**3GPP TSG RAN meeting #91e RP-20XXXX**

**Electronic Meeting, March 15-25, 2021**

## Status Report to TSG

**Agenda item:** 9.8.7 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: 09/2021 | Performance part: 03/2022 | Testing part: - |
| **Overall Completion level** | Study Item: - | Core part: Overall: 30% RAN1: 35%RAN2: 30%RAN4: 25% | Performance Part: Overall: 0% RAN1: 0%RAN2: 0%RAN4: 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

|  |  |
| --- | --- |
| **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 #104-e meeting****R1-2101940 [Draft] Reply LS on Paging Enhancement MediaTek****Decision:** As per email decision posted on Feb 4th, the draft LS is endorsed. Final LS is approved in [R1-2102136](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2102136.zip).Agreement:* Carrying UE subgroups information is considered in physical layer design for paging enhancement

Agreements:For the evaluation and comparison of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, the following are assumed:* Behv-A:
	+ PEI indicates UE should monitor a PO if UE’s group/subgroup is paged
	+ UE is not required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO
* Behv-B:
	+ PEI indicates whether or not UE should monitor a PO
	+ UE is required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO

Agreements:For the evaluation and comparison of PEI candidate designs, companies to report* Description of how PEI design can co-exist with existing channels/signals, and impact to legacy UEs.
	+ Rel-15 designs for multiplexing PEI with legacy channels/signals are assumed as baseline
	+ Other multiplexing method with legacy channels/signals can be additionally reported with justification

Agreements:* Take Alt 1 as mandatory, and Alt 2 as optional

**Alt 1:** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging PDSCH is 1%,
	1. When Behv-A is assumed:
		1. The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%: MDR\_Joint\_A = MDR\_PEI + (1 – MDR\_PEI) MDR\_PagingPDCCH
		2. The False-Alarm Rate (FAR) of PEI should be no larger than [1%]
	2. When Behv-B is assumed:
		1. The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%: MDR\_Joint\_B = FAR\_PEI + (1 – FAR\_PEI) MDR\_PagingPDCCH
		2. The MDR of PEI should be no larger than [1%]
	3. Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
2. Companies to provide:
	1. Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	2. The required #REs to comply with the performance assumptions
	3. The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions

**Alt 2:** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging DCI is 1%,
	1. When Behv-A is assumed:
		1. The MDR of PEI should be no larger than 0.1%
		2. The False-Alarm Rate (FAR) of PEI should be no larger than 1%
	2. When Behv-B is assumed:
		1. The FAR of PEI should be no larger than 0.1%
		2. The MDR of PEI should be no larger than 1%
	3. Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
2. Companies to provide:
	1. Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	2. The required #REs to comply with the performance assumptions
	3. The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions

Agreements:For the evaluation of resource overhead with PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, companies to provide estimated overheads for PEI candidate designs based on the following factors:1. Assumption of Behv-A/B
2. Required #REs from performance evaluations
3. 10% group paging rate per PO as baseline; other group paging rates can be optionally considered

and based on the following assumptions with justification (up to each company)1. Whether and how coexistence with legacy UEs is considered
2. Whether and how indication(s) to multiple POs and/or UE subgroups by one PEI is considered
3. Whether and how multi-beam transmission is considered

Agreements:Further study the design on how to provide the indications for UE subgroups over PEI and/or paging PDCCH, subject to the metrics agreed in RAN1 102e. |
| **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 #104-e Meeting**Agreements:Configuration of TRS/CSI-RS occasion(s) for idle/inactive Ues include at least:* powerControlOffsetSS,
* scramblingID
* firstOFDMSymbolInTimeDomain,
* startingRB.
* nrofRBs,
* FFS other parameters
* FFS applicable values

Agreements:The SCS configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs can be discussed and down-selected from following alternatives at RAN1#104b-e:* Alt1: same as initial BWP
* Alt2: configurable parameter

Agreements:Multiple RS resources can be configured for TRS/CSI-RS occasion(s) for idle/inactive UEs. * FFS details (including whether or not to restrict the RS to be TRS only)

Agreements:For a cell with TRS/CSI-RS occasions configured for IDLE/Inactive UEs, IDLE/Inactive UE’s assumption on the availability of TRS/CSI-RS at the configured occasion(s) is informed to the idle/inactive UE based on explicit indication.* FFS details (e.g., the signalling, detailed information for the TRS/CSI-RS, etc.)
* There is no intended blind detection of the presence/absence of TRS/CSI-RS at the UE side in this feature. That is, the UE assumes TRS/CSI-RS is not present if the network does not indicate it is available (or indicates it is unavailable).

**Conclusion**From RAN1 perspective, there is no consensus on supporting RRM measurement for serving cell functionality for TRS/CSI-RS occasion(s) for idles/inactive UEs.Agreements:The configuration of the frequency location of TRS/CSI-RS occasion(s) for idle/inactive UEs are discussed and down-selected from following alternatives at RAN1#104bis-e:* Alt-1: within initial DL BWP
* Alt-2: is not restricted by initial BWP
	+ IDLE/INACTIVE mode UE is not expected to receive TRS/CSI-RS outside the initial DL BWP.

Agreements:To study QCL information of TRS/CSI-RS occasion(s) for idle/inactive UEs from following alternatives: * Alt-1: From higher layer configuration, e.g. qcl-InfoPeriodicCSI-RS
* Alt-2: QCL assumptions associated with transmitted SSBs implicitly, e.g. similar to PDCCH monitoring in PO
* FFS details
* Other alternatives are not precluded

**Conclusion:**Decide at RAN1#104b-e, whether or not to support periodic CSI-RS in addition to periodic TRS for TRS/CSI-RS occasion(s) for idle/inactive UEs. |
| **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 #104-e Meeting**Agreements:* Strive for a common design for DCI based PDCCH monitoring adaptation in active time for an active BWP to support functionalities inclusive of both SSSG switching and PDCCH skipping for a duration.
	+ Details FFS

Agreements:* Further study whether and how to minimize the impact to data scheduling for new transmissions and retransmissions.
	+ FFS details
* Further study the application delay for PDCCH adaptation indication

Agreements:* For DCI based PDCCH skipping in active time for an active BWP (if supported), the following can be further considered,
	+ Explicit indication of PDCCH adaptation
		- Scheduling DCI
			* Format 1\_1
			* Format 0\_1
			* Format 0\_2/1\_2
		- Non-scheduling DCI
			* Format 2\_6 in active time
			* Format 2\_0
			* Format 1\_1 (SCell dormancy case 2)
		- additional indication mechanism
			* By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
			* By reusing Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS details
	+ DCI dynamically indicates a duration/periodic interval for skipping
		- FFS: how to indicate the duration/period interval, e.g., number of slots or skipping current DRX
	+ PDCCH skipping for a duration indicated by minimum scheduling offset
	+ Others are not precluded

Agreements* For DCI based SSSG switching in active time for an active BWP (if supported), the following can be further considered,
	+ Explicit indication of PDCCH adaptation
		- Scheduling DCI based
			* Format 1\_1,
			* Format 0\_1,
			* Format 0\_2/1\_2
			* ~~Format 1\_0~~
		- Non-scheduling DCI
			* Format 2\_6 in active time
			* Format 2\_0
			* ~~Format 1\_0~~
			* Format 1\_1 (SCell dormancy case 2)
		- additional indication mechanism
			* By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
			* By associating Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS details
		- DCI dynamically indicates a duration for the switched SSSG, UE switch back to previous/default SSSG after duration ends
	+ Timer-based SSSG switching, including RRC configured a timer, UE switch back after timer expired.
	+ SSSG activation/deactivation
	+ FFS: Implicit SSSG switching
		- SSSG switching triggered by SR
		- SSSG switching triggered by RACH
		- Default SSSG that a UE monitors when coming out of DRX to monitor an ON duration.
* FFS: whether/how to support SSSG switching for multiple groups of cell(s).
* FFS: whether/how to support SSSG switching in active time with DCP outside active time
* FFS: whether / how to support more than 2 SSSGs,
	+ FFS: number of SSSGs
* FFS: a search space set group to emulate PDCCH skipping
* Others are not precluded

Agreements:* The following alternatives can be considered for DCI based PDCCH monitoring adaptation in active time for an active BWP for power saving
	+ Alt 1: Enhancement of Rel-16 SSSG switching to support PDCCH monitoring adaptation including skipping for a duration
	+ Alt 2a: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and SSSG switching
	+ ~~Alt 2b: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and PDCCH monitoring periodicity adaptation~~
	+ Others not precluded
 |

#### 2.1.2 Remaining open issues

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

* For scope item 1) - a):
	+ Decide and specify the physical layer design based on DCI, SSS or TRS/CSI-RS for paging early indication (PEI) before paging occasion, according to the agreed criteria in RAN1 #104e
	+ Further study how to provide the indications for UE subgroups over PEI and/or paging PDCCH, subject to the metrics agreed in RAN1 #102e
	+ Specify the association and timing relation between PEI and UE groups and subgroups, if supported, as well as UE paging monitoring behaviour with PEI.
* For scope item 1) - b):
	+ Decide at RAN1#104b-e, whether or not to support periodic CSI-RS in addition to periodic TRS for TRS/CSI-RS occasion(s) for idle/inactive UEs
	+ Specify how gNodeB indicates the availability of TRS/CSI-RS at the configured occasion(s) for idle/inactive UEs based on explicit indication
	+ Specify details for the configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs
* For scope item 2) - a):
	+ Discuss and decide the approaches to support both skipping PDCCH monitoring for a duration and SSSG switching for a common framework by considering Alt 1 (Enhancement of Rel-16 SSSG switching) and/or Alt 2a (Enhancement of DCI(s) utilized for Rel-16 power saving adaptation).
	+ Discuss and decide, if agreed, design details, including whether and how to minimize impact to data scheduling (for new transmissions and retransmissions), application delay, DCI format(s) for explicit 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 #113-e MeetingR2-2100389 Report of [POST112-e][064][Pow17] Group Determination (Intel) Intel CorporationR2-2101301 Network assigned subgrouping Intel Corporation FOR BOTH DOCS ABOVE* There is support to have UE ID based enhancement
* There is still significant interest to have other additional methods (but also some concerns). The approach to have a single mechanism that can take several aspects into account can be a way forward. There are still questions on the details, e.g. whether CN or RAN would provide a parameter.

Chair: Plan to make decisions at next meeting this topic is treated, so companies that have preferences for certain methods need to clearly explain justifications. - MTK think that the study phase is supposed to be concluded at this meeting.  |
| **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:** |
| RAN2 #113-e Meeting* [AT113-e][041][ePowSav] TRS/CSI-RS for IDLE INACTIVE (Xiaomi)

 Scope: Take the documents in 8.9.3 into account, except availability signalling which is postponed. Collect comments, determine agreeable points, open points and their main options and related justifications.  Intended outcome: Report, Agreements (if possible).  Deadline: Thursday Feb 4 UTC 1100: Deadline for comments on agreements. Deadline for other aspects: EOM* [041] On signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

SIB signalling is the baseline;Other dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally considered with justification. It is assumed they do not work alone.* [041] RAN2 will down select from the following options on SIB signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

Option 2: Existing SIB, other than SIB1;Option 3: New SIB type, e.g. SIB-x; |

#### 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 UE grouping design for paging enhancement, including paging subgroup determination.
	+ Reply RAN1 LS to provide information of RAN2 decision(s) on UE sub-grouping for paging enhancement.
	+ Specify configurations for UE grouping as well as paging early indication based on RAN1 design
* For scope item 1) – b):
	+ Discuss and decide whether and how dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally utilized with justification.
	+ Discuss and decide SIB type, Option 2 (Existing SIB) or Option 3 (New SIB type), for providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s), based on RAN1 design on detailed configurations.

## 2.3 RAN3

#### 2.3.1 Agreements: N/A (RAN3 is not involved in the WI)

#### 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 #98-e Meeting****Approved: WF on R17 UE power saving RLM/BM relaxation (R4-2103670)**Issue 2-2-1: Confirmation on beneficial Scenarios, from UE power saving gain perspective* Agreements
	+ Further evaluate UE power saving gains for the following UE implementations:
		- UE meets Rel-15 RRM measurement period and accuracy requirements
		- Option 1:
			* UE uses all L1 samples for RRM measurements based on Rel-15 assumptions
		- Option 2:
			* How many L1 samples UE applies for RRM measurements is up to UE implementation (e.g. UE can use lower number of measurement samples for RRM measurements)
			* Further discuss how many samples to use for evaluations
			* Companies shall evaluate RRM measurements accuracy for the proposed number of samples.
		- FFS whether Option 2 can be considered for requirements definition
		- Further assess impact on PDCCH monitoring due to relax UE measurements for RLM/BFD

Issue 2-2-1: Confirmation on beneficial Scenarios, from UE power saving gain perspective* RAN4 to identify the scenarios that power saving gain can be observed.

Issue 2-2-2: Feasible Scenarios for Power Saving, from system impact perspective* RAN4 to identify the scenarios that system impact can be acceptable.
* FFS the feasibility of following scenarios from system level perspective:
	+ SSB-based and CSI-RS based RLM/BFD measurement relaxation in FR1 for low mobility and high/medium SINR UE.
	+ CSI-RS based RLM/BFD measurement relaxation in FR2 for low mobility and high/medium SINR UE
	+ SSB-based RLM/BFD measurement relaxation in FR2 for stationary and high/medium SINR UE

Issue 2-2-3: DRX cycle* The applicability of DRX cycles for RLM/BFD relaxation should be studied and decided based on the ongoing simulation study.
	+ FFS DRX cycle length <= 80 ms

Issue 2-3-1: Criteria which the UE is allowed to relax the RLM/BM requirements* At least take UE mobility into account as the relaxation criteria.
* also take serving cell’s quality into account
* FFS whether and how to take other aspects into account

Issue 2-3-3: How to consider serving cell’s quality as relaxation criteria* RAN4 to further discuss how to take serving cell’s quality into account for the relaxation criteria
	+ FFS how to consider serving cell’s quality. E.g. Based on SINR or BLER.
	+ FFS how to address different UE implantation issues.
	+ FFS: When radio link quality > Qout + X (dB) for RLM and Qout,LR + Y (dB) for BFD relaxation
		- X and Y are FFS.

Issue 2-3-2: How to consider UE mobility as relaxation criteriaFFS the following options* + Option 1: R16 low-mobility criterion should not be directly reused in R17 SINR-based criterion for RLM/BFD relaxation.
	+ Option 2: R16 RRM relaxation criterion can be used as baseline for RLM/BFD relaxation.
	+ Option 3: “low mobility criteria” should consider both UE velocity and the channel quality variation.
	+ Option 4: Consider time associated with a given condition when determining UE mobility state.
	+ Option 5: Low mobility scenario under which the UE is allowed to apply the RLM/BFDBM requirements is determined and configured to UE by the network

Other options are not precludedIssue 2-3-4: Network or UE to determine if the relaxation criteria is fulfilled* Network to enable and disable this feature.
	+ FFS Should the relaxation criteria be predefined or configurable?
	+ FFS Should it be network or UE to determine the relaxation criteria is fulfilled or not?

Issue 2-4-1: Scheme of RLM/BFD measurements relaxation* Use of a scaling factor to extend the RLM/BFD evaluation period.

Issue 2-4-2: relaxation factor determination* Scaling factor defining the relaxed RLM/BFD evaluation period is defined based on
	+ DRX cycle and RLM-RS periodicity
		- FFS based on max(TDRX, TSSB)
		- FFS other factors are not precluded, e.g. estimated SINR level, UE mobility, N factor, P factor, RS type, FR1 or FR2.
* FFS whether scaling factor can be different for different SINR regions (e.g. high/medium SINR)

Issue 2-4-3: relaxation factor: different relaxation factor in FR1 and FR2* RAN4 further to discuss whether different relaxation factors can be allowed for FR1 and FR2 based on ongoing simulation study.

Issue 2-5-1: Reverting to the normal RLM operationThe 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).* FFS the following options
	+ Option 1a: revert when the relaxation criterion is not met
	+ Option 1b: revert when N310 starts to count, i.e. 1 out-of-sync indication.
	+ Option 1c: revert when T310 is running, i.e. N310 out-of-sync indication.
	+ Option 1d: revert when observed link quality degradation.
	+ Option 1e: revert regarding observed mobility state change.

Other options are not precludedIssue 2-5-2: Reverting to the normal BFD operation* Option 1: Reverting to the normal BFD operation upon detect 1 beam failure instance indication.
* Option 2: The UE while performing relaxed BFD upon beam failure detection reverts to the normal BFD operation (i.e. without relaxation).
* Option 3: There might be no benefit to configure conditions for UE reverting to normal BFD.
* Option 4: Whether reverting to normal BFD operation aligns with whether reverting to normal RLM operation

Other options are not precluded.Issue 2-5-3: Relaxation of RLM/BFD when not all serving cells in intra-band CA/DC meets relaxation criteriaThe following options have been discussed in this meeting* + Option 1: For intra-band CA case, the UE should relax only on serving cells where the relaxed criteria is fulfilled.
	+ Option 2: if UE has fulfilled the criterion for operating RLM/BFD in relaxed mode in one serving cell (SpCell), then it is allowed to operate RLM/BFD in relaxed mode in all other serving cells (e.g. Scells).
	+ Option 3:if UE has failed to fulfil the criterion for operating RLM/BFD in relaxed mode in one serving cell (SpCell), then it shall revert to normal RLM/BFD operation (i.e. without relaxation) in all other serving cells (SCells).
	+ Other options are not precluded.
	+ FFS how many cells that UE is required to perform RLM/BFD in intra-band CA/DC.

Issue 2-5-4: Relaxation on PDCCH monitoringNot to further discuss whether PDCCH monitoring should be relaxed until RAN1 design is stable.Agreement: Issue 2-5-4 Relaxation on PDCCH monitoring is kept as FFS.Issue2-5-5: Relaxation rules among serving cells for intra-band CA/DC scenario* FFS
	+ Option1: For intra-band CA case, RAN4 to define the same RLM/BFD measurement relaxation criteria for the serving cells.

Other options are not precluded**The following are for information*** Based on simulation results submitted for RAN4#98e meeting, it can be observed that
	+ With FTP model is considered with DRX of 40 ms, if L1 measurement intervals for RRM are also extended K times
		- For FR1 SSB-based RLM/BFD relaxation, at least 3 sources show that the power saving gain is 8.7% to 16.4% for K=2, 13% to 20.5% for K=4, and 15.1% to 25.8% for K=8.
		- For FR2 CSI-RS based RLM/BFD relaxation, one source shows that the power saving gain is 15.6% for K=2, 21.8% for K=4.
	+ By extending only RLM/BFD measurement interval without extending RRM measurement interval
		- At least 2 sources show minimal or no power saving gain.
* Based on simulation results submitted for RAN4#98e meeting, it can be observed that
	+ Regarding delta SINR, for FR1 SSB-based RLM OOS relaxation,
		- with mobility of 3 km/h, at least 2 sources show that the delta SINR is 1.3 dB to 2dB for K=2 , 2.6 dB for K=4, less than 8dB for K=8.
		- with mobility of 30 km/h, at least 2 sources show that the delta SINR is 2.8 dB to 4.6dB for K=2 , 5.1 to 6.2 dB for K=4, 7.4 to 8.8 dB for K=8.
	+ Regarding delta SINR, for FR1 SSB-based BFD/INS relaxation, it can be observed that the delta SINR is less than the delta SINR observed for FR1 SSB-based RLM OOS relaxation.
	+ Regarding increased RLF latency, for FR1 SSB-based RLM OOS relaxation,
		- with mobility of 3 km/h, at least 2 sources show that the increased latency is less than 40ms for K=2, less than 120ms for K=4, and less than 280ms for K=8 with 95% probability.
			* The increase is less than 2.5% for K=2, less than 7.5% when K=4 and less than 17.5% when K=8, as T310 = 1000ms and N310 = 1.
		- with mobility of 30 km/h, at least 2 sources show that the increased latency is less than 40ms for K=2, less than 120ms for K=4, and less than 280ms for K=8 with 95% probability.
			* The increase is less than 2.5% for K=2, less than 7.5% when K=4 and less than 17.5% when K=8, as T310 = 1000ms and N310 = 1.

