**3GPP TSG RAN WG1 #102-e R1-200xxxx**

**e-Meeting, Aug 17th – 28nd, 2020**

**Title: [draft]** LS on evaluation methodology for UE power saving enhancements

**Response to:**

**Release:** Release 17

**Work Item:** NR\_UE\_pow\_sav\_enh

**Source:** MediaTek, RAN1

**To:** RAN2

**Cc:** RAN4

**Contact Person:**

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**Attachments:** None

**1. Overall Description:**

In response to WID of Rel-17 UE power saving enhancements, RAN1 is expected to inform RAN2 about the evaluation methodology updates related to paging enhancement(s) as well as the evaluation assumptions related to connected-mode power saving enhancements.

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| --- |
| 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
	1. (Omitted)
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.
	1. (Omitted)
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Accordingly, RAN1 would like to inform RAN2 the following related agreements:

1. Evaluation methodology updates for paging enhancements:

Agreements:

For study of Rel-17 paging enhancement, the following are assumed as a baseline for FR1 and FR2:

* Reference configuration for FR1/FR2 as specified in Section 8.1.1/8.1.2 of TR 38.840
	+ Note: the setting for some PDSCH parameters may not be applicable for RedCap UEs
* Baseline paging cycle length: [1.28] second
* SS burst related assumptions:
	+ 20 ms periodicity
	+ 2 ms duration for serving cell RRM measurement, which can overlap with the one for synchronization before PO
	+ FFS time/frequency tracking
* Measurement related assumptions:
	+ 20 ms SMTC periodicity
	+ 2 ms SMTC window for intra-frequency RRM measurement, assuming synchronized deployment
	+ [5 ms SMTC window and 6 ms measurement gap for inter-frequency RRM measurement]
		- Note: RAN4 requirement assumes one frequency layer per measurement gap, and 0.5 ms is assumed for switch in/out a frequency layer
* Note: the inclusion of potential TRS/CSI-RS occasions can be considered

Agreements:

The following power consumption model for FR1 is utilized for the evaluations of Rel-17 UE power saving enhancements in idle/inactive mode

* FFS: FR2 power consumption model for idle/inactive mode operations

|  |  |  |
| --- | --- | --- |
| Power State | Relative Power(FR1 reference from TR 84.840) | Relative Power (Idle/inactive-mode operation with reception bandwidth 20 MHz) |
| Deep Sleep (PDS) | 1 | 1 |
| Light Sleep (PLS) | 20 | 20 |
| Micro sleep (PMS) | 45 | 45 |
| PDCCH-only (PPDCCH) | 100 | 50Note |
| PDCCH + PDSCH (PPDCCH+PDSCH) | 300 | 120 |
| PDSCH-only (PPDSCH) | 280 | 112 |
| SSB/CSI-RS proc. (PSSB) | 100 (synchronization or serving cell measurement) | 50 |
| Intra-frequency RRM measurement (Pintra) | ·        150 (synchronous case, N=8, measurement only; Pintra, meas-only)·        200 (combined search and measurement; Pintra, search+meas) | ·        [60] (synchronous case, N=8, measurement only; Pintra, meas-only)·        [80] (combined search and measurement; Pintra, search+meas) |
| Inter-frequency RRM measurement (Pinter) | ·        150 (measurement only per freq. layer; Pinter, meas-only)·        150 (neighbor cell search power per freq. layer; Pinter, search-only)·        Micro sleep power assumed for switch in/out a freq. layer | ·        [60] (measurement only per freq. layer; Pinter, meas-only)·        [150] (neighbor cell search power per freq. layer; Pinter, search-only)·        Micro sleep power assumed for switch in/out a freq. layer |
| Note: Power scaling to 20MHz reception bandwidth follows the rule in Section 8.1.3 of TR 38.840, i.e., max{reference power \* 0.4, 50}. |

Agreements:

Group paging rate of 10% is assumed for the evaluation of Rel-17 paging enhancement

* FFS: Another group paging rate > 10%
* Note: If UE sub-grouping is applied, the sub-group paging rate can be reduced w.r.t. the total sub-group number for a PO

Agreements:

For the study on paging enhancements to reduce unnecessary paging reception, the following metrics are considered:

* UE power saving gain (relative to a given feature or overall)
* Impact to UE paging detection probability
	+ FFS: Link level simulation assumptions
* System impact, including
	+ Additional resource overhead and its implications
	+ Impact to Rel-15/Rel-16 idle/inactive-mode UEs and connected-mode UEs
	+ Impact to other legacy functionalities, including SI change and ETWS indication
	+ [Note: NW energy consumption evaluation is not precluded]

Agreements:

* For the study of paging enhancement, 1, 2, or 3 SS burst processing is assumed before PO
	+ Note: in choosing one or more values (1, 2, or 3) for the evaluations, companies to provide justification

Proposed Agreements:

For the estimation of average power consumption for idle/inactive mode UE over a paging cycle, the following example calculations for FR1 can be referenced. Companies to report the assumed UE processing timeline(s) with justification for the estimation of average power consumption.

* Example 1: 3 SS bursts are utilized before PO (e.g. for low SNR)

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| --- | --- | --- |
| **UE operations in a paging cycle** | **Time duration (ms)** | **Energy contribution(relative power \* ms)** |
| SSB processing  | 2 | PSSB \* 2 |
| Light sleep | 18 | PLS \* 18 + 100Note1 |
| SSB processing  | 2 | PSSB \* 2 |
| Light sleep | 18 | PLS \* 18 + 100 Note1 |
| SSB processing and intra-frequency RRM measurement | 2 | (PSSB + (Pintra, search+meas \* [1/4]Note2 + Pintra, meas-only \* (1 – [1/4] Note2) ) ) \* 0.85Note3 \* 2 |
| Light sleep | 8 | PLS \* 8 + 100 Note1 |
| PO reception | 4 | (PPDCCH \* (1 – RG) +PPDCCH+PDSCH \* RGNote4) \* 4 |
| Light sleep | 6 | PLS \* 6 + 100 |
| Switch to another frequency layer | 0.5 | PMS \* 0.5 |
| Inter-freq. RRM measurement | 5 | (Pinter, search-only \* [1/4]Note2 + Pinter, meas-only \* (1 – [1/4] Note2) ) \* 5 |
| Switch back to serving frequency | 0.5 | PMS \* 0.5 |
| Deep sleep | 1214  | PDS \* 1214 + 450Note5 |
| **(Total)** | **1280** | **Total Energy**  |
| **Average power consumption = Total Energy / 1280** |
| Note 1: Additional transition energy (relative power \* ms) for light sleep as specified in Table 19 of TR 38.840Note 2: Cell search rate for intra/inter-frequency RRM measurement Note 3: Scaling convention to combine two different types of UE operations as in Section 8.1.3 of TR 38.840Note 4: RG is the paging rate to the UE groupNote 5: Additional transition energy (relative power \* ms) for deep sleep as specified in Table 19 of TR 38.840 |

* Example 2: 2 SS bursts are utilized before PO (e.g. for medium SNR)

|  |  |  |
| --- | --- | --- |
| **UE operations in a paging cycle** | **Time duration (ms)** | **Energy contribution(relative power \* ms)** |
| SSB processing  | 2 | PSSB \* 2 |
| Light sleep | 18 | PLS \* 18 + 100 Note1 |
| SSB processing and intra-frequency RRM measurement | 2 | (PSSB + (Pintra, search+meas \* [1/4]Note2 + Pintra, meas-only \* (1 – [1/4] Note2) ) ) \* 0.85Note3 \* 2 |
| Light sleep | 8 | PLS \* 8 + 100 Note1 |
| PO reception | 4 | (PPDCCH \* (1 – RG) +PPDCCH+PDSCH \* RGNote4) \* 4 |
| Light sleep | 6 | PLS \* 6 + 100 |
| Switch to another frequency layer | 0.5 | PMS \* 0.5 |
| Inter-freq. RRM measurement | 5 | (Pinter, search-only \* [1/4]Note2 + Pinter, meas-only \* (1 – [1/4] Note2) ) \* 5 |
| Switch back to serving frequency | 0.5 | PMS \* 0.5 |
| Deep sleep | 1254  | PDS \* 1254 + 450Note5 |
| **(Total)** | **1280** | **Total Energy**  |
| **Average power consumption = Total Energy / 1280** |
| Note 1: Additional transition energy (relative power \* ms) for light sleep as specified in Table 19 of TR 38.840Note 2: Cell search rate for intra/inter-frequency RRM measurement Note 3: Scaling convention to combine two different types of UE operations as in Section 8.1.3 of TR 38.840Note 4: RG is the paging rate to the UE groupNote 5: Additional transition energy (relative power \* ms) for deep sleep as specified in Table 19 of TR 38.840 |

