel/signal in RAN1 #106-e,* PDCCH-based PEI
* SSS-based PEI

Proposed Working Assumption* PDCCH-based PEI

Supported by 20 companies, but can not be accepted by 3 companies, i.e., Intel, CATT, Sony. |
| **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**AgreementSupport 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.AgreementL1 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

AgreementSelect either package 1 or package 2Package 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 durationby 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 (proposed for RAN Plenary decision in RAN#93-e)
	+ Specify details for subgroups indication with PEI
	+ Specify PEI monitoring occasion determination and UE paging monitoring behaviour with PEI (Behv-A and/or Behv-B)
	+ 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.

**Action to RAN Plenary:**

**It is requested for RAN Plenary to intervene and decide PEI physical-layer channel/signal, taking into account the above RAN1 status for scope item 1) – a).**

## 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.
 |
| **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 co-existence of CN-assigned and UEID-based UE paging subgrouping
	+ Specify configurations for UE subgrouping as well as paging early indication 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 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: N/A (RAN3 is not yet involved)

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

## 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 configuredWhen 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 > 80msIf 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 3-3-1/3-3-2Issue 3-3-1: good serving cell quality criteria for RLMThe 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 BFDThe 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 criteriaNo 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 periodPrevious 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 factorsPrevious 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 CAFFS:* 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

|  |
| --- |
| * **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:**

R1-2108660 Summary#6 of paging enhancements Moderator (MediaTek Inc.)R1-2106479 Paging enhancements for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2106520 Potential Paging Enhancements TCL Communication Ltd.R1-2106521 Discussion on power saving enhancements for paging ZTE, SanechipsR1-2106606 Paging enhancements for idle/inactive mode UE power saving vivoR1-2106708 Discussion on potential paging enhancements for UE power saving Spreadtrum CommunicationsR1-2106815 Paging enhancements for idle/inactive UE power saving SonyR1-2106898 Discussion on paging enhancements SamsungR1-2106983 Paging enhancement for UE power saving CATTR1-2106998 Discussion on paging enhancements with PEI Transsion HoldingsR1-2107044 On paging early indication Nordic Semiconductor ASAR1-2107182 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2107253 Further discussion on Paging enhancements for power saving OPPOR1-2107356 Paging enhancements for idle/inactive UE power saving Qualcomm IncorporatedR1-2107414 Discussion on paging early indication design CMCCR1-2107453 Discussion on potential paging enhancements LG ElectronicsR1-2107519 Design of Paging Early Indication for Idle-Mode UE Power Saving MediaTek Inc.R1-2107599 On Paging Enhancements for UE Power Saving Intel CorporationR1-2107622 On paging enhancement PanasonicR1-2107750 Paging enhancements for idle/inactive-mode UE AppleR1-2107806 Paging enhancements for UE power saving InterDigital, Inc.R1-2107869 Discussion on paging enhancement NTT DOCOMO, INC.R1-2107932 Potential paging enhancements for power saving XiaomiR1-2107998 Design of Paging Enhancements EricssonR1-2108122 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2108515 Final summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)R1-2106480 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2106519 TRS/CSI-RS occasions for IDLE/inactive mode TCL Communication Ltd.R1-2106522 TRS for RRC idle and inactive UEs ZTE, SanechipsR1-2106607 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2106709 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2106816 Considerations on TRS/CSI-RS occasion(s) for idle/inactive UEs SonyR1-2106899 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2106984 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2107045 On TRS design for idle/inactive UEs Nordic Semiconductor ASAR1-2107183 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2107254 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2107357 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2107415 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCCR1-2107454 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2107520 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2107600 On TRS/CSI-RS Ocassions for UE Power Saving Intel CorporationR1-2107623 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2107751 Indication of TRS configurations for idle/inactive-mode UE power saving AppleR1-2107798 Discussion on TRS/CSI-RS occasions for idle/inactive UEs SharpR1-2107807 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2107870 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2107933 On TRS/CSI-RS configuration and indication for idle/inactive UEs XiaomiR1-2107999 Provisioning TRS occasions to Idle/Inactive UEs EricssonR1-2108123 On RS information to IDLE/Inactive mode Ues Nokia, Nokia Shanghai Bell* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2108620 FL summary#5 of DCI-based power saving adaptation Moderator (vivo)R1-2106481 Extensions to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSiliconR1-2106524 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE, SanechipsR1-2106610 Discussion on DCI-based power saving adaptation in connected mode vivoR1-2106710 Discussion on power saving techniques for connected-mode UE Spreadtrum CommunicationsR1-2106901 Discussion on DCI-based power saving techniques SamsungR1-2106986 PDCCH monitoring adaptation CATTR1-2107017 Discussion on DCI-based power saving adaptation NECR1-2107046 On PDCCH monitoring adaptation Nordic Semiconductor ASAR1-2107184 Enhanced DCI based power saving adaptation Lenovo, Motorola MobilityR1-2107255 DCI-based power saving adaptation solutions OPPOR1-2107358 DCI-based power saving adaptation during DRX ActiveTime Qualcomm IncorporatedR1-2107416 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2107455 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG ElectronicsR1-2107476 DCI-based power saving adaptation during DRX active time ETRIR1-2107521 On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.R1-2107533 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IISR1-2107601 On PDCCH Monitoring Adaptation during DRX active time Intel CorporationR1-2107624 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime PanasonicR1-2107752 Enhanced DCI-based power saving adaptation AppleR1-2107808 PDCCH monitoring reduction in Active Time InterDigital, Inc.R1-2107871 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2108001 Design of active time power savings mechanisms EricssonR1-2108014 Discussion on DCI-based power saving adaptation ITRIR1-2108048 A common framework for SSSG switching and PDCCH skipping ASUSTeKR1-2108124 UE power saving enhancements for Active Time Nokia, Nokia Shanghai Bell* **Others**