**Approved: Updated evaluation assumptions for R17 RLM/BFD relaxation (R4-2104066)****Approved: Work Plan of Rel-17 Power Saving Enhancements (R4-2103669)** |

#### 2.4.2 Remaining open issues

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

* Prioritized topics for study phase:
	+ Confirmation on beneficial Scenarios, from UE power saving gain perspective
	+ Feasible Scenarios for Power Saving, from system impact perspective
	+ Criteria which the UE is allowed to relax the RLM/BM requirements
	+ Scheme of RLM/BFD measurements relaxation
	+ Reverting to the normal RLM operation
	+ Reverting to the normal BM operation
* Other topics for further specification:
	+ The applicability of DRX cycles for RLM/BFD relaxation
	+ How to consider serving cell’s quality as relaxation criteria
	+ How to consider UE mobility as relaxation criteria
	+ Network or UE to determine if the criteria for relaxation is fulfilled
	+ Relaxation factor determination
	+ Relaxation factor: different relaxation factor in FR1 and FR2
	+ Relaxation of BM when not all serving cells in intra-band CA/DC meets relaxation criteria
	+ Relaxation on PDCCH monitoring
	+ Relaxation rules among serving cells for intra-band CA/DC scenario
	+ NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS

## 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-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 #104-e Meeting*** **Potential paging enhancements:**

R1-2101948 Summary for Paging Enhancements Moderator (MediaTek)R1-2100168 Further discussion on Paging enhancements for power saving OPPOR1-2100216 Paging enhancement(s) for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2100392 Paging enhancement for UE power saving CATTR1-2100394 Details of PEI configuration CATTR1-2100452 Paging enhancements for idle/inactive mode UE power saving vivoR1-2100454 Discussion on paging grouping vivoR1-2100523 Discussion on power saving enhancements for paging ZTE , SanechipsR1-2100525 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE , SanechipsR1-2100544 Potential paging enhancements TCL Communication Ltd.R1-2100591 Design of paging early indication for idle/inactive-mode UE power saving MediaTek Inc.R1-2100662 On paging enhancements for UE power saving Intel CorporationR1-2100824 Discussion on potential paging enhancements Spreadtrum CommunicationsR1-2100866 Paging enhancement in Idle/Inactive state SonyR1-2100903 Discussion on potential paging enhancements LG ElectronicsR1-2100998 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2101052 Discussion on paging early indication design CMCCR1-2101125 Paging enhancement for power saving XiaomiR1-2101217 Discussion on paging enhancements SamsungR1-2101300 On paging enhancement PanasonicR1-2101392 Paging early indication for idle/inactive-mode UE AppleR1-2101474 Paging enhancements for idle/inactive UE power saving Qualcomm IncorporatedR1-2101503 Paging enhancements for UE power saving InterDigital, Inc.R1-2101720 Paging indication based on sub-time units InterDigital, Inc.R1-2101555 Design of Paging Enhancements EricssonR1-2101622 Discussion on paging enhancements NTT DOCOMO, INC.R1-2101664 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2101218 Moderator summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)R1-2100169 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2100217 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2100393 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2100453 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2100524 TRS for RRC idle and inactive UEs ZTE , SanechipsR1-2100545 TRS/CSI-RS occasion(s) for idle/inactive UEs TCL Communication Ltd.R1-2100592 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2100663 TRS/CSI-RS functionality during idle/inactive mode Intel CorporationR1-2100814 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2100867 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SonyR1-2100904 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2100999 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2101053 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCCR1-2101126 On TRS/CSI-RS occasion(s) for idle/inactive UEs XiaomiR1-2101219 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2101301 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2101393 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving AppleR1-2101475 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2101504 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2101544 On TRS/CSI-RS occasions for idle/inactive UEs SharpR1-2101556 Provisioning of TRS occasions to Idle/Inactive UEs EricssonR1-2101623 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2101665 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**

R1-2101893 FL summary#1 of power saving for Active Time Moderator (vivo)R1-2100170 DCI-based power saving adaptation solutions OPPOR1-2100218 Extension(s) to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSiliconR1-2100395 PDCCH monitoring adaptation CATTR1-2100455 Discussion on DCI-based power saving adaptation in connected mode vivoR1-2100498 Extension to Rel-16 DCI-based power sabing adaptation during DRX Active Time GDCNIR1-2100526 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE , SanechipsR1-2100593 On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.R1-2100664 Discussion on PDCCH monitoring reduction techniques during active time Intel CorporationR1-2100815 Discussion on power saving techniques for connected-mode UEs Spreadtrum CommunicationsR1-2100905 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG ElectronicsR1-2100980 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation Asia Pacific Telecom, FGIR1-2101000 Enhanced DCI based power saving adaptation Lenovo, Motorola MobilityR1-2101054 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2101220 Discussion on DCI-based power saving techniques SamsungR1-2101285 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IISR1-2101302 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime PanasonicR1-2101394 Enhanced DCI-based power saving adaptation AppleR1-2101476 DCI-based power saving adaptation during DRX ActiveTime Qualcomm IncorporatedR1-2101505 PDCCH monitoring reduction in Active Time InterDigital, Inc.R1-2101558 Design of active time power savings mechanisms EricssonR1-2101567 Power saving adaptation during Active Time ASUSTeKR1-2101624 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2101666 UE power saving enhancements for Active Time Nokia, Nokia Shanghai Bell* **Others**

R1-2101557 Modeling of Network Power Consumption EricssonR1-2101740 Analysis on power consumption for IDLE mode UE Huawei, HiSiliconR1-2100171 Discussion on RLM relaxation OPPOR1-2100396 System overhead analysis of PEI and TRS/CSI-RS for IDLE mode UE CATTR1-2100456 Discussion on RLM/BFD/RRM relaxation vivoR1-2100527 Further discussion on potential power saving schemes for RRC connected UEs ZTE , SanechipsR1-2100816 Discussion on other power saving techniques Spreadtrum CommunicationsR1-2101257 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2101559 Evaluation results for UE power saving schemes Ericsson |
| **RAN2 Contributions** |
| **RAN2 #113-e Meeting****Organizational, Scope and Requirements:**R2-2100029 LS on Paging Enhancement (R1-2009801; contact: MediaTek) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2R2-2100030 LS on signalling method for TRS/CSI-RS occasion(s) for idle/inactive UE(s) (R1-2009848; contact: Samsung) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2**Idle/inactive-mode UE power saving:**R2-2100389 Report of [POST112-e][064][Pow17] Group Determination (Intel) Intel CorporationR2-2101301 Network assigned subgrouping Intel CorporationR2-2100143 Paging Enhancements\_UE Grouping Samsung Electronics Co., LtdR2-2100144 Paging Enhancements\_DRX cycle for monitoring paging Samsung Electronics Co., LtdR2-2100153 Discussion on paging enhancement for power saving OPPO discussionR2-2100298 Considerations on UE grouping mechanism with Paging Enhancement CATTR2-2100313 Power saving enhancements for paging reception Qualcomm IncorporatedR2-2100390 Discussion on paging enhancement Xiaomi CommunicationsR2-2100457 Paging enhancement in idle inactive mode for power saving vivoR2-2100682 Paging Enhancements for UE Power Savings Convida WirelessR2-2100852 NR UE Power Save Paging IDLE/INACTIVE UE Grouping Schemes AppleR2-2100911 Discussion on enhancements for idle/inactive-mode UE power saving SonyR2-2100993 UE subgrouping for paging enhancement LG Electronics Inc.R2-2100994 draft LS on Paging Enhancement for UE power saving LG Electronics Inc.R2-2101115 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2101148 Detail on paging sub-grouping indication and determination Nokia, Nokia Shanghai BellR2-2101274 Paging enhancements for idle/inactive mode UE Huawei, HiSiliconR2-2101539 UE-Group Paging Early Indication MediaTek Inc.R2-2101738 Paging enhancements EricssonR2-2101841 Paging Enhancements for Power Saving Asia Pacific Telecom, FGIR2-2101887 Considerations on UE paging enhancement CMCCR2-2101895 Further discussion on UE grouping ZTE corporation, Sanechips * Other aspects RAN2 impacts

