3GPP TSG RAN WG1 #120   R1-2500885
Athens, Greece, February 17th – 21st, 2025

Agenda item: 9.5.1

Source: Lenovo

Title: On-demand SSB SCell operation

Document for: Discussion and Decision

1   Introduction

In RAN#102, a work item "Enhancements of network energy savings for NR" was agreed [1]. One objective is to support on-demand SSB for SCell operation for UEs in connected mode.

> Specify procedures and signalling method(s) to support on-demand SSB SCell operation for UEs in connected mode configured with CA, for both intra-/inter-band CA. [RAN1/2/3/4]
>
> - Specify triggering method(s) (select from UE uplink wake-up-signal using an existing signal/channel, cell on/off indication via backhaul, Scell activation/deactivation signalling)
>
> - Note1: On-demand SSB transmission can be used by UE for at least SCell time/frequency synchronization, L1/L3 measurements and SCell activation, and is supported for FR1 and FR2 in non-shared spectrum.

In this contribution, we provide solutions for the procedures and signalling methods to support on-demand SSB for SCell.

2 Discussion

2.1   Cases and Scenarios for OD-SSB

In RAN1#116, two cases were identified for UE assumption of SSB transmission on a cell supporting on-demand SSB SCell, where a first case is that SSBs are not transmitted before on-demand SSBs are triggered while the second case is that before on-demand SSBs are triggered, SSBs are transmitted but maybe e.g., with a long periodicity.

> **RAN1#116 Agreement**
>
> Regarding the UE assumption on SSB transmission on a cell supporting on-demand SSB SCell operation, the following cases are identified for further study:
> - Case #1: No always-on SSB on the cell
> - Case #2: Always-on SSB is periodically transmitted on the cell
> - FFS: Whether always-on SSB and on-demand SSB are not cell-defining SSB if transmitted.
> FFS: Which scenario the above applies for

In RAN1#116bis, multiple scenarios were identified for which on-demand SSB can be triggered. It was agreed to support scenario #2 and scenario #2A for on-demand SSB triggered by gNB, for both case 1 and case 2, and FFS for scenario #3A and scenario #3B.

For the identified scenarios and cases (as per RAN1#116 agreement), on-demand SSB can be triggered by gNB at least for the following scenarios/cases:

- Scenario #2 and Case #1
- Scenario #2 and Case #2
- Scenario #2A and Case #1
- Scenario #2A and Case #2
- FFS: Scenario #3A and Case #1
- FFS: Scenario #3A and Case #2
- FFS: Scenario #3B and Case #1
- FFS: Scenario #3B and Case #2
- For Case #1, once on-demand SSB is triggered, its transmission is in a periodic manner.
  - Note: This does not imply periodic on-demand SSB is transmitted indefinitely after triggered.
- Notes:
  - Scenario #2A refers to
    - "When UE receives SCell activation command (e.g., as defined in TS 38.321)"
  - Scenario #3A refers to
    - "After UE receives SCell activation command (e.g., as defined in TS 38.321) until SCell activation is completed"
  - Scenario #3B refers to
    - "When SCell activation is completed and SCell is activated" or
    - "After SCell activation is completed and SCell is activated"
  - For discussion purpose under AI 9.5.1, always-on SSB is SSB supported in Rel-18 specifications.
  - Timing for on-demand SSB transmission (e.g. when the triggered SSB starts and ends) will be separately discussed.

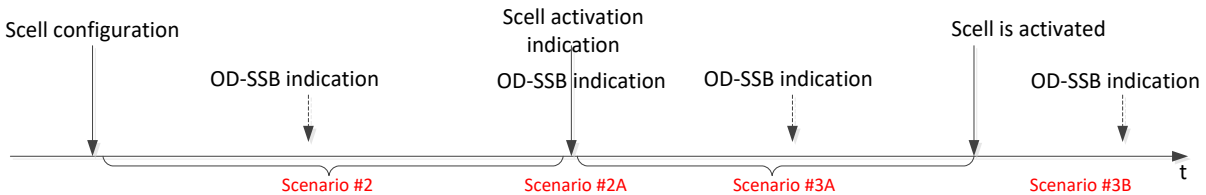Figure 1 provides an illustration of the identified scenarios for on-demand SSB triggering.

Figure 1 OD-SSB scenarios

Regarding the supported cases and scenarios, since it was already supported to trigger OD-SSB upon SCell is activated in Scenario #2A, there is no strong motivation to support OD-SSB for Scenario #3A. For Scenario #3B, we think at least Case #2 can be supported. The always-on SSB can be transmitted with a long periodicity, and then OD-SSB can be triggered based needs (e.g., L1/L3 measurement). Besides, Case #1 can be supported in Scenario #3B since it can provide more NES saving gain than Case 1. However, more standard impacts are expected for Case #1 in Scenario #3B.

Proposal 1: Support OD-SSB for Scenario #3B. OD-SSB for Scenario #3A is not supported.

2.2 Signalling methods for OD-SSB

Regarding the signalling design to support on-demand SSB, it was agreed in RAN1#117 to support RRC based signalling and MAC CE based signalling and FFS on DCI based signalling.

- For a cell supporting on-demand SSB SCell operation,
  - Support RRC based signalling to indicate on-demand SSB transmission on the cell.
  - Support MAC CE based signalling to indicate on-demand SSB transmission on the cell.
  - FFS: Whether to support DCI based signalling to indicate on-demand SSB transmission on the cell.
    - This DCI signalling does not provide SCell activation/deactivation.
    - If supported, details on DCI including UE-specific or group-common DCI, DCI contents, etc.

