3GPP TSG RAN WG1 #120 **R1- 2501206**
Athens, Greece, Febuary 17th – 21st, 2025

Source: **NTT DOCOMO, INC.**
Title: **Discussion on on-demand SSB SCell operation**
Agenda Item: **9.5.1**
Document for: **Discussion and Decision**

1. Introduction

At the RAN #102 meeting, the new work item of "Enhancement of network energy savings for NR" was agreed [1]. In this contribution, we provide our views on the first scope on on-demand SSB (OD-SSB) SCell operation.

2. Discussion

2.1 Applicable cell

Agreement@118
For a cell supporting on-demand SSB SCell operation, at least the following is supported
- On-demand SSB on the cell is not located on synchronization raster.
- On-demand SSB on the cell is non-cell-defining SSB

FFS: Additional support of OD-SSB for CD-SSB located on sync-raster

Agreement@116bis
For a cell supporting on-demand SSB SCell operation,
- Note: It is up to gNB implementation whether always-on SSB (if transmitted) on the cell is cell-defining SSB or not.
- For on-demand SSB on the cell, downselect between the following alternatives
  - Alt-1: It is up to gNB implementation whether on-demand SSB is cell-defining SSB or not.
  - Alt-2: On-demand SSB is limited to non-cell-defining SSB.
    - FFS: Further limitations to on-demand SSB

There was a discussion whether OD-SSB can be a cell-defining SSB (CD-SSB) or not as shown in the above agreements [2].

From NW operator's perspective, it is restrictive that specification defines OD-SSB only to be a non-cell-defining SSB (NCD-SSB). NW implementation can avoid any negative impact caused by OD-SSB for other UEs that are not relevant to OD-SSB operation even if the OD-SSB is configured as CD-SSB, i.e., on sync-raster and associated with RMSI. For example, by setting the cell as cell barred, any irrelevant UEs cannot use the cell unless NW dedicatedly configures them with the cell, which is achieved without any new specification enhancement.

Even in the operation based on the legacy spec., there can be a case where a periodicity of CD-SSB or SSB on sync-raster is changed via SIB1 update. In this case, some UEs may detect SSB in some time (may detect a first occasion) or miss SSB in other time (may miss a subsequent occasion) during cell search/RRM. The problem that is not restricted in the spec can be avoided or minimized by NW implementation. Therefore, the situation is same between the legacy SSB and OD-SSB, thus, OD-SSB for CD-SSB located on sync-raster should be supported.

Proposal 1:

- Support OD-SSB for CD-SSB located on sync-raster.

2.2 Relationship between on-demand SSB and always-on SSB

2.2.1 Frequency location

Agreements@RAN1#119
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.

Agreement@RAN1#119

Response to Q3 (What is the relation in terms of frequency location between the always-on SSB and OD-SSB?) of Obj.1:

- The frequency location of on-demand SSB is the same as the frequency location of always-on SSB at least for the case where al-ways-on SSB is not CD-SSB. RAN1 is discussing the frequency location of OD-SSB for the case where always-on SSB is CD-SSB.

In the previous meeting, there was a discussion related to SSB types between OD-SSB and always-on SSB (AO-SSB) according to the frequency location since the combinations of the types of SSBs and frequency locations are sensitive. For example, CD-SSB and NCD-SSB should not be placed on the same sync raster to avoid confusions whether the UE can access to the cell or not. On the other hand, placing them in different frequencies might cause more RF tuning, which may be limited operation for UEs. Here, we discuss the suitable combinations.

AO-SSB is CD-SSB located on a sync raster

We support both Alt. 1 and Alt. 2 with some restrictions.

For Alt. 1, OD-SSB and AO-SSB should satisfy the condition to avoid RF tuning (which may require measurement gap) while conducting measurements using both AO-SSB and OD-SSB. The RF tuning process has some limit against number of operations according to the RRM requirements. One of the conditions as to avoid such process is to let both AO-SSB and OD-SSB be placed within the same active BWP. Thus, at least we support Alt. 1 with the condition that AO-SSB and OD-SSB are placed within the same active BWP.

For Alt. 2, we support for the case that OD-SSB is CD-SSB on a sync raster, but not support for the case that OD-SSB is NCD-SSB on a sync raster. Placing both CD-SSB and NCD-SSB on the same sync raster cause negative impact on UE to camp on since the former SSB includes information for SIB1 access, but the latter does not. On the other hand, we support for the case when both AO-SSB and OD-SSB are CD-SSB located on the same sync raster. One of the reasons is already expressed in section 2.1. In addition, if this case is not supported, OD-SSB transmission is not assumed when AO-SSB is CD-SSB on a sync raster. We would like to avoid limiting the use-case scenario of OD-SSB.

AO-SSB is CD-SSB located not on a sync raster

Second, for the case where always-on SSB is CD-SSB not located on a sync raster, we support only Alt. A with the restriction that OD-SSB and AO-SSB should be located within the same active BWP to avoid RF tuning when OD-SSB and AO-SSB are not located on the same frequency.

Proposal 2:

- For the types of SSBs of AO-SSB and OD-SSB, we support following alternatives.
  - Alt. 1 with the restriction that UE does not require to do RF tuning. (E.g., AO-SSB and OD-SSB are placed on the same active BWP)
  - Alt. 2 with the restriction that OD-SSB is CD-SSB on a sync raster (same as AO-SSB)
  - Alt. A for the case where
    - OD-SSB and AO-SSB are located on the same frequency.
    - OD-SSB and AO-SSB are not located on the same frequency with the restriction that UE does not require to do RF tuning.

2.2.2 SSB burst periodicity

Agreement@119

- New periodicity value for on-demand SSB other than the legacy values (i.e., 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms) is NOT introduced in Rel-19.

Agreement@119

Response to Q1 (What is the relation in terms of periodicity between always-on SSB and OD-SSB?) of Obj.1:

- The periodicity of on-demand SSB is one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms.
- The periodicity of on-demand SSB can be configured separately from the periodicity of always-on SSB.
- RAN1 is discussing what is the relation between periodicity of always-on SSB and periodicity of on-demand SSB and it has been identified that the main use case is that the periodicity of on-demand SSB is equal to or smaller than that of always-on SSB.

Further update to be made based on RAN1#119 progress.

There was a discussion related to the periodicity of OD-SSB and the agreement was that the periodicity of OD-SSB can take the same value of the legacy spec. Further discussion is required for the relation between OD-SSB and AO-SSB in terms of periodicity whether to make restrictions to the OD-SSB periodicity or not.

In our view, we support to make periodicity restriction/assumption of OD-SSB such that it is smaller than or equal to the periodicity of AO-SSB. The use-case of the OD-SSB in case #2 with its periodicity larger than that of AO-SSB is not clear.

Proposal 3:

- We support to make periodicity restriction/assumption of OD-SSB such that it is smaller than or equal to the periodicity of AO-SSB.

2.2.3 QCL relationship

Agreement@119
Response to Q2 (What is the relation in terms of time location between always-on SSB and OD-SSB?) of Obj.1:
- RAN1 understands the time location of OD-SSB in Q2 refers to the time location of possible OD-SSB burst
- RAN1 is still discussing the relation in terms of time location between always-on SSB and OD-SSB

Agreement@119
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.

There was a discussion on spatial relations between AO-SSB and OD-SSB and an agreement was made only for the case when the SSB indices within OD-SSB burst and the SSB indices within AO-SSB burst are identical and the centre frequency location of AO-SSB and OD-SSB are the same. We would further discuss applicable SSB-index arrangements for OD-SSB as well as the QCL assumptions in terms of frequency locations.

When AO-SSB and OD-SSB have the same centre frequency

SSB-index arrangements can be considered for 3 options:
- Option 1: The set of SSB indices of AO-SSB and those of OD-SSB are identical.
- Option 2: The set of SSB indices of OD-SSB becomes a subset of the set of SSB indices of AO-SSB.
- Option 3: there is no index overlap between AO-SSB and OD-SSB.

The first case was already agreed in the preceding meetings.

A use-case of the second option can be that, assuming AO-SSB covers the whole area in the cell, it is known to NW in prior that UEs supporting OD-SSB operation is located only in a part of area.

For the use-case of the third case, it can be applicable when there are some areas where AO-SSB do not cover, but OD-SSB wants to cover with higher transmit power. We support at least option 1 and 2.

Proposal 4:

- For the applicable SSB-index arrangements for OD-SSB in case2, we support following options.
  - Option 1: The set of SSB indices of AO-SSB and those of OD-SSB are identical.
  - Option 2: The set of SSB indices of OD-SSB is a subset of the set of SSB indices of AO-SSB.

