

3GPP RAN #84
Newport Beach
3-6 June 2019

RP-190993

Qualcomm

Agenda Item: 9.4.6

Qualcomm Incorporated

Views on UE power saving WI



Considerations for WID Update

- RAN1 has been working on UE power saving WI for two meetings (#96bis and #97) since the WI was approved in RAN #83
 - Currently RAN1 has the following sub-agendas for UE power saving
 - 7.2.9.1 PDCCH-based power saving signal/channel
 - Power saving techniques to be supported by the power saving signal/channel are to be concluded by RAN2 SI
 - 7.2.9.2 Procedure of cross-slot scheduling power saving techniques
 - Near completion
- RAN2 started working on UE power saving SI since RAN #83 and it is to be concluded in #84
 - Some of the sub-agenda items may have RAN1 impact but further study is needed
 - 11.11.4.1 PDCCH-based power saving signals/channel
 - FFS UE behaviors when WUS collides with legacy DRX active time and when there is a miss detection of WUS
 - 11.11.4.2 DCI-based power saving adaptation
 - FFS Whether to support PDCCH-monitoring skipping and whether it should be enabled only when DRX is configured
 - 11.11.4.3 BWP/SCell operation in RRC_CONNECTED
 - FFS Whether MIMO layer adaptation should be per-BWP
 - Some other RAN2 agenda items need further study due to the limited TUs available in the SI
 - 11.11.2 Power saving enhancements of paging procedure
 - FFS whether to support extending the DRX cycle length to 10.24s in idle and inactive mode, and techniques to reduce false alarm rate
 - 11.11.3 Efficient transition from RRC_CONNECTED to RRC_IDLE/RRC_INACTIVE
 - FFS mechanism for a UE to indicate its preference of transitioning out of RRC_CONNECTED state
 - 11.11.4.4 Other aspects of power saving in RRC_CONNECTED
 - FFS methods to reduce power consumption in CA/DC configuration. Additional DRX enhancements
 - 11.11.5 Power consumption reduction in RRM measurements
 - FFS Measurement relaxation rules, involving RAN4
- Only 3 meetings remaining with 1 TU each

Importance of FR2 power optimization

- UE power consumption for FR2 is generally higher than for FR1
 - For the same CC bandwidth, the following power consumption model for FR1 (30kHz SCS) and FR2 (120kHz SCS) is agreed (TR 38.840):

Power State	Characteristics	Relative Power	
		FR1	FR2
PDCCH-only	No PDSCH and same-slot scheduling; this includes time for PDCCH decoding and any micro-sleep within the slot.	100	175
SSB or CSI-RS proc.	SSB can be used for fine time-frequency sync. and RSRP measurement of the serving/camping cell.. TRS is the considered CSI-RS for sync. FFS the power scaling for processing other configurations of CSI-RS. (Note 2 SSBs in a slot for the ref. config.)	100	175
PDCCH + PDSCH	PDCCH + PDSCH. ACK/NACK in long PUCCH is modeled by UL power state.	300	350
UL	Long PUCCH or PUSCH.	250 (0 dBm) 700 (23 dBm)	350 (FFS Tx power level)

- **→ UE power consumption for PDCCH monitoring for FR2 is 75% higher than FR1**
- CA usage for FR2 is prevalent, exacerbating high power consumption issue
 - Scaling factor of 1.7x for 2CC and 3.4x for 4CC (for DL, compared to 1CC) is agreed in TR 38.840
- Power saving for deployments involving FR2 (e.g. FR2 CA, FR1+FR2 CA) is extremely important
- **Our view** is to prioritize power saving techniques which can be highly effective for FR2
 - [Wake-up signaling](#): Monitored on PCell/PSCell and applied to multiple SCells
 - [SCell power saving](#): Minimize PDCCH monitoring on FR2 SCells
 - [PDCCH skipping](#): Take advantage of tendency for NW to schedule UE in TDM manner (due to analog BF)

RAN1 Priorities

Qualcomm views

- Current WI topics in RAN1
 - Continue working on the remaining issues for PDCCH-based power saving signal/channel (7.2.9.1) and cross-slot scheduling power saving technique (7.2.9.2)
- WI scope/topics to be updated in RAN1
 - Confirm and augment the scope for RAN1 sub-agenda item 7.2.9.1 to support the following
 - Wake-up signaling for C-DRX
 - Include potential support for SCell power saving enhancements
 - PDCCH skipping
- Introduce new sub-agenda items for the following
 - [SCell power saving enhancements](#) (clarify which agenda this should be discussed in)
 - Allow UE to reduce power consumption for SCell by suspending PDCCH monitoring or by dormancy behavior
 - [Adaptation of maximum number of MIMO layers](#) (can be combined with BWP enhancement below)
 - Reduced max number of MIMO layers can be configured for particular BWP(s). Adaptation based on BWP switching
 - To minimize spec impact, reduced number of antennas facilitated by above can be based on UE implementation transparent to the NW
 - [BWP enhancements](#) (may start after cross-slot scheduling completion)
 - Improved BWP switching supported with PDCCH-based power saving signal/channel
 - Lower switch delay for non-RF parameters change, triggering of A-CSI with BWP switch

RAN2 Priorities

Qualcomm views

- Currently there are too many topics to study with only one TU
 - RAN2 may risk not being able to generate useful output in the WI, because limited meeting time has to be spread among topics
- What RAN2 can do to be more productive
 - Focus on a few key topics that have the most impact on power saving
 - Increase its TU by re-locating meeting time previously reserved for Rel-15 CRs but no longer needed
- Topics to focus on: power saving enhancements in RRC_CONNECTED
 - RAN2 aspects of power saving signal/channels
 - Power saving enhancements for CA/DC configuration, especially those related to FR2 deployment
 - Additional enhancements for DRX, with a focus on differentiated DRX procedures on FR1 and FR2 cells
 - Other misc topics under RRC_CONNECTED
 - UE assistance information for power saving
 - Fast RRC state transition

SCell power saving: Logistics

- Coordination is needed between UE power saving and MR-DC/CA for SCell power saving
 - RAN1: 7.2.13.4 Support of efficient and low latency serving cell configuration/activation/setup
 - In official email discussion (R1-1905915), the following is noted:
 - If supported, additional L1 signaling mechanisms can enable fast adaptation from sparse/no PDCCH monitoring to more frequent PDCCH monitoring on the activated Scells.*
 - *Potential additional L1 signalling mechanisms include*
 - *Using DCI on Pcell to control PDCCH monitoring on Scell(s)*
 - *Configuring Scell(s) with two different BWPs, one with frequent PDCCH monitoring occasions and one with sparse/no PDCCH monitoring, and using DCI on Pcell to switch BWPs on Scell(s). The BWPs can have different CSI measurement/reporting configuration.*
 - RAN2: 11.10.4.2 LTE_NR_DC_CA_enh-Core
 - The following agreement was reached in RAN2 #106:
 - 1 *SCell dormant state like LTE euCA will not be introduced in NR.*
 - 2 *'dormancy' behaviour will be studied as a solution for fast return to SCell utilisation for data transfer. The 'dormancy' behaviour implies that the UE stops monitoring PDCCH but continues other activities such as CSI measurements, AGC and beam management. RAN1/4 input required on feasibility and benefit.*
 - And LS (R2-1908483) was sent to RAN1 and RAN4 to ask below questions on the latency benefit and feasibility of 'dormancy' behavior and temporary RS
 - *Q 2: which part of latency can be reduced via the 'dormancy' behaviour and by how much?*
 - *Q 3: if the latency can be reduced, is it feasible to support 'dormancy' behaviour from RAN1/RAN4 perspective? If it is feasible, what are expected spec impacts from RAN1/RAN4 perspective?*
 - RAN2: The scope for 11.11.4.3 BWP/SCell operation in RRC_CONNECTED is clarified as follows
 - 'Dormant state' aspects will be discussed in 11.10.4.2 and contributions on this AI should focus on SCell enhancements after SCell is activated.*
 - Given that RAN2 has decided SCell 'dormant state' will not be introduced in NR, 'dormancy behavior' can be viewed as a form of SCell enhancement after SCell is activated, so its power saving enhancements could be within scope for 11.11.4.3
- **Our view:**
 - Discuss potential overlap between SCell PDCCH monitoring reduction and SCell dormancy behavior, and whether they should be treated in the same agenda; If in different agenda, what the differentiation would be

Possible WID Update

Additional objectives based on outcome of RAN2's UE power saving studies

1. Power saving techniques with UE adaptation with focus in RRC_CONNECTED mode [RAN1, RAN2]
 - Specify PDCCH-based power saving signal/channel triggering UE adaptation in RRC_CONNECTED
 - Support wakeup signal in triggering UE adaptation to the DRX operation in RRC_CONNECTED mode
 - Support mechanism in skipping PDCCH monitoring, including when DRX is not configured
 - Specify the procedure of cross-slot scheduling power saving techniques
 - Note: The procedure is in addition to Rel-15 cross-slot scheduling procedure
 - Specify the power saving techniques of UE adaptation to the BWP/SCell operation
 - Including potential support using the PDCCH-based power saving signal/channel
 - Specify the power saving techniques of UE dynamic adaptation to the maximum number of MIMO layers
 - Based on BWP adaptation
 - Specify the UE assistance information for the associated power saving techniques
 - Specify techniques for enabling fast state transition from RRC_CONNECTED to RRC_IDLE or RRC_INACTIVE
2. Evaluate the required switching and interruption times for UE dynamic adaptation to the maximum number of MIMO layers **based on BWP adaptation** [RAN4]
 - Note: Switching on/off the RF is part of the evaluation



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