* Example 2: 1 SS burst is utilized before PO (e.g. for high SNR)

|  |  |  |
| --- | --- | --- |
| **UE operations in a paging cycle** | **Time duration (ms)** | **Energy contribution(relative power \* ms)** |
| SSB processing and intra-frequency RRM measurement | 2 | (PSSB + (Pintra, search+meas \* [1/4]Note1 + Pintra, meas-only \* (1 – [1/4] Note1) ) ) \* 0.85Note2 \* 2 |
| Light sleep | 8 | PLS \* 8 + 100 Note3 |
| PO reception | 4 | (PPDCCH \* (1 – RG) +PPDCCH+PDSCH \* RGNote4) \* 4 |
| Deep sleep | 1266 | PDS \* 1266 + 450Note5 |
| **(Total)** | **1280** | **Total Energy**  |
| **Average power consumption = Total Energy / 1280** |
| Note 1: Cell search rate for intra/inter-frequency RRM measurement Note 2: Scaling convention to combine two different types of UE operations as in Section 8.1.3 of TR 38.840Note 3: Additional transition energy (relative power \* ms) for light sleep as specified in Table 19 of TR 38.840Note 4: RG is the paging rate to the UE groupNote 5: Additional transition energy (relative power \* ms) for deep sleep as specified in Table 19 of TR 38.840 |

1. Evaluation assumptions for connected-mode power saving enhancements:

Agreements:

* Reusing power model in TR38.840 for evaluation of DCI-based power saving adaptation schemes.
	+ Note: company reporting additional power model for missing state or update is not precluded.

Agreements:

* Company should report assumptions used for periodic measurement activities for the Rel-17 DCI-based power saving adaptation evaluation.
	+ The periodic activities defined in TR38.840 can be reused.
	+ Measurement for RLM/BFD every C-DRX cycle can be optionally modelled

Proposed Agreements:

* The performance metrics described in TR38.840 section 8.2 is reused for power saving evaluation of Rel-17 DCI-based power saving adaptation during ActiveTime.
* The following Rel-15 / 16 features is recommended of the power consumption as reference for baseline. Company can report the feature combinations being used in the analysis.
	+ DRX
		- C-DRX cycle 40msec for VoIP
			* 10ms IAT, 8ms On-duration
			* Assume max two packets bundled
		- C-DRX cycle 160msec for FTP
			* Alt 1: 20 msec IAT, 8ms On-duration
			* Alt 2: short DRX
				+ 20 ms IAT, 8ms On-duration
				+ 20 ms for short DRX cycle, 4 cycles
		- C-DRX cycle 40ms for [‘frequent data traffic’ / ’optional traffic model’] if defined in Rel-17
			* 10ms IAT, 8ms On-duration
		- Note: Other settings are not precluded and up to company to report
	+ DCP for DRX adaptation,
		- DCP offset  to DRX ON = 2 ms, other values are not precluded
	+ Cross-slot scheduling adaptation
		- Minimum K0 can be adapted from 0 to 1 for FR1, 0 to [4] for FR2
	+ BWP switching, including
		- MIMO layer adaptation,
			* Max # of MIMO layer can be adapted from 4 layer to 2 layer for FR1, 2 layer to 1 layer for FR2
		- PDCCH monitoring period adaptation
			* PDCCH monitoring period can be adapted from per slot monitoring to X slot monitoring
				+ X = [2] for FR1 and [8] for FR2
		- Bandwidth adaptation
			* Bandwidth can be adapted from 100MHz to 20MHz for FR1, FFS for FR2
		- Note:
			* BWP transition time type 2 is assumed, BWP transition duration is
				+ 5 slot @ 30kHz SCS for FR1,
				+ 18 slot@120kHz SCS for FR2
				+ the slot-average power level for BWP transition duration is according to TR38.840
				+ BWP transition time type 1 can be optional modelled
			* Whether BWP switching is modeled depends on the assumed UE capability and evaluated schemes.
	+ Scell dormancy assumption for CA capable UEs
		- FR1 & FR2: SCell dormancy with [160 ms] periodic CSI measurement and reporting
* Other settings
	+ CA assumption if configured for CA capable UEs
		- For FR1, FFS
		- For FR2, 4\*100MHz can be considered.
	+ Assumptions for scheduler
		- For FR1, no restriction on the beam assumptions being used in each slot
		- For FR2, gNB equally schedule the slots for UEs targeting to different beams.
		- Baseline indication delay from last data scheduling to power saving indication sent by the gNodeB
			* BWP switching
				+ BWP switching indication is Y (ms) after last PDSCH of a packet/data burst

Y = [8], other values are not precluded

* + - Note: the assumptions does not necessary mean to restrict or precluded any implementation. Other assumptions are not precluded and can be reported by companies.

**2. Actions:**

**To RAN2:**

RAN1 respectfully asks RAN2 to take the evaluation methodology for paging enhancements into account in the corresponding RAN2 study. For the connected-mode evaluation assumptions, if there is significant concern, please reply RAN1 with the suggested change(s).

**3. Date of Next RAN1 Meetings:**

TSG-RAN WG1 Meeting 103-e 26 October – 13 November 2020 e-Meeting

TSG-RAN WG1 Meeting 104 01 – 05 March 2021 Athens, Greece