3GPP TSG RAN WG1 meeting #120 **R1-2500128**

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Title: **Discussion on on-demand SSB for NES**

Source: **ZTE Corporation, Sanechips**

Agenda item: **9.5.1**

Document for: **Discussion and decision**

1 Introduction

In 3GPP RAN1#119 meeting, the agreements about on-demand SSB SCell operation for UEs in connected mode were achieved as below [1].

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

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

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.
    - 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.

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*)

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

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 this contribution, further discussion about the procedures of on-demand SSB SCell operation is provided.

2 Discussion on relations between on-demand SSB and always-on SSB

In 3GPP RAN4 #112bis meeting, RAN4 discussed the impacts on RRM requirements for on-demand SSB and identifies the questions as below.

Based on the discussion, RAN4 identified that the relation between always-on SSB and on-demand SSB (i.e. Case#2 as agreed in RAN1) has impacts on UE's behavior and requirements in SCell. RAN4 would like RAN1 to clarify at least the following aspects:

- Q1: What is the relation in terms of periodicity between always-on SSB and OD-SSB?
- Q2: What is the relation in terms of time location between always-on SSB and OD-SSB?
- Q3: What is the relation in terms of frequency location between the always-on SSB and OD-SSB?
- Q4: What is the spatial relation between the always-on SSB and OD-SSB?

In last meeting, RAN1 discussed the above questions and achieved some agreements.

■ Q1: What is the relation in terms of periodicity between always-on SSB and OD-SSB?

For Q1, RAN1 agreed that the periodicity of on-demand SSB can be one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms, and can be configured separately from the periodicity of always-on SSB.

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. For example, the on-demand SSB with smaller periodicity can accelerate the deactivated SCell measurement procedure in scenario #2. The on-demand SSB with smaller periodicity can effectively reduce the SCell activation delay in scenario #2A.

In addition, with proper time domain location configuration, the always-on SSB and on-demand SSB with the same periodicity can also achieve the effect of a smaller period of SSB.

Therefore, the on-demand SSB periodicity can be smaller than or equal to that of the always-on SSB.

Proposal 1: The periodicity of on-demand SSB can be smaller than or equal to that of the always-on SSB, and can be one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms.

■ Q2: What is the relation in terms of time location between always-on SSB and OD-SSB?

When the periodicity of on-demand SSB can be smaller than or equal to that of the always-on SSB, there are three possible time location relationships between always-on SSