

Source: Tejas Networks Ltd
Title: On demand SSB SCell operation for NES
Agenda item: 9.5.1
Document for: Discussion and Decision

1. Introduction

Based on the WI description in RP-234065 [1], the following objective has been agreed on on-demand SSB SCell operation for NES:

- Specify procedures and signaling 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 signaling)
 - 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.

2.1 On demand SSB transmission indication and deactivation

RAN1#118-bis, 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

RAN1#119→Agreement

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

In the previous RAN1#118-bis meeting, an agreement was made on the deactivation of on-demand SSB transmission. Different options are proposed for on-demand SSB deactivation. In RAN1#119 meeting out of several options two option are agreed.

- **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

On top of above options, option 4 and 4a should be supported. As it will further enhance the NES. When SCELL is deactivated either due to MAC-CE or SCELL timer expiry, terminating the SSB transmission will further improve NES gains.

Proposal 1: Supporting option4 i.e., On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell.

Proposal 2: Support Option 4a i.e., On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired.

Proposal 3: FFS: Combination of Option 1 and Option 2.

2.2 Frequency location of on demand SSB

In the previous RAN1#119 meeting, there was an agreement on the frequency location of OD-SSB.

Agreement

- Down-select at least one of the following alternatives.
- Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.
- Alt 2: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB

- Alt 3: Do not support the case where always-on SSB is CD-SSB on a synchronization raster.
- Down-select at least one of the following alternatives.
- Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.
- Alt B: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB
- Alt C: Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster.

Two cases are considered for OD-SSB, as shown below.

- case1: when always-on SSB is CD-SSB on a synchronization raster
 - Alt1: the frequency location of on-demand SSB is different from the frequency location of always-on SSB.
 - Alt2: the frequency location of on-demand SSB is the same as the frequency location of always-on SSB
 - Alt3: Do not support the case where always-on SSB is CD-SSB on a synchronization raster.
- case 2: If always-on SSB is CD-SSB and not on a synchronization raster
 - Alt A: The frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB
 - Alt B: The frequency location of on-demand SSB is the same as the frequency location of always-on SSB
 - Alt C: Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster.

For the case where always on SSB is CD SSB on synchronisation raster, Alt2 should not supported as OD-SSB is NCD SSB and this will affect legacy UE. Legacy UEs may not be able to connect to the CELL if OD-SSB (which is NCD SSB) transmitted on the synchronisation raster as they are not provided with the configuration required for decoding SIB1. And this SCELL can be PCELL to some other UEs. Hence supporting Alt 1 for the case where always-on SSB is CD-SSB on a synchronization raster.

Where as for the case where always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of the OD-SSB can be at same or different frequency location as that of always on SSB.

Proposal 4: Supporting Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.

Proposal 5: Supporting Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.

2.3 CSI reporting for a cell supporting OD-SSB transmission

Agreement

- For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), consider only one or both of the following options for UE to perform L1 measurement based on on-demand SSB.
 - Option 1: A CSI report configuration is associated with both of on-demand SSB and always-on SSB
 - Option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB
 - FFS: Whether OD-SSB and always on SSB have same beam or not

An agreement was made in the RAN1#118-bis meeting about the CSI reporting for the always on SSB and on-demand SSB for case#2. Two options are kept for selection. Option 1 includes a single CSI reporting for OD-SSB and AO-SSB. Option 2 include a separate CSI reporting for OD-SSB and AO-SSB.

- **Option 1:** A CSI report configuration is associated with both of on-demand SSB and always-on SSB
- **Option 2:** A CSI report configuration is associated with one of always-on SSB and on-demand SSB.

Option 2 follow the legacy mechanism, to indicate the CSI reporting separately for two kinds of SSB. The implementation complexity is less.

Proposal 6: Supporting option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB.

2.4 Mux cases between OD-SSB and AO-SSB

Agreement

For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), study at least the following Mux-Cases.

- Mux-Case #1: No time-domain overlap between always-on SSB and on-demand SSB
- Mux-Case #2: Always-on SSB and on-demand SSB overlap at least in time or frequency domain

In the previous RAN1#118-bis meeting, two multiplexing cases are selected for further study. Where case-1 is about no time domain overlap between OD-SSB and AO-SSB. In this case OD-SSB and AO-SSB are separated in time domain. This case is helpful for the UE's, as UE's will get more time domain opportunities for measuring the SSB and sending the CSI reports. This will reduce the SCELL activation delay.

- Mux-Case #1: No time-domain overlap between always-on SSB and on-demand SSB
- Mux-Case #2: Always-on SSB and on-demand SSB overlap at least in time or frequency domain

Whereas case#2 is about, AO-SSB and OD-SSB overlap at least in time or frequency. Overlapping in time is not much useful from the UE perspective as it will reduce the time domain occurrences of the OD-SSB. And measuring two SSB's at different frequency location is not useful from the UE perspective. Whereas overlap in frequency is fine, as both OD-SSB and AO-SSB will share the same frequency resources and it can reduce the additional signalling overhead required for indicating the frequency domain location of the OD-SSB.

Proposal 7: Supporting Mux-Case #1: No time-domain overlap between always-on SSB and on-demand SSB.

Since OD-SSB was introduced, handling of SSB collision with other channels should be discussed. Rules should be defined for the OD-SSB collision with the other channels.

Proposal 8: Collision handling of OD-SSB with other channels should be discussed.

2.5 Time domain location of the OD-SSB

Agreement

For a cell supporting on-demand SSB SCell operation, support to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC for both Case #1 and Case #2.

- For Case #1 (i.e., No always-on SSB on the cell),
 - Based on two parameters, where one is to indicate SFN offset from a reference point and the other is to indicate half frame index
 - The reference point is SFN which satisfies $(\text{SFN index} * 10) \text{ modulo } (\text{OD-SSB periodicity}) = 0$
 - If SFN offset parameter is NOT configured, UE assumes SFN offset set to 0.
 - If half frame index parameter is NOT configured, UE assumes half frame index set to 0.
 - The value range of SFN offset is 0 to 15 unless longer periodicity for on-demand SSB than 160 ms is introduced.
 - The value range of half frame index is 0 or 1.
- For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), down-select one of the following alternatives.
 - Alt A: Same as for Case #1
 - Alt B: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to *ssb-TimeOffset*)

In the previous RAN1#119 meeting, there is an agreement on the time domain location of the OD-SSB, for two different cases. Two options are proposed under case 2. Using different configuration i.e., separate SFN offset and half frame index for OD-SSB and always on SSB can create condensed SSB resources in time domain. This will give base station a micro sleep duration which will further improve the NES gain. Hence supporting Alt A.

Proposal 9: Supporting Alt A: Same as for Case #1.

Conclusions

Proposal 1: Supporting option4 i.e., On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell.

Proposal 2: Support Option 4a i.e., On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired.

Proposal 3: FFS: Combination of Option 1 and Option 2.

Proposal 4: Supporting Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.

Proposal 5: Supporting Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.

Proposal 6: Supporting option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB.

Proposal 7: Supporting Mux-Case #1: No time-domain overlap between always-on SSB and on-demand SSB.

Proposal 8: Collision handling of OD-SSB with other channels should be discussed.

Proposal 9: Supporting Alt A: Same as for Case #1.

References

[1] RP-234065, “NewWID: Enhancements of network energy savings for NR”, Ericsson, December 2023.