Among those cases, we would discuss the QCL assumptions in the following. The first option already reached to an agreement. For the second option, we support the QCL assumption same as what was agreed for the same SSB-index to avoid negative impact on UEs using AO-SSB as QCL source RS when OD-SSB and AO-SSB are transmitted at the same timing. For the third option, since there is no index overlaps for this case, no relationship is necessary for QCL assumption between OD-SSB and AO-SSB.

When AO-SSB and OD-SSB have different centre frequencies

We think that QCL between OD-SSB and AO-SSB should not be assumed to avoid legacy rule in the spec saying that "The UE shall not assume quasi co-location for any other SS/PBCH block transmissions."

Proposal 5:

- For the spatial relationship between AO-SSB and OD-SSB,
  - When AO-SSB and OD-SSB have the same centre frequency
    - Support the QCL assumption for the same SSB-index
  - When AO-SSB and OD-SSB have different centre frequencies
    - QCL between OD-SSB and AO-SSB should not be assumed.

2.3 OD-SSB configurations

Implicit deactivation

Agreement@119
- New periodicity value for on-demand SSB other than the legacy values (i.e., 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms) is NOT introduced in Rel-19.

Agreement@118bis

For a cell supporting on-demand SSB SCell operation, support to provide at least the following parameters for on-demand SSB configuration by RRC at least for Case #1.
- Sub-carrier spacing of the on-demand SSB
  - FFS if this can be absent
- Physical Cell ID of the on-demand SSB
- FFS: Time domain location of on-demand SSB burst such as SFN offset and half frame index
- Downlink transmit power of on-demand SSB
- FFS: The number of N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
- FFS: whether the above parameters are configured by reusing legacy RRC parameters or new RRC parameters

Agreement@117

For a cell supporting on-demand SSB SCell operation, at least the followings for on-demand SSB are known to UE.
- Sub-carrier spacing of the on-demand SSB
- Physical Cell ID of the on-demand SSB
- Location of on-demand SSB burst
- Downlink transmit power of on-demand SSB
- FFS: Other parameters
- FFS: whether each of above parameters is configured/indicated explicitly or not

Agreement@117

For a cell supporting on-demand SSB SCell operation, at least the following for on-demand SSB via higher layer RRC signaling is supported.
- Frequency of the on-demand SSB
- SSB positions within an on-demand SSB burst by using signaling similar to ssb-PositionsInBurst
- Periodicity of the on-demand SSB
- FFS: Whether more than one on-demand SSB configurations can be configured for the cell to UE
- FFS: Whether the RRC is newly introduced or existing RRC is reused

In the previous meeting, discussions on how to determine the number of N or durations of OD-SSB TX. The controversial point is that at the time of configuring the parameters for OD-SSB (e.g., SCell addition), the number of N is hard to be assumed since the N can be different according to how OD-SSBs are used. In such aspects, we would discuss in the following.

We think that the candidates of number N or durations are configured during SCell addition and necessary N will be indicated when OD-SSB is demanded.

Since there are multiple use-cases for using OD-SSB (E.g., OD-SSB activation, L1 measurement in scenario #3B, L3 measurement in scenario #2, or all the time for scenario #3B in case #1), it is difficult to set optimal N for each use-cases.

Our suggestion is that the candidate values of OD-SSB TX duration could cover all candidates of integer multiple of SMTC periodicity to support L3 measurement in case #1 and SCell activation in case #2. Although we can optimize OD-SSB TX duration for each detailed condition of L3 meas./SCell activation (e.g., know-cell or unknown-cell, measurement gap is required or not), and several number of OD-SSB bursts are sufficient for L1 meas., specifying all those patterns require a lot of spec. work which is not worth compared to its benefit. Thus, we think defining candidates of OD-SSB TX duration based on integer multiple of SMTC periodicity should be sufficient. In this sense, there can happen that OD-SSB which is used for measurement is turned off (deactivated), and for dealing with the errors, some spec impact is expected (e.g., performance degradation in RAN4, UE assumption of no-deactivation in RAN1 or RAN2).

Proposal 6:

- For determination of the number/duration of OD-SSB bursts, we support the following mechanism:
  - The candidate values of OD-SSB TX duration are RRC-configured, integer multiple of SMTC periodicity
  - Error cases handling should be specified (e.g., performance degradation in RAN4, UE assumption of no-deactivation in RAN1 or RAN2) in deactivation of OD-SSB which is being measurement.