FFS: Scenarios where the above signallings are applicable

RAN1#118 further agreed the cases and scenarios for RRC based signalling and MAC CE based signalling.

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RAN1#118 Agreement

For a cell supporting on-demand SSB SCell operation,
- Support RRC based signalling to indicate on-demand SSB transmission on the cell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration.
    - FFS: Whether to support RRC based signalling for other cases.
- Support MAC CE based signalling to indicate on-demand SSB transmission on the cell for Scenarios #2 and #2A.

Note: Deactivation and adaptation of on-demand SSB transmission can be separately discussed.

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Regarding the "FFS: Whether to support DCI based signalling to indicate on-demand SSB transmission on the cell", we think at least for Scenario #2 and Scenario 3B, group common DCI based indication of on-demand SSB should be supported. When triggering on-demand SSB for multiple UEs configured in a same SCell, group common DCI based triggering is better than UE specific MAC CE based triggering in terms of lower signalling overhead and lower latency.

With group common DCI based signalling and MAC CE based signalling, UE-specific DCI based indication will not be pursued for on-demand SSB.

Proposal 2: In addition to the agreed RRC and MAC CE based signaling methods, support group common DCI based signalling to indicate on-demand SSB transmission at least for Scenario #2 and Scenario #3B.

RAN1#118bis agreed to support deactivation of on-demand SSB transmission. Quite a few options are listed in the agreements regarding how on-demand SSB is deactivated from a UE perspective.

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RAN1#118bis Agreement:

- For a cell supporting on-demand SSB SCell operation, deactivation of on-demand SSB transmission is supported. In order to deactivate on-demand SSB transmission from a UE perspective, support at least one of the following options.
    - Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
    - Option 1A: Explicit indication of deactivation for on-demand SSB via RRC for on-demand SSB transmission indication
    - Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
    - Option 3: Configuration/indication of the duration of on-demand SSB transmission window
    - Option 4: On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell
    - Option 4A: On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired
    - Option 5: On-demand SSB transmission, if any, is deactivated when SCell activation is completed
    - Option 6: Explicit indication of deactivation for on-demand SSB via [group-common] DCI
    - FFS: Each option is applicable to which Cases or Scenarios
    - FFS: Details related to each of the above options

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It was further agreed to support Option 1 and Option 2 in RAN1#119.

For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.
- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
  - Deactivation by RRC is up to RAN2
  - FFS: Which scenario Option 1 is used
- Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
  - FFS: Whether Option 4, 4a is needed in addition to Option 2
  - FFS: Whether the value of N can be implicitly determined using a timer

Option 1 can be used for L3 measurement (e.g., in scenario #2 and #3B), which may require longer period SSB transmission and where measurement reporting may be based on triggering event.

Proposal 3: Option 1 of using explicit indication of deactivation for on-demand SSB can be used for L3 measurement in at least scenario #2 and #3B.

For the case that multiple UEs are configured with a same SCell, it should be possible that for one UE, the SCell is deactivated while for other UEs, it is still active and on-demand SSB is transmitted. With explicit indication of deactivation for on-demand SSB, UE can assume on-demand SSB is still available after SCell is deactivated, if deactivation signaling of on-demand SSB is not received.

Proposal 4: From a UE perspective, if deactivation signaling of on-demand SSB is not received, UE can assume on-demand SSB is still available after SCell is deactivated.

2.3 Spatial relation between always-on SSB and OD-SSB

Regarding the spatial relation between always-on SSB and OD-SSB, RAN1#119 agreed to support at least the case where SSB indices within OD-SSB burst are identical to SSB indices within always-on SSB burst, and to discuss further whether to support SSB indices within on-demand SSB burst to be a subset of SSB indices within always-on SSB burst.

Response to Q4 (What is the spatial relation between the always-on SSB and OD-SSB?) of Obj.1:
- SS/PBCH blocks with the same SSB indexes for always-on SSB and on-demand SSB are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and when applicable, spatial RX parameters.
  - Applies at least for the case when the centre frequency locations of always-on SSB and OD-SSB is same
- When a signal/channel is configured to be QCLed with a SSB index, the signal/channel is QCLed with the same SSB index of always-on SSB and on-demand SSB (if transmitted) with the same QCL parameters according to existing specifications
  - Applies at least for the case when the centre frequency locations of always-on SSB and OD-SSB is same
- At least the case where SSB indices within on-demand SSB burst are identical to SSB indices within always-on SSB burst is supported. RAN1 is discussing whether to support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

In our view, when gNB triggers OD-SSB for a specific UE, if gNB knows a subset of SSBs that may provide good channel quality to the UE, it may transmit only those SSBs instead of transmitting the full set SSBs as in always-on SSB burst. This is beneficial in terms of gNB energy saving.

Proposal 5: Support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

3   Conclusion

In summary, we have following proposals for on-demand SSB for SCell:

Proposal 1: Support OD-SSB for Scenario #3B. OD-SSB for Scenario #3A is not supported.

Proposal 2: In addition to the agreed RRC and MAC CE based signaling methods, support group common DCI based signalling to indicate on-demand SSB transmission at least for Scenario #2 and Scenario #3B.

Proposal 3: Option 1 of using explicit indication of deactivation for on-demand SSB can be used for L3 measurement in at least scenario #2 and #3B.

Proposal 4: From a UE perspective, if deactivation signaling of on-demand SSB is not received, UE can assume on-demand SSB is still available after SCell is deactivated.

Proposal 5: Support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

4   References

[1] RP-234065, "New WID: Enhancements of network energy savings for NR", RAN#102.