Source: TCL
Title: Discussion on on-demand SSB Scell operation for NES
Agenda Item: 9.5.1
Document for: Discussion and Decision

1   Introduction

In this contribution, we give the discussion on on-demand SSB SCell operation for NES based on agreement in last several meeting [1][2], including signaling of on-demand SSB operation, transmission timing of indicated SSB, relationship between on-demand SSB and always-on SSB.

2   Signaling of on-demand SSB operation

Based on RAN 1 #118b, the options for deactivation of OD-SSB can be categorized in three sets:

-    Explicit deactivation indication signaling: Option 1, 1A and 6.

-    Implicit deactivation UE behavior or pe-definition: Option 2, 3, 4, 4A, 5.

For last meeting, regarding the deactivation of on-demand SSB, following agreement was given.

> **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

For option 1, explicit indication via MAC-CE has been agreed to used for deactivation of OD-SSB. For this case, at least scenario #3 could be used. For example, for scenario #3-1, Scell is configured to a UE and UE receives Scell activation command but not activation complete, then explicit indication for deactivation of OD-SSB could be used due to UE has basically achieved synchronization or measured functionality after on-demand transmission. Thus, we propose at least to support scenario #3 used for option 1.

Proposal 1: For the explicit indication of deactivation for on-demand SSB via MAC-CE, scenario #3 at least should be supported.

For option 4 and 4a, when UE receives SCell deactivation or the timer for SCell deactivation is expired, UE could deactivate OD-SSB transmission. In our understanding, there is no any additional signaling to indicate deactivation of OD-SSB, which is better way to reduce signaling overhead. Also, after Scell deactivation, it is not necessary to have signaling transmission for OD-SSB deactivation. In addition, the value of N implicitly determined using a timer might not be necessary from our perspective due to the number N of on-demand SSB bursts might be indicated by gNB directly.

Proposal 2: Support option 4 or 4a for OD-SSB deactivation.

Proposal 3: Not support the value of N is implicitly determined using a timer.

# 3 Transmission timing of the indicated on-demand SSB

Regarding transmission timing of on-demand SSB, the following agreement was made in RAN 1 #118b:

Agreement (RAN1#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~~]~~ ~~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.
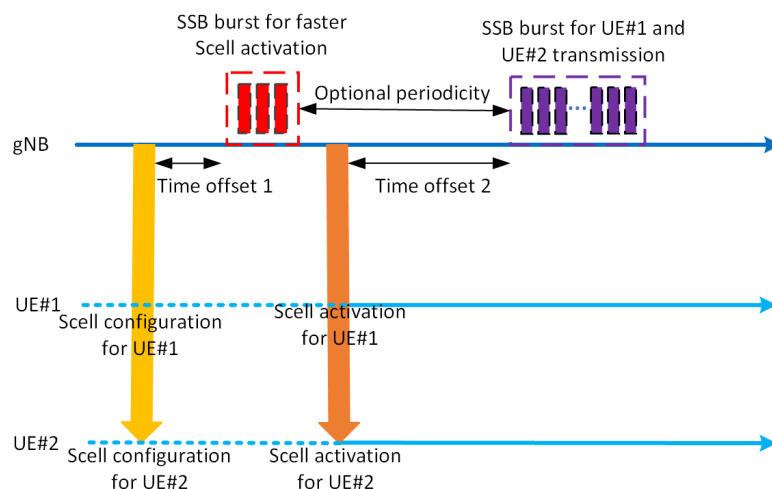

From discussion in previous meeting, we discover some critical issues or scenarios have not been clarified yet. One case is that UE could expect different OD-SSB transmission within one Scell operation during different periods. For example, 1st OD-SSB transmission could be used for scenario #2 or 3A to help Scell activation, which brings some benefit of shorter activation time. Also, 2nd could be used to keep synchronization after Scell activation. It is different from always-on SSB configuration. Ans also, 1st and 2nd OD-SSB have at least different transmission period. In this case, to activate 2nd OD-SSB transmission, same scheme for time instance A could be used for this scenarios. However, if 1st OD-SSB has been activated based on agreed T, how to activate 2nd OD-SSB should be considered. As shown figure below, offset 1 or offset 2 could be configured for 2nd OD-SSB activation.
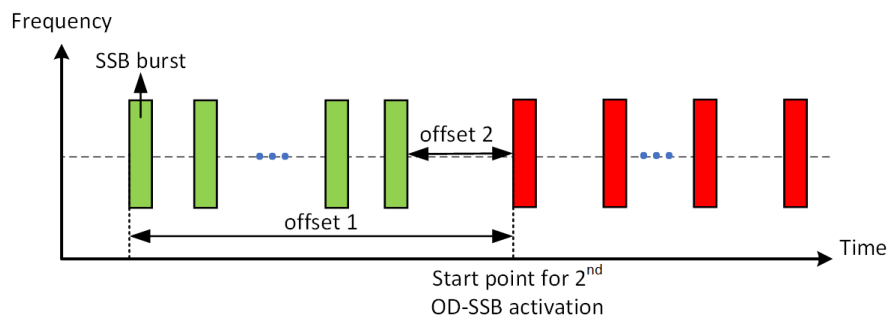
Proposal 4: UE expects that multiple on-demand SSB is transmitted from time instance A plus potential time offset.

FFS: how to configure potential time offset.

Another case is there might more than one UEs are configured Scell and indicated same/different OD-SSB transmission numerologies. As shown in figure below, one cell is configured as one Scell for UE #1 and UE 2 at same time (here, different scenarios could be expanded). After Scell is configured for UE 1 # and UE #2, OD-SSB #1 transmission is indicated by gNB for faster Scell activation. There might be one fixed time offset 1 between Scell configuration and OD-SSB transmission, which could be scheduled by MAC CE as like mentioned in agreement above. After a while, Scell is activated for UE#1 and UE#2, then same or different OD-SSB could be sent for synchronization or other function. Similarly, there might be one fixed time offset 2 between Scell activation and OD-SSB transmission, then also may be scheduled by MAC CE. Two OD-SSB burst may be same or different configuration, but in our understanding, at least frequency multiplexing is needed for UE #1 and UE #2.

SSB burst for faster Scell activation

SSB burst for UE#1 and UE#2 transmission

Optional periodicity

gNB

Time offset 1

Time offset 2

UE#1

Scell configuration for UE#1

Scell activation for UE#1

UE#2

Scell configuration for UE#2

Scell activation for UE#2

For this case, group-common signaling can be used for Scell operation for UE #1 and UE #2 at least including configuration and activation. This method is benefit for signaling saving due to redundant or repeated signaling could be avoided. In addition, in our understanding, dynamic time offset could be supported to meet the requirement of expanding scenarios. Thus, just like some company said in last meeting, we support considering dynamic offset indicated by MAC CE to indicate same or different position of OD-SSB.

Proposal 5: Support dynamic offset indicated by MAC CE to indicate same or different position of OD-SSB transmission.

- **FFS how to indicate dynamic offset for different scenarios.**

4 Relationship between on-demand SSB and always-on SSB.

4.1 Contents of on-demand SSB configuration/indication

Two agreements have been achieved for content configuration/indication of OD-SSB.

> **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.
>
> **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 (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*)

For case #2, OD-SSB and AO-SSB could be combined for synchronization or L1 measurement. For this case, some part of parameters could be configured as same. Also, we think OD-SSB and AO-SSB at least has same frequency position. Same parameter could be frequency, SCS, SSB positions within an on-demand SSB burst, etc. However, periodicity of the on-demand SSB/location of on-demand SSB burst may need configure separately.

Proposal 6: Same parameter like frequency, SCS, SSB positions within an on-demand SSB burst could be configured for AO-SSB and OD-SSB for case #2.

Proposal 7: Periodicity of the on-demand SSB/location of on-demand SSB burst may need configure separately for AO-SSB and OD-SSB for case #2.

For scenario #2 and #3, different configuration for OD-SSB transmission could be supported. For example, OD-SSB transmission for scenario #2 could be used for sync or L1 measurement, which help gNB to configure suitable Scell. As for scenario #3, OD-SSB transmission could help faster Scell activation and maintain sync if configured Scell. In our understanding, multiple OD-SSB configurations should be supported and consider how to activate/deactivate configured multiple OD-SSB. For this case, to avoid UE switching more often, same frequency for different OD-SSB transmission should be supported.

Proposal 8: Support multiple OD-SSB configurations and consider how to activate/deactivate configured multiple OD-SSB.

Proposal 9: Support multiple OD-SSB configurations with same frequency position.

4.2 Whether on-demand SSB is CD-SSB or not

For the question about whether OD-SSB is CD-SSB or not, the following agreement was made in RAN 1 last meeting:

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.

For case #2, firstly we think same BWP could be configured for AO-SSB and OD-SSB. If same frequency position has been assumed for AO-SSB and OD-SSB, then UE could assume cosistent MIB content. To avoid UE receive OD-SSB to update SI to have extra signaling overhead, it is better to support OD-SSB is an NCD-SSB. Then AO-SSB could be NCD-SSB as well. From above analysis, we prefer Alt 3 or Alt C and FFS whether or not AO-SSB is on a synchronization raster.

Proposal 10: Support Alt 3 or Alt C for what AO-SSB is an NCD-SSB.

If OD-SSB and AO-SSB all are NCD-SSB, how to indicate the frequency position of CD-SSB by NCD-SSB indication needs to be carefully considered. For AO-SSB, it could use legacy scheme to indicate the position of CD-SSB, however, whether/how to indicate the position of CD-SSB needs to be further considered.

Proposal 11: If OD-SSB and AO-SSB all are NCD-SSB, how to indicate the frequency position of CD-SSB by NCD-SSB indication needs to be carefully considered.

4.3 How to multiplex on-demand SSB and always-on SSB

This topic is associated with the inquiry of the relationship between always-on SSB and on-demand SSB from RAN4. Last meeting have given related agreement for time domain/frequency domain/spatial domain, and the agreement for frequency domain is listed as below

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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.

As above mentioned, to avoid UE switching more often, same frequency for different OD-SSB transmission should be supported. Similarly, we think AO-SSB and OD-SSB should have same frequency position to reduce UE complexity.

Proposal 12: Support same frequency location for AO-SSB and OD-SSB.

5 Conclusion

This paper discussed how to design on-demand SSB Scell operation, with the following observation/proposals:

Proposal 1: For the explicit indication of deactivation for on-demand SSB via MAC-CE, scenario #3 at least should be supported.

Proposal 2: Support option 4 or 4a for OD-SSB deactivation.

Proposal 3: Not support the value of N is implicitly determined using a timer.

Proposal 4: UE expects that multiple on-demand SSB is transmitted from time instance A plus potential time offset.

FFS: how to configure potential time offset.

Proposal 5: Support dynamic offset indicated by MAC CE to indicate same or different position of OD-SSB transmission.
- **FFS how to indicate dynamic offset for different scenarios.**

Proposal 6: Same parameter like frequency, SCS, SSB positions within an on-demand SSB burst could be configured for AO-SSB and OD-SSB for case #2.

Proposal 7: Periodicity of the on-demand SSB/location of on-demand SSB burst may need configure separately for AO-SSB and OD-SSB for case #2.

Proposal 8: Support multiple OD-SSB configurations and consider how to activate/deactivate configured multiple OD-SSB.

Proposal 9: Support multiple OD-SSB configurations with same frequency position.

Proposal 10: Support Alt 3 or Alt C for what AO-SSB is an NCD-SSB.

Proposal 11: If OD-SSB and AO-SSB all are NCD-SSB, how to indicate the frequency position of CD-SSB by NCD-SSB indication needs to be carefully considered.

Proposal 12: Support same frequency location for AO-SSB and OD-SSB.

References

[1] Chair notes, 3GPP TSG RAN WG1 #119, November, 2024.
[2] Summary #4 of on-demand SSB for NES (9.5.1), 3GPP TSG RAN WG1 #119, November, 2024.