R2-2100458 RAN2 impacts on TRS/CSI-RS in idle inactive mode vivoR2-2100816 TRS/CSI-RS for idle and inactive mode UE SHARP CorporationR2-2100912 Discussion on TRS/CSI-RS configuration of idle/inactive-mode UEs SonyR2-2101275 On potential TRS/CSI-RS for idle/inactive mode UE Huawei, HiSiliconR2-2101310 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai Bell R2-2101739 TRS/CSI-RS exposure EricssonR2-2101888 Considerations on TRS CSI-RS occasion(s) for idle inactive UE(s) CMCCR2-2100853 NR UE Power Save TRS/CSI-RS Signaling for IDLE/INACTIVE UEs AppleR2-2100154 Discussion on signaling aspects of TRS/CSI-RS occasion(s) for idle/inactive Ues OPPOR2-2100299 Considerations on configuration of TRS/CSI-RS CATTR2-2100345 Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi CommunicationsR2-2101302 TRS/CSI-RS configuration and availability for idle/inactive-mode UE Intel Corporation   |
| **RAN4 Contributions** |
| **RAN4 #98-e Meeting**R4-2103719 Email discussion summary: [98e][238] NR\_UE\_pow\_sav\_enh\_RRM Moderator (MediaTek)* **General and work plan [NR\_UE\_pow\_sav\_enh]:**

R4-2103669 Work plan of Rel-17 Power Saving Enhancements MediaTek inc.* **UE measurements relaxation for RLM and/or BFD [NR\_UE\_pow\_sav\_enh-Core]**

R4-2100043 On RLM and RLF relaxation for UE power saving ZTE CorporationR4-2100219 UE measurements relaxation for RLM and/or BFD AppleR4-2100474 Discussion on RLM/BFD relaxation factor CATTR4-2100478 Initial performance evaluation for for RLM/BFD relaxation factor CATTR4-2100725 Discussion on relaxation of RLM/BFD measurements XiaomiR4-2100821 Discussion on RLM/BFD relaxation for NR power saving enhancement CMCCR4-2101139 Discussion and simulation results for RLM/BFD measurement relaxation NokiaR4-2101222 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc.R4-2101462 Discussion on R17 RLM/BFD relaxation vivoR4-2101463 Simulation results for R17 RLM/BFD relaxation vivoR4-2101542 Discussion on UE measurement relaxation for RLM and/or BFD OPPOR4-2101685 Discussion on feasibility of RLM/BFD measurement relaxation scheme for power saving enhancements Huawei, HiSiliconR4-2102239 Updated simulation assumptions for evaluating UE power saving for RLM and BM EricssonR4-2102240 Simulation results on UE power saving for RLM and BM EricssonR4-2102241 Discussions on UE power saving for RLM and BM EricssonR4-2102587 Discussion on RLM/BFD Relaxation Qualcomm IncorporatedR4-2103670 WF on R17 UE power saving RLM/BM relaxation MediaTekR4-2104066 Updated evaluation assumptions for R17 RLM/BFD relaxation vivo, MediaTek |