Agenda Item: 9.5.1

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Title: **On-demand SSB for SCell**

Document for: **Discussion/Decision**

1   Introduction

In RAN1 #119 meeting, the following agreements for on-demand SSB for SCell have been agreed.

Agreement

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.

Agreement

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 always-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.

Agreement

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.
    - o   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
    - o   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.

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.
    - o   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.
  - o 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*)

Agreement
- 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
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
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
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
  - o Deactivation by RRC is up to RAN2
  - o 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
  - o FFS: Whether Option 4, 4a is needed in addition to Option 2
  - o FFS: Whether the value of N can be implicitly determined using a timer

In this contribution, we provide some discussion on on-demand SSB for SCell.

2 On-demand SSB activation

2.1 MAC CE based on-demand SSB activation

For MAC CE based on-demand SSB indication, the following has been agreed in RAN1 #118b meeting.

Agreement

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~~]~~ ~~of~~within 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 $T\_min = m + 3N_{slot}^{subframe,\mu} + 1$ 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 $N_{slot}^{subframe,\mu}$ is as defined in current specification.
    - RAN4 to confirm that T_min can be equal to $m + 3N_{slot}^{subframe,\mu} + 1$
  - (Working assumption) $T = T\_min$
- Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

Agreement

For a cell supporting on-demand SSB SCell operation, at least for the following parameter(s), multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.

- Periodicity of the on-demand SSB
- FFS: Any other relevant parameters

The first remaining issue is the action delay of the MAC CE. Current working assumption is not quite aligned. The first working assumption defines T should be no less than T_min, where the second working assumption defines T is T_min. Since the SSB is a cell-specific signal and the MAC CE is a UE-specific signal, to align the timing for different UEs, it is better that the value of T can be configured by the NW, which should not be less than T_min.

The second remaining issue is the remaining content for the MAC CE. It has been agreed that the MAC CE can indicate the periodicity of the on-demand SSB. Other than the periodicity, for the MAC CE based on-demand SSB indication for SCell, the NW should at least provide the SCell index and the activation/deactivation status for each SSB. With regard to different UEs with different SCell activation timeline, the NW can also provide the value of the action delay T.

Proposal 1: For MAC CE based on-demand SSB indication, confirm the first working assumption that T is not less than T_min and revert the second working assumption that T is T_min.

Proposal 2: Support the MAC CE based on-demand SSB indication for SCell to provide the following information in addition to the periodicity of the on-demand SSB:

- *SCell index*

- *Activation/deactivation status for each on-demand SSB for the SCell*

- ***The value of the action delay T***

2.2 RRC configuration for on-demand SSB activation

In RAN1 #117 meeting, the following on RRC based on-demand SSB indication has been agreed.

> **Agreement**
> - 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

The remaining issue is whether more than one on-demand SSB configurations can be configured and whether new RRC parameters should be introduced or not. Since the MAC CE can be used to indicate the activation/deactivation status for some SSBs, the NW only needs to provide one on-demand SSB configuration. The on-demand SSB may be based on a different configuration compared to the always-on SSBs. Therefore, the RRC parameters should be new RRC parameters to be introduced.

Proposal 3: Support the NW configures one on-demand SSB configuration and introduce new RRC parameters for the agreed configuration for on-demand SSB including

- ***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***

3 On-demand SSB deactivation

In RAN1 #119, the following for on-demand SSB deactivation has been agreed.

> **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

Option 2 requires the NW to predict when the SSB should be deactivated when the NW decides to activate the SSBs. With regard to different UE status and network energy saving status, it is not easy to predict the number of SSBs. Therefore, compared to option 2, Option 1 could be better.

Proposal 4: Support option 1 for on-demand SSB deactivation

4 Rate matching with regard to dynamic activation/deactivation of SSB

Since the NW can activate/deactivate SSBs in an SCell dynamically, and transmit the activation/deactivation signaling to the UEs by UE-dedicated signaling. Then as shown in Figure 1 for UE-dedicated signal, the rate matching pattern can be based on the activated SSBs. However, for non-UE dedicated signal, the rate matching pattern should still be based on the SSB configured in *ssb-PositionsInBurst*.
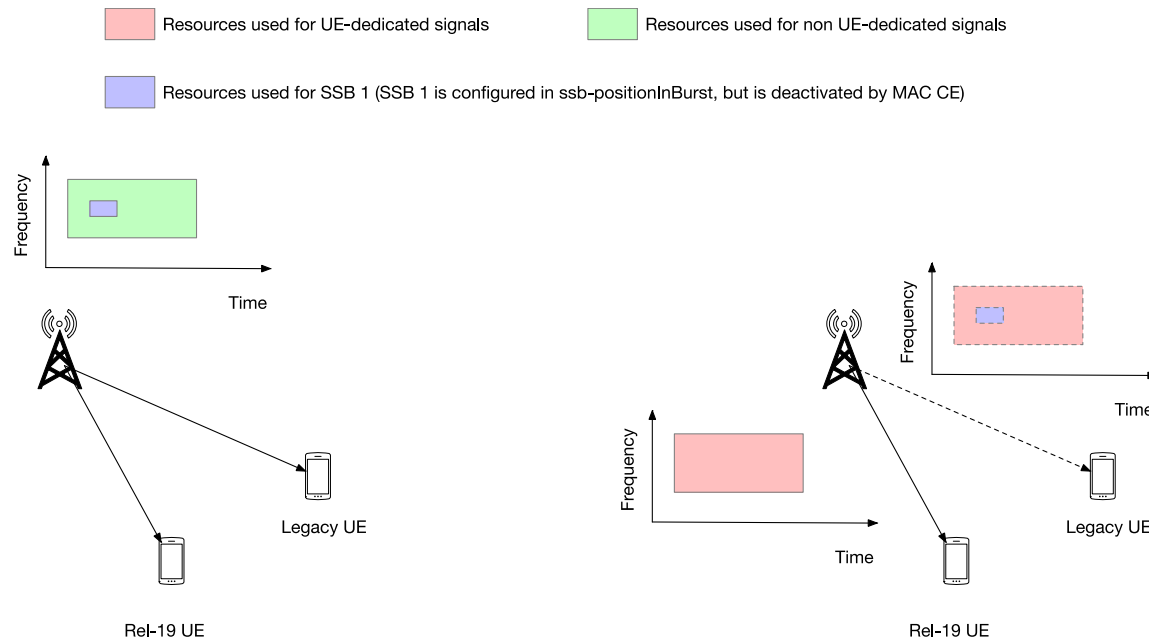

Figure 1: Rate matching pattern for different UEs in the SCell

Proposal 5: For non-UE dedicated signals, the rate matching pattern should be based on the activated SSBs.

Proposal 6: For UE-dedicated signals, the rate matching pattern should be based on SSB configured in ssb-positionInBurst.

5 L1 measurement based on on-demand SSB

In RAN1 #118 and #118b meeting, the following has been agreed on L1 measurement based on on-demand SSB.

> **Agreement**
> - 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**
> 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

Currently, SSB can be configured for L1-RSRP/L1-SINR report, RLM, BFD and CBD. A first issue is to clarify whether the on-demand SSB can be configured for RLM/BFD/CBD or not. If the on-demand SSB can be configured for L1-RSRP/L1-SINR report, it should be also applicable for RLM/BFD/CBD.

For on-demand SSB based measurement, the UE may only need to measure the activated SSBs instead of all the configured SSBs. Then when reporting the SSBRI, the UE can indicate one of the activated SSBs based on the SSBRI.

Further, for CSI report configuration with on-demand SSB configured, since the NW may dynamically activate or deactivate the on-demand SSB, then it is necessary to consider mechanism to dynamically activate or deactivate such CSI report configuration, especially the periodic CSI report.

In addition, one remaining issue is whether to support the on-demand SSB for LTM. Since the LTM is also based on L1-RSRP, and the target cell may apply NES, it is necessary to support the on-demand SSB for LTM.

Proposal 7: Support to configure the on-demand SSB for RLM/BFD/CBD.

Proposal 8: For L1-RSRP/L1-SINR report based on on-demand SSB, support the UE to report the SSBRI based on the activated SSBs.

Proposal 9: Support to dynamically activate/deactivate the CSI report configuration with on-demand SSB configured.

Proposal 10: Support the on-demand SSB based L1-RSRP measurement and report for LTM

6   Connection between on-demand SSB and always-on SSB

In RAN1 #119 meeting, some connections between the on-demand SSB and always-on SSB have been agreed. There are still some open issues on the connections between the on-demand SSB and always-on SSB with regard to the time-domain property, e.g., periodicity, and spatial-domain property when they are based on different central frequencies.

Regarding the periodicity for on-demand SSB and always-on SSB, a typical use case for NES is to configure the on-demand SSB with a lower periodicity than the always-on SSB. However, with regard to further extension for other use cases, it is unnecessary to introduce the restriction for NW configuration.

Regarding the spatial-domain property when on-demand SSB and always-on SSB are in different central frequencies, since the on-demand SSB and always-on SSB are in the same serving cell, they can be QCLed with regard to QCL-TypeA and QCL-TypeD, which is similar to existing QCL indication. Currently, the NW can configure the TRS as the source RS for QCL-TypeA and QCL-TypeD indication for the PDSCH. There is no additional constraints that the TRS and PDSCH should be based on the same central frequency.

Proposal 11: How to configure the periodicity for on-demand SSB is up to NW implementation.

Proposal 12: When always-on SSB and on-demand SSB are in the same serving cell with different central carrier frequency, 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

7   Conclusion

In this contribution, we provided discussion on on-demand SSB for SCell. Based on the discussion, the following proposals are provided.

Proposal 1: For MAC CE based on-demand SSB indication, confirm the first working assumption that T is not less than T_min and revert the second working assumption that T is T_min.

Proposal 2: Support the MAC CE based on-demand SSB indication for SCell to provide the following information in addition to the periodicity of the on-demand SSB:

- *SCell index*

- *Activation/deactivation status for each on-demand SSB for the SCell*

- *The value of the action delay T*

Proposal 3: Support the NW configures one on-demand SSB configuration and introduce new RRC parameters for the agreed configuration for on-demand SSB including

- *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*

Proposal 4: Support option 1 for on-demand SSB deactivation

Proposal 5: For non-UE dedicated signals, the rate matching pattern should be based on the activated SSBs.

Proposal 6: For UE-dedicated signals, the rate matching pattern should be based on SSB configured in ssb-positionInBurst.

Proposal 7: Support to configure the on-demand SSB for RLM/BFD/CBD.

Proposal 8: For L1-RSRP/L1-SINR report based on on-demand SSB, support the UE to report the SSBRI based on the activated SSBs.

Proposal 9: Support to dynamically activate/deactivate the CSI report configuration with on-demand SSB configured.

Proposal 10: Support the on-demand SSB based L1-RSRP measurement and report for LTM

Proposal 11: How to configure the periodicity for on-demand SSB is up to NW implementation.

Proposal 12: When always-on SSB and on-demand SSB are in the same serving cell with different central carrier frequency, 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