Time location of OD-SSB

Agreement@119
- 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 (SFN index *10) modulo (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 meeting, the time location parameter related to OD-SSB was discussed, where OD-SSB time location can be determined based on using SFN-Offset and half-frame index for case #1. The further discussions should be considered for case #2. One of the approaches is that the OD-SSB time location should be determined based on the same agreement in case #1. The other approach is it can be determined based on relative time from AO-SSB (e.g., ssb-TimeOffset).

Our preference is the same mechanism as case #1 (Alt. A). It can reduce the specification complexity. Different parameter setting mechanisms depending on case #1/#2 is bothersome in terms of specification simplification perspectives.

In the last meeting, the proponent of Alt. B seemed to mention that Alt. B could create a flexible pattern regardless of relationship between AO and OD-SSB's periodicities and AO-SSB's SFN offset, e.g., avoid the case where the combination of OD-SSB and AO-SSB TX have non-uniformity and OD-SSB TX start at the different timing as AO-SSB's. However, we do not see any critical problem by using Alt A with proper NW implementation.

Proposal 7:

- For OD-SSB parameters related to time location in case #2, we support the same agreed mechanism for case #1, i.e., OD-SSB time locations in case #2 are determined based on SFN-offset and half-frame index.

2.4 Activation and Deactivation of on-demand SSB

Agreement@116bis

For a cell supporting on-demand SSB SCell operation, further study the following options.
- Option 1: Separate signaling between legacy/existing signaling (e.g., RRC, MAC CE) providing SCell activation/deactivation and signaling providing On-demand SSB transmission indication.
- Option 2: A single signaling in which both SCell activation/deactivation and On-demand SSB transmission indication are provided.
  - FFS: Details of the signaling
- Other options are not precluded.

FFS: Details on On-demand SSB transmission indication

Agreement@117
- For a cell supporting on-demand SSB SCell operation,
  - Support RRC based signaling to indicate on-demand SSB transmission on the cell.
  - Support MAC CE based signaling to indicate on-demand SSB transmission on the cell.
  - FFS: Whether to support DCI based signaling to indicate on-demand SSB transmission on the cell.
    - This DCI signaling 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 signalings are applicable

Agreement@118
For a cell supporting on-demand SSB SCell operation,
- Support RRC based signaling 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 signaling for other cases.
- Support MAC CE based signaling 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.

Agreement@116bis
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.

Agreement@116
For the following identified scenarios for on-demand SSB SCell operation, focus future RAN1 discussion to down-select (both may be selected) between the two scenarios.
- Scenario #2: SCell is configured to a UE but before the UE receives SCell activation command (e.g., as defined in TS 38.321)
- Scenario #3: After UE receives SCell activation command (e.g., as defined in TS 38.321)
  - This does not preclude SCell for which activation is completed
  - FFS: The case where SCell activation is completed

FFS: Application timing between NW triggering message and on demand SSB transmission

Agreement@116
- 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

It was discussed how gNB indicates on-demand SSB TX and in which scenario(s)/case(s) in CA procedure OD-SSB transmission can be triggered. We show our supporting signaling for each of use-cases per scenario/case in Table 1 (yellow highlighted parts have not been agreed yet, the other parts are already agreed or almost agreed in our understanding.) and depict our understanding on signaling for OD-SSB triggering in each scenario and case in the Fig. 1.

	Scenario #2	**Scenario #2A**	**Scenario #3A**	**Scenario #3B**
Use-case of OD-SSB	L3 meas.	Scell activation	Scell activation L3/L1 meas. triggered in the former scenario.	L3/L1 meas For normal Scell operation in case#1 (e.g., sync)
OD-SSB transmission	Support	Support	Support	Support
RRC indication	Support	Support	Not support (SSB properties should not be changed during SCell activation procedure due to complex UE behavior)	Support (Our position is neutral)

MAC CE indication	Support	Support	Not support Same as the above	Support Same as the above
DCI indication	Support group-common.	Not support	Not support Same as the above	Support

Table. 1: Summary of docomo's view on OD-SSB operation in each scenario

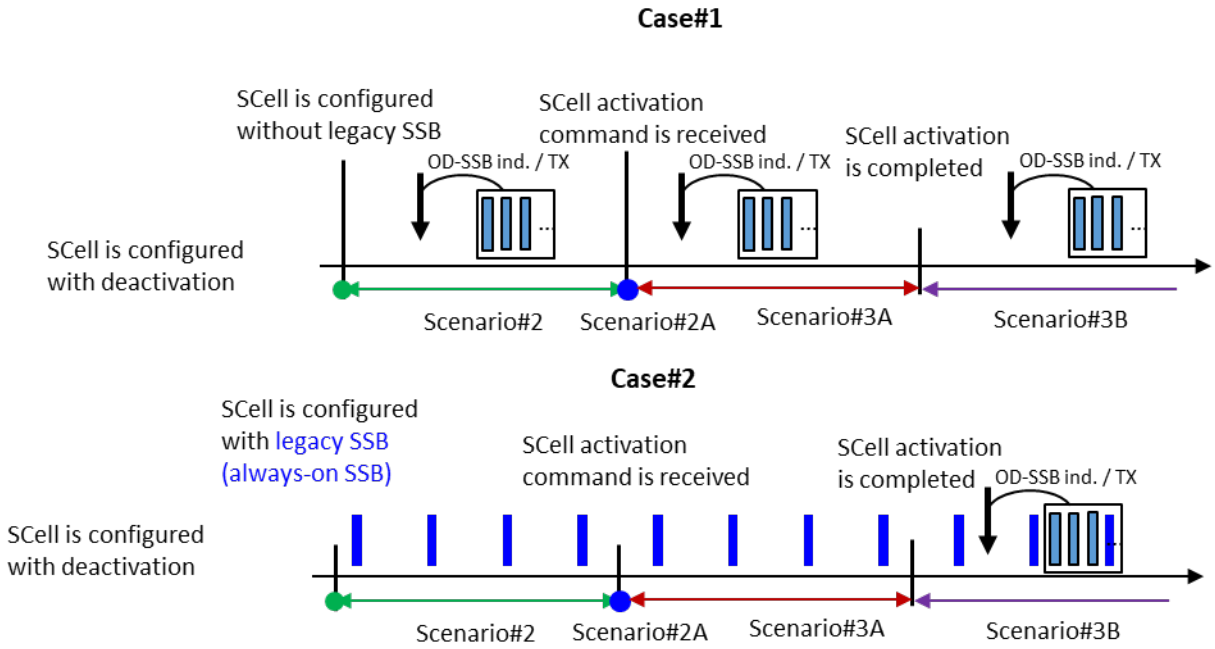

Fig. 1: Scenarios and cases in CA procedure

RRC based indication

Although support of RRC based indication was agreed only in scenario #2A (with direct SCell activation), we think that in other scenarios, at least scenario #2 should also be supported. We see no reason to preclude support of spec. in other cases. RRC based indication in scenario #2 would be useful, e.g., there could be a case where gNB finds OD-SSB operation applicable after gNB configures SCell addition (without OD-SSB config.) based on some events through its implementation.

Proposal 8:

- In scenario #2, support RRC signaling for indication of OD-SSB transmission separately from SCell activation/deactivation indication.

DCI based indication

It was agreed that a UE can be indicated with OD-SSB in scenario #2. We believe that most promising use-case of OD-SSB is L3 measurement, by which NW can obtain knowledge about which configured SCell/beam is better to be activated while minimizing the amount of NW TX.

We'd like to note that more efficient indication way needs to be pursued especially in scenario #2. Based on our understanding, even in the legacy spec, RRM meas. and SSB TX on deactivated SCell are totally under NW control and RRC-configured (including whether SSB TX and L3 meas. are performed or not). So, supporting only dedicated-signaling based indication of OD-SSB is not much different from the legacy RRC based indication of always-on SSB, and as a result, no/less additional NES gain is expected. Also, we believe that OD-SSB, when it is indicated, should be available for more than one UEs in many cases. Therefore, if we have a UE-dedicated approach only, the amount of signaling exchanges for OD-SSB indication will increase subject to the number of UEs involved, which opposes the intention of NES. In that sense, the efficient indication of OD-SSB transmission, such as group-common signaling for OD-SSB triggering should be realized in our view.

Proposal 9:

- In scenario #2/#3B, support group-common DCI signaling for indication of OD-SSB transmission separately from SCell activation/deactivation indication.

FFS scenarios/cases

In scenario #3A:

It was not agreed that a UE can be indicated with OD-SSB TX by any signalling yet in scenario #3A. In fact, it seems not needed in our view. During the SCell activation procedure, UE needs to obtain SCell's condition, e.g., synchronization/AGC/channel conditions on the SCell based on SSB detection. Therefore, UE should be indicated the OD-SSB transmission before the SCell activation (i.e., in scenario #2), or when the SCell activation is indicated (i.e., in scenario #2A), and additional indication and transmission on top of them during the middle of SCell activation procedure (i.e., scenario #3A) would not be essential and would increase complexity of UE behavior.

Proposal 10:

- In scenario #3A, indication of OD-SSB which may change SSB properties that a UE uses for SCell activation procedure is NOT necessary

Scenario #3B (During SCell operation after activation completion)

It was not agreed that a UE can be indicated with OD-SSB in scenario #3B either.

After activation success, a UE will perform normal SCell operation such as monitoring PDCCH for data TX/RX, CSI reporting or SRS transmission on SCell. We understand that the legacy UE behavior in scenario #3B seems to be defined with the assumption that a UE can perform normal SCell operation relying on periodic legacy always-on SSB with <= 160 ms (except for SSB-less SCell operation) e.g., to maintain synchronization, AGC, QCL property, etc.

Observation 1:

- On-demand SSB during activated SCell operation (in scenario #3B) can be used for normal SCell operation e.g., for monitoring PDCCH on SCell.

From NES perspective, at least SCell SSB operation other than the legacy always-on SSB in scenario #3B should be supported. In other words, it would be necessary to consider coarser SSB TXs (e.g., longer periodicity such as 320, 640 ms, and/or aperiodic transmission) for Rel-19 NES capable UEs on active SCell in order to achieve real NES gain in SCell operation with on-demand SSB. Otherwise, once SCell is activated for a UE, NW has to transmit SSB at least every 160 ms, which is almost the same as the possible operation supported in the current specifications, i.e., NES gain over Rel-18 is NOT achieved.

Unfortunately, in the last RAN1 meeting, it was agreed that no new OD-SSB periodicity would be introduced, so to achieve this, "aperiodic based" OD-SSB in case #1 is necessary which means OD-SSB can be completely turned off and turned on again on activated SCell.

A potential controversial point would be whether it is feasible operation that all SSB including always-on and on-demand SSB can be completely stopped in scenario #3B from a UE perspective. From our perspective, even in the current specification, a UE does not need to always monitor all SSBs on SCell in some cases, e.g., during UE DRX or cell DTX, so with some restriction on SCell operation, scenario #3B + case #1 would be possible operation.

Proposal 11:

- Support indication mechanism to activate or deactivate OD-SSB during activated SCell operation (in scenario #3B and case #1) in terms of practical NES operation.
  - With some restriction on UE behavior on SCell operation,
    - FFS: some restrictions, e.g., during UE DRX or cell DTX.

2.5 Deactivation of on-demand SSB

In the 118bis RAN1 meeting, deactivation behavior in time domain of OD-SSB was discussed.

Agreement@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

Agreement@118bis

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

In the previous meeting, OD-SSB deactivation indications were agreed at least for MAC-CE and implicit indication after number N OD-SSB bursts transmissions. For those mechanisms, further discussions should be made. For MAC-CE indication, further discussion is required for usage scenarios. Whether option 4/4a is needed in addition to option 2 or not should also be discussed.

MAC-CE deactivation indication use-case

MAC-CE deactivation indication can be used in scenario #2 and #3B. In scenario #2, we think unnecessary OD-SSB transmission can be reduced after UE finishes conducting L3 measurements for both case #1/#2. Also, after SCell deactivation is triggered without implicit OD-SSB deactivation, NW can trigger OD-SSB deactivation when the transmissions of OD-SSB are not necessary in case #2. In scenario #3B, after UE completes SCell activation without implicit OD-SSB deactivation, and NW find unnecessary to transmit OD-SSB, NW can save energy by deactivating OD-SSB transmission.

Whether to support option 4/4a

We support option 4/4a which are both implicit deactivation indications. Relying on those indications can reduce the signaling overhead of indications, thus, it is reasonable to support both options. Even when the number of N of OD-SSB bursts to be transmitted, exceeded transmissions of SSBs after UE finishes SCell activations are useless. Also, OD-SSB transmission after SCell is deactivated is not always required. We think it should be a typical case for OD-SSB operation that OD-SSB TX should be turned off when after SCell is deactivated.

Proposal 12:

- Support indication mechanism to activate or deactivate OD-SSB during activated SCell operation (in scenario #3B and case #1) in terms of practical NES operation.
- For MAC-CE deactivation indication, we support the following scenarios and cases,
  - In scenario 2 and case #1/#2
    - After UE finishes conducting L3 measurement
  - In scenario #3B and at least case #2
    - After UE complete SCell activation without implicit OD-SSB deactivation, but NW find it unnecessary.
- In addition to MAC CE, we support option 4/4a.

Other deactivation options to support

First, we support OD-SSB deactivation using group-common DCI (option 6) since indicating deactivation to a group of UEs at the same time is efficient. The option 6 can be used to scenario #2 and scenario #3B if OD-SSB transmission indications are supported.

Proposal 13:

- For OD-SSB deactivation mechanisms,
  - ➢ support group-common DCI signaling (option 6)

2.6 OD-SSB Transmission Timing for RRC indications

Agreement@118bis

The previous RAN1 agreement is partly confirmed and further revised as follows.

- For SSB burst(s) indicated by on-demand SSB SCell operation via a MAC CE, UE expects that on-demand SSB burst(s) is transmitted from time instance A which is determined as follows.
  - Alt 3-1: Time instance A is the beginning of the first slot containing [candidate SSB index 0 or the first actually transmitted SSB index] ofwithin the first "possible" on-demand SSB burst which is at least T slots after the slot where UE receives a signalling from gNB to indicate on-demand SSB transmission
    - The SSB time domain positions of on-demand SSB burst are configured by gNB.
      - The location(s) (e.g., SFN offset, half frame index) in the time domain of "possible" on-demand SSB burst and SSB position within the burst should be configured by the gNB
  - Note: The value of T is not less than existing timeline required for UE's MAC CE processing for SCell activation
  - (Working assumption): T is not less than T_min=$m + 3N_{\text{slot}}^{\text{subframe},\mu}$+1 where slot n+m is a slot indicated for PUCCH transmission with HARQ-QCK information when the UE receives MAC CE signaling to indicate on-demand SSB transmission ending in slot n, and $N_{\text{slot}}^{\text{subframe},\mu}$ is as defined in current specification.
    - RAN4 to confirm that T_min can be equal to $m + 3N_{\text{slot}}^{\text{subframe},\mu}$+1
  - (Working assumption) T=T_min

In the preceding meetings, it was agreed that OD-SSB transmission timing using MAC-CE has been agreed. On the other hand, for the case of RRC transmission indication, there is not agreement on when the actual OD-SSB will start to transmit.

We support to define transmission timing of OD-SSB by RRC-based on indication. This is because without specifying the transmission timing assumption, the number of OD-BB burst transmission cannot be aligned between UE and UE. For example, when the number of OD-SSB burst is configured/indicated and gNB deactivates the OD-SSB implicitly, the above misalignment would cause negative impact on measurement based on OD-SSB or reception of other signal/channels.

In terms of the time duration that UE should assume, we support to define the similar equation agreed above with some modification, e.g., based on RRC procedure delay which is defined in the legacy TS38.331.

Proposal 14:

- For RRC based transmission indication of OD-SSB, we support to define the transmission timing.

2.7 L1 measurement

Agreement@118bis

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

Agreement@118

Update the previous RAN1 agreement as follows

- At least support L1 measurement based on on-demand SSB
  - For L1 measurement based on on-demand SSB, periodic, semi-persistent, [and aperiodic] L1 measurement reports based on existing CSI framework are supported.
    - FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB
    - The support of LTM is a separate discussion point

Agreement@117

At least support L1 measurement based on on-demand SSB

- For L1 measurement based on on-demand SSB, periodic, semi-persistent, [and aperiodic] L1 measurement reports based on existing CSI framework are supported.
  - FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB

In the last meeting, there was a discussion related to CSI report configuration association. As a result, the above agreement was made as to how always-on SSB and OD-SSB are associated to one CSI report configuration.

We support both option 1 and option 2 according to the use-case.

The option 1, where a CSI report configuration can associate with both OD-SSB and AO-SSB, can be useful for UE to complete L1 measurement fast by using both OD-SSB and AO-SSB instead of using only AO-SSB. L1 measurement is completed with single/multiple samples of the specified SSB-index according to the configuration, so it is beneficial for UEs to receive increased number of the same SSB-index withing a period of time.

Also, it is useful to fix one to one association between CSI report configuration as in option 2 when the properties of OD-SSB and AO-SSB are different (E.g., QCL, TX power, frequency). With those different SSB properties, UE cannot measure them as one CSI report and/or NW cannot assume whether the value fluctuation of the reports comes from the differences of SSB properties or channel differences.

Proposal 15:

- In terms of CSI report configuration for L1 measurement,
  - We support both option 1 and option 2, which option to use is up to NW implementation.

3. Conclusions

In this contribution, we provided the following observations and proposals of on-demand SSB SCell operation for network energy saving.

Proposal 1:

- Support OD-SSB for CD-SSB located on sync-raster.

Proposal 2:

- For the types of SSBs of AO-SSB and OD-SSB, we support following alternatives.
  - Alt. 1 with the restriction that UE does not require to do RF tuning. (E.g., AO-SSB and OD-SSB are placed on the same active BWP)
  - Alt. 2 with the restriction that OD-SSB is CD-SSB on a sync raster (same as AO-SSB)
  - Alt. A for the case where
    - OD-SSB and AO-SSB are located on the same frequency.
    - OD-SSB and AO-SSB are not located on the same frequency with the restriction that UE does not require to do RF tuning.

Proposal 3:

- We support to make periodicity restriction/assumption of OD-SSB such that it is smaller than or equal to the periodicity of AO-SSB.

Proposal 4:

- For the applicable SSB-index arrangements for OD-SSB in case2, we support following options.
  - Option 1: The set of SSB indices of AO-SSB and those of OD-SSB are identical.
  - Option 2: The set of SSB indices of OD-SSB is a subset of the set of SSB indices of AO-SSB.

Proposal 5:

- For the spatial relationship between AO-SSB and OD-SSB,
  - When AO-SSB and OD-SSB have the same centre frequency
    - Support the QCL assumption for the same SSB-index
  - When AO-SSB and OD-SSB have different centre frequencies
    - QCL between OD-SSB and AO-SSB should not be assumed.

Proposal 6:

- For determination of the number/duration of OD-SSB bursts, we support the following mechanism:
  - The candidate values of OD-SSB TX duration are RRC-configured, integer multiple of SMTC periodicity
  - Error cases handling should be specified (e.g., performance degradation in RAN4, UE assumption of no-deactivation in RAN1 or RAN2) in deactivation of OD-SSB which is being measurement.

Proposal 7:

- For OD-SSB parameters related to time location in case #2, we support the same agreed mechanism for case #1, i.e., OD-SSB time locations in case#2 are determined based on SFN-offset and half-frame index .

Proposal 8:

- In scenario #2, support RRC signaling for indication of OD-SSB transmission separately from SCell activation/deactivation indication.

Proposal 9:

- In scenario #2/3B, support group-common DCI signaling for indication of OD-SSB transmission separately from SCell activation/deactivation indication.

Proposal 10:

- In scenario #3A, indication of OD-SSB which may change SSB properties that a UE uses for SCell activation procedure is NOT necessary

Observation 1:

- On-demand SSB during activated SCell operation (in scenario #3B) can be used for normal SCell operation e.g., for monitoring PDCCH on SCell.

Proposal 11:

- Support indication mechanism to activate or deactivate OD-SSB during activated SCell operation (in scenario #3B and case#1) in terms of practical NES operation.
  - With some restriction on UE behavior on SCell operation,
    - FFS: some restrictions, e.g., during UE DRX or cell DTX.

Proposal 12:

- Support indication mechanism to activate or deactivate OD-SSB during activated SCell operation (in scenario #3B and case#1) in terms of practical NES operation.
- For MAC-CE deactivation indication, we support the following scenarios and cases,
  - In scenario2 and case #1/#2
    - After UE finishes conducting L3 measurement
  - In scenario3B and at least case#2
    - After UE complete SCell activation without implicit OD-SSB deactivation, but NW find it unnecessary.
- In addition to MAC CE, we support option 4/4a.

Proposal 13:

- For OD-SSB deactivation mechanisms,
  - support group-common DCI signaling (option6)

Proposal 14:

- For RRC based transmission indication of OD-SSB, we support to define the transmission timing.

Proposal 15:

- In terms of CSI report configuration for L1 measurement,
  - We support both option 1 and option 2, which option to use is up to NW implementation.

References

[1] RP-234065, New WID: Enhancements of network energy savings for NR, RAN Meeting #102, December 11th-15th, 2023.
[2] 3GPP, RAN1 #119 meeting, Chairman's notes