R1-2106523 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE, SanechipsR1-2106525 Further discussion on potential power saving schemes for RRC connected UEs ZTE, SanechipsR1-2106608 Discussion on paging grouping vivoR1-2106609 UE Power Model for Downlink Reception vivoR1-2106985 Details of PEI configuration CATTR1-2106987 Link level performance for UE power saving CATTR1-2107673 Analysis on power consumption for IDLE mode UE Huawei, HiSiliconR1-2107674 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2107934 Other aspect for idle/inactive-mode UE power saving XiaomiR1-2108000 NW power consumption evaluation of SIB based TRS availability signaling EricssonR1-2108002 Evaluation results for UE power saving schemes Ericsson |
| **RAN2 Contributions** |
| **RAN2 #115-e Meeting****Idle/inactive-mode UE power saving:**R2-2108062 Discussion on enhancements for idle/inactive-mode UE power saving SonyR2-2108685 Summary of [Post114-e][076][ePowSav] Paging SubGrouping CATT**Idle/inactive-mode UE power saving:** **Architecture**R2-2106998 Further details of UE Subgrouping Samsung Electronics Co., LtdR2-2107067 Discussion on grouping-based paging OPPOR2-2107068 Discussion on UE paging capabilities OPPOR2-2107222 Paging subgroup assignment Qualcomm IncorporatedR2-2107385 The architecture of paging enhancement Xiaomi CommunicationsR2-2107406 Architecture for paging enhancement by UE subgrouping vivoR2-2107549 Further considerations on Network assigned subgrouping Intel CorporationR2-2107721 Further discussion on CN-assigned paging grouping Transsion HoldingsR2-2107880 UE ID based subgroup LG Electronics Inc.R2-2107902 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2108011 CN and RAN responsibility split for paging subgrouping Nokia, Nokia Shanghai BellR2-2108027 Further discussion on paging subgrouping Huawei, HiSiliconR2-2108028 Discussion on paging subgrouping supporting on UE and network Huawei, HiSiliconR2-2108237 Grouping methods for Paging EricssonR2-2108461 Handling network nodes not supporting UE paging subgrouping Futurewei TechnologiesR2-2108590 UE Paging Subgroup Assignment MediaTek Inc.R2-2108592 CN and RAN responsibility split for paging subgrouping Nokia, Nokia Shanghai BellR2-2108686 Further Consideration on Paging Subgroup CATTR2-2109094 [AT115-e][043][ePowSav] Paging Subgrouping (Nokia) Nokia (Rapporteur)**Idle/inactive-mode UE power saving:** **Control and Procedure details**R2-2106999 UE Idenity for paging subgrouping Samsung Electronics Co., LtdR2-2107000 DRX cycle for monitoring paging Samsung Electronics Co., LtdR2-2107069 Discussion on PEI monitoring OPPOR2-2107223 Paging reception with cross-slot scheduling Qualcomm IncorporatedR2-2107407 UE subgrouping procedure for paging enhancement vivoR2-2107538 How a UE determines the PEI radio resource(s) to monitor for paging Xiaomi CommunicationsR2-2107553 Further considerations on the UE behaviour for Network assigned subgrouping Intel CorporationR2-2107595 Signallaing aspects of IDLE/INACTIVE paging subgrouping for enhanced power save AppleR2-2107879 NW assigned subgroup LG Electronics Inc.R2-2107881 Paging subgroup indication LG Electronics Inc.R2-2107903 Consideration on the configuration for UE paging grouping Lenovo, Motorola MobilityR2-2108012 Subgroup indication via PEI Nokia, Nokia Shanghai BellR2-2108029 Further considerations on other paging enhancements Huawei, HiSiliconR2-2108238 PEI monitoring in NR: CN and System level impacts EricssonR2-2108272 Further Consideration on NW assigned subgrouping and UE ID based grouping ZTE CorporationR2-2108534 Considerations on assistance information and procedures for paging subgrouping CMCCR2-2108593 Paging Monitoring with PEI and UE Subgrouping MediaTek Inc.* Other aspects RAN2 impacts

R2-2107001 TRS\_CSIRS for RRC IDLE and RRC INACTIVE Samsung Electronics Co., LtdR2-2107070 Discussion on signaling aspects of TRS/CSI-RS occasion(s) for idle/inactive Ues OPPOR2-2107408 Discussion on TRS CSI-RS in idle inactive mode vivoR2-2107409 RAN2 impact on RLM/BFD relaxation for power saving vivoR2-2107536 Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi CommunicationsR2-2107537 LS to RAN1 on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi CommunicationsR2-2107550 TRS/CSI-RS configuration and availability for idle/inactive-mode UE Intel CorporationR2-2107596 TRS/CSI-RS signalling aspects for IDLE/INACTIVE UEs for enhanced power save AppleR2-2107901 TRS/CSI-RS configuration for Idle/inactive mode UE Lenovo, Motorola MobilityR2-2108013 RAN2 impact on connected mode power saving Nokia, Nokia Shanghai BellR2-2108030 Discussion on potential TRS/CSI-RS Huawei, HiSiliconR2-2108063 Discussion on TRS/CSI-RS configuration of idle/inactive-mode UEs SonyR2-2108239 Provision of TRS Configurations to UEs in idle and inactive EricssonR2-2108240 TRS Availability Signaling to UEs in idle and inactive EricssonR2-2108263 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai BellR2-2108271 Further Consideration On TRS and CSI-RS for idle and inactive UE ZTE CorporationR2-2108535 Considerations on TRS/CSI-RS occasion(s) for idle/inactive UE(s) CMCCR2-2108687 Further Consideration on Configuration of TRS/CRI-RS CATTR2-2109037 Summary of 8.9.3 - Other aspects RAN2 impacts EricssonR2-2109072 Report from [AT115-e][044][ePowSav] TRS CSIRS for RRC Idle and Inactive (Ericsson) Ericsson |
| **RAN4 Contributions** |
| **RAN4 #100-e Meeting*** **General**

R4-2112179 LS on criteria for RLM/BFD relaxation vivo* **UE measurements relaxation for RLM and/or BFD**

R4-2115348 WF on RLM/BFD relaxation for UE Power Saving enhancements Moderator (MediaTek inc.)R4-2111959 Further discussion on RLM/BFD relaxation for UE power saving enhancement CATTR4-2112090 UE measurements relaxation for RLM and/or BFD AppleR4-2112180 Discussion on R17 RLM and BFD relaxation for NR vivoR4-2112204 Discussion on RLMBFD relaxation for NR power saving enhancement CMCCR4-2112259 On Power Saving RRM Requirement Qualcomm, Inc.R4-2112413 Further discussion on UE measurements relaxation for RLM and/or BFD XiaomiR4-2112878 Discussion about RLM/BFD measurement relaxation Nokia, Nokia Shanghai BellR4-2113137 Discussions on UE power saving for RLM and BM Intel CorporationR4-2113820 Further discussion on RLM/BFD measurement relaxation Huawei, HiSiliconR4-2113887 On RLM and RLF relaxation for UE power saving ZTE CorporationR4-2114081 Discussions on UE power saving for RLM and BM EricssonR4-2114153 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc. |