

3GPP RAN Plenary #102

RP-233379

December 11th - 15th, 2023, Edinburgh, Scotland

Agenda Item: 9.1.1.5

# Views on Scope for NR Network Energy Savings in Rel-19

Qualcomm Incorporated

# On-demand SSB in Inter-band CA for Connected UEs

- Intra-band CA with SSB-less carriers was supported in Rel-15 for FR1 and FR2
- Inter-band CA with SSB-less carriers has been specified in Rel-18 for FR1 only
  - Feasibility requirements make the feature applicable to limited scenarios
- Rel-19 should support on-demand SSB carriers for scenarios that inter-band CA with SSB-less carriers is infeasible (e.g., FR1 with non-collocated cells and FR2).
  - On-demand SSB is used for SCell time/frequency synchronization, L1/L3 measurement and SCell activation
- **Proposal 1: Specify procedures and signaling method to support SCell operation with on-demand SSB for connected mode UEs in inter-band CA [RAN1, RAN2, RAN3, RAN4].**
  - Note: On-demand SSB is used for SCell time/frequency synchronization, L1/L3 measurement and SCell activation.

# SIB1 Transmission for Idle UEs (1/3)

- Two following options to enhance SIB1 transmission in non-anchor NES cell for idle/inactive UEs.
  - **Option 1 (on-demand SIB1):** The non-anchor cell transmits on-demand SIB1 triggered by an uplink wake-up signal using an existing signal/channel. The wake-up signal configuration is provided by the anchor cell.
  - **Option 2 (SIB1-less):** An anchor cell transmits SIB1 of the non-anchor cell.
- R19 should only specify one option to enhance SIB1 transmission. Hence, we make the following proposal.
- **Proposal 2:** Specify procedures and signaling method to enhance SIB1 transmission for a non-anchor NES cell for idle/inactive UEs. RAN down-selects one of the following options for the SIB1 transmission in the non-anchor cell.
  - **Option 1:** The non-anchor cell transmits on-demand SIB1 triggered by an uplink wake-up signal using an existing signal/channel. The wake-up signal configuration is provided by the anchor cell.
  - **Option 2:** An anchor cell transmits SIB1 of the non-anchor cell.

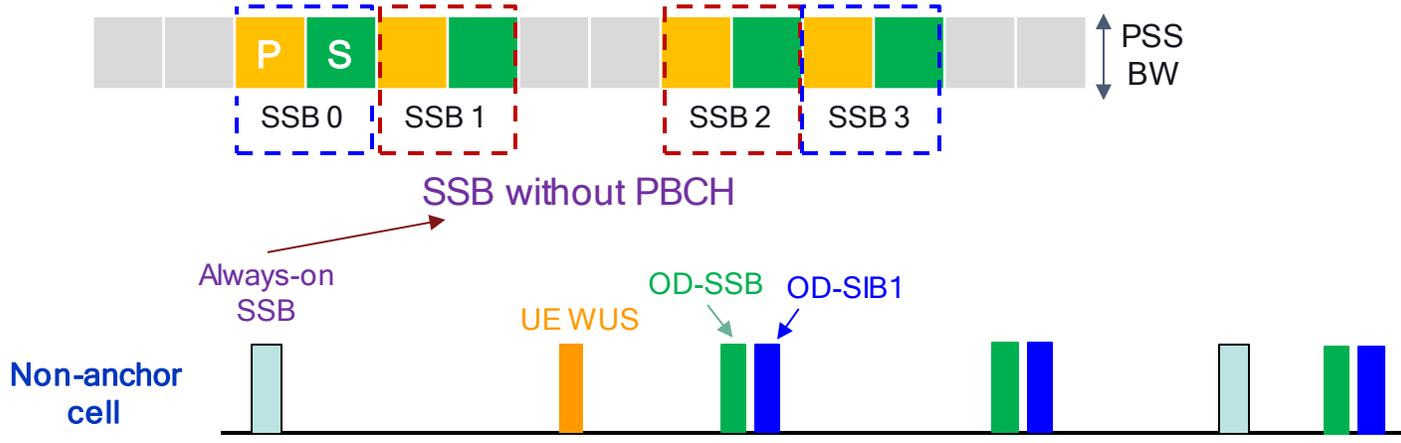
Option	SSB	SIB1	RACH	NES		
				Empty	Low load	Medium load
1	Y	On-demand	Y	10.4%	7.1%	2.0%
2	Y	N	Y	15.2%	10.4%	2.9%

*FR1, 100MHz BW, 30kHz SCS, 8 beams, 64 TxRUs, Set 1 NW power model, 20ms SSB, 160ms SIB1, 40ms RACH*

Option	SSB	SIB1	RACH	NES
1	Y	On-demand	Y	2.5%
2	Y	N	Y	2.5%

*FR2, 100MHz BW, 120kHz SCS, 32 beams, 20ms SSB/RMSI/RACH periodicity, SSB-RMSI Mux pattern 3*

# SIB1 Transmission for Idle UEs: On-demand SSB/SIB1 (2/3)



FR	SSB	SIB1	RACH	NES
FR1	Y	OD	Y	10.4%
	On-demand	On-demand	Y	22.1%
FR2	Y	OD	Y	2.5%
	On-demand	On-demand	Y	8.2%

FR1: 100MHz BW, 30kHz SCS, 8 beams, 64 TxRUs, Set 1 3GPP NW power model, 40ms WUS/RACH, 160ms SIB1, empty cell

FR2: 100MHz BW, 120kHz SCS, 32 beams, 20ms SSB/RMSI/RACH periodicity, SSB-RMSI Mux pattern 3

- Supporting only on-demand SIB1 provides minimal NES for FR2 with SSB/SIB1 Mux patterns 2/3.
- NES is higher if on-demand SSB can be supported together with on-demand SIB1 transmission
  - SSB without PBCH should be transmitted to support UE wake-up signal transmission.
- If on-demand SIB1 Tx is in R19 scope, we propose having on-demand Tx for both SSB and SIB1.
- **Proposal 3:** Specify procedures and signaling method to support on-demand transmission for both SSB and SIB1 in a non-anchor NES cell for idle/inactive UEs [RAN1, RAN2, RAN3, RAN4].
  - SSB/SIB1 transmission is triggered by an uplink wake-up signal using an existing signal/channel with its configuration provided by an anchor cell.
  - SSB without PBCH is transmitted in the non-anchor cell.

# SIB1 Transmission for Idle UEs: SSB/SIB1-less Operation (3/3)

FR	SSB	SIB1	RACH	NES
FR1	Y	N	Y	15.2%
	N	N	Y	46.5%
	Y	N	Y	2.5%
FR2	Y	N	On-demand	16.8%
	N	N	Y	16.5%
	N	N	On-demand	22.6%

*FR1, 100MHz BW, 30kHz SCS, 8 beams, 64 TxRUs, Set 1 3GPP NW power model, 40ms WUS/RACH, 160ms SIB1, empty cell*

*FR2, 100MHz BW, 120kHz SCS, 32 beams, 20ms SSB/RMSI/RACH periodicity, SSB-RMSI Mux pattern 3, on-demand RACH by NW coordination*

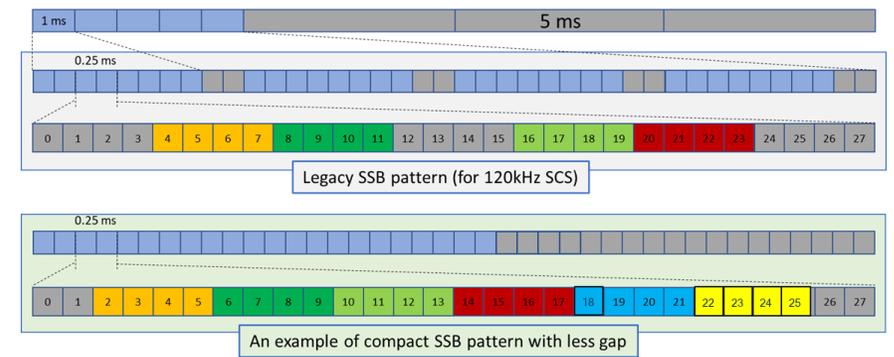
- Supporting only SIB1-less operation provides minimal NES for FR2 with SSB/SIB1 Mux patterns 2/3.
  - If SIB1-less operation is in R19 scope, it is beneficial to support RACH enhancements for non-anchor NES cell.
- In addition, NES is higher if SSB-less can be supported together with SIB1-less operation. Therefore, **if SIB1-less operation is in R19 scope, we suggest having SSB-less operation in the scope as follows**
- **Proposal 4:** Specify support for SSB/SIB1-less operation for non-anchor NES cell for UEs in idle/inactive mode. [RAN2, RAN1, RAN3, RAN4]
  - UE measures SSB of an anchor carrier for access of the non-anchor NES carrier.
  - UE can access from SIB1-less non-anchor NES cell, for which the SIB1 is carried on an anchor cell.
  - Paging is transmitted on an anchor cell.
  - Specify RACH enhancements for non-anchor NES cell.

# Compact Beam-sweeping of Broadcast Channels

- Legacy patterns for beam-sweeping of SSB and RACH occasions are defined with some time gap between consecutive beams to accommodate control and data scheduling.
  - For RMSI (in multiplexing pattern 1), and depending on number of RMSI PDCCH/PDSCH symbols, there also may be gaps.
- For no or low load scenarios, such time gaps may not be needed. More compact patterns with less time gap would be more NW energy efficient.
- Proposal 5:** Support compact beam-sweeping pattern for SSB, RACH occasions, and RMSI [RAN1, RAN4].

Scheme	Transmission				ES % (w/ no UEs)	
	SSB	SIB1	DRS	RACH	Legacy burst	Compact burst
0	Y	Y	N	Y	Baseline	8.5%
1	Y	N/OD	N	Y	2.5%	10.9%
2	N/OD	N/OD	Y	Y	8.2%	16.7%
3	N	N/OD	N	Y	16.5%	22.6%
4	Y	N	N	N/OD	16.8%	18.4%
5	N	N	Y	N/OD	22.6%	25.1%

FR2, 100MHz BW, 120kHz SCS, 32 beams, 1 TxRUs, 20ms SSB/RMSI/DRS/RACH periodicity, SSB-RMSI multiplexing pattern 3. For compact bursts, zero gap is assumed.

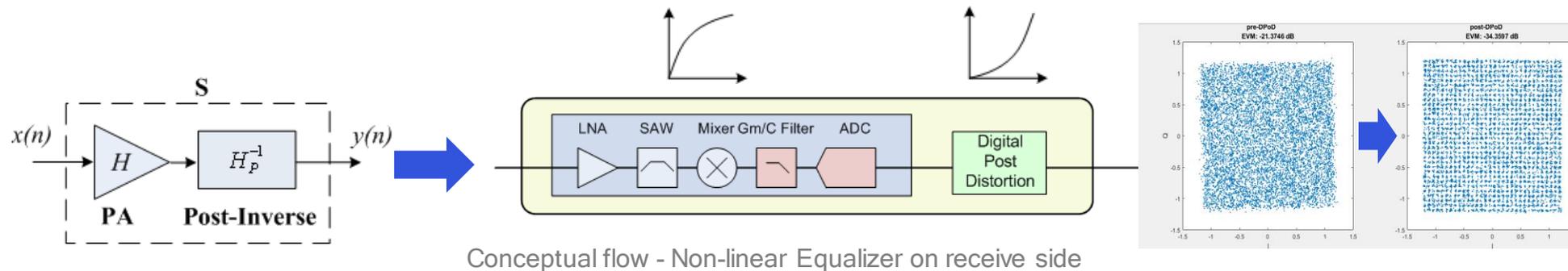


# Further Cell DTX/DRX Enhancement

- R18 cell DTX/DRX does not achieve expected NES due to a limited list of physical channels to be turned off during non-active time
  - Beneficial to further identify PHY channels to be dropped during non-active time
- Furthermore, it is beneficial to support cell DTX/DRX in mTRP deprioritized in R18 due to lack of time.
- Dynamic switching among multiple cell DTX/DRX configurations was actively discussed in R18. However,
  - Performance analysis was not provided in R18 SI
  - Compared to R18 DTX/DRX configuration, NES is expected to be negligible at high UE complexity/power.
- Supporting cell DTX/DRX for idle/inactive UEs makes significant impact to UE operation
  - Turning off SSB/SIB1 in cell DTX negatively impacts to UE cell search and idle mode operation.
  - gNB can achieve cell DTX/DRX for paging and PRACH by current implementation.
- **Proposal 6:** Specify further enhancements on cell DRX/DTX in RRC connected mode [RAN1, RAN3, RAN4]
  - Further identify physical channels to be turned off during non-active time of cell DTX/DRX
  - Specify support of cell DTX/DRX in mTRP
  - Inter-node information exchange of cell DTX/DRX configurations
- **Proposal 7:** R19 does not include multiple cell DTX/DRX configurations for a cell. In particular, dynamic switching among the cell DTX/DRX configurations is not supported.
- **Proposal 8:** Cell DTX/DRX operation is not specified for idle/inactive UEs.

# Power Domain Enhancements

- PAPR reduction techniques (D-2/3/4/5) increase the energy efficiency of the power amplifier
  - The techniques provides methods to compensate the power amplifier's non-linearity
  - The power consumption of the PA is reduced by reducing the power feed of the power amplifier. This introduce non-linearity from the reduce backoff, but is compensated by the techniques, maintaining the performance (UPT, latency...)
- Digital Post Distortion (D-5) showed the highest performance gain (16.1%, Set3 FR2)
  - PA efficiency is calculated per R1-2209996 and changing  $P_{\max}$  is based on power feed
- DPoD technique description
  - UE receiver is applying the post-distortion processing (e.g., non-linear equalization stage to “invert” the non-linearity)
  - gNB transmits reference signals or information to aid the UE to perform post-distortion processing (semi static attributes)
  - Can be combined with DPD on the gNB (optimized to reduce OOB emissions) while DPoD handles in-band distortion



- **Proposal 9:** Specify procedures and signaling to support UE post-distortion (i.e., technique D-5) [RAN1, RAN4].

# RAN3 specific enhancements

## Paging enhancements

- In Rel-18, backhaul signaling over F1AP was specified to assist in paging certain UEs (e.g., stationary UEs) in RRC\_INACTIVE i.e., gNB-DU informs gNB-CU on the last visited beams so that the gNB-CU can page the UE(s) on a limited set of beams instead of the whole cell for subsequent paging, thereby saving energy.
- A few other items were deprioritized due to lack of time, and we propose to discuss them in Rel-19:
- **Proposal 10**: Specify backhaul signaling to support the following paging enhancements [RAN3]
  - Beam-specific paging for UEs in RRC\_IDLE
  - Assistance to neighboring NG-RAN nodes for paging in specific cells/beams (e.g., for pseudo-stationary UEs)

## Enhancements to cell (de)activation

- Current specifications only allow the gNB-CU to initiate cell (de)activation.
- A gNB-DU might have better knowledge of the energy consumption of its served cells/beams and therefore should be able to initiate/assist in cell (de)activation and we therefore propose the following:
- **Proposal 11**: Specify backhaul signaling to support gNB-DU assisted/initiated cell (de)activation in case of split-gNB deployments [RAN3]



# Thank you

Follow us on: **f** **t** **in** **@**

For more information, visit us at:

[www.qualcomm.com](http://www.qualcomm.com) & [www.qualcomm.com/blog](http://www.qualcomm.com/blog)

Nothing in these materials is an offer to sell any of the components or devices referenced herein.

©2018-2020 Qualcomm Technologies, Inc. and/or its affiliated companies. All Rights Reserved.

Qualcomm is a trademark or registered trademark of Qualcomm Incorporated. Other products and brand names may be trademarks or registered trademarks of their respective owners.

References in this presentation to “Qualcomm” may mean Qualcomm Incorporated, Qualcomm Technologies, Inc., and/or other subsidiaries or business units within the Qualcomm corporate structure, as applicable. Qualcomm Incorporated includes Qualcomm’s licensing business, QTL, and the vast majority of its patent portfolio. Qualcomm Technologies, Inc., a wholly-owned subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, substantially all of Qualcomm’s engineering, research and development functions, and substantially all of its product and services businesses, including its semiconductor business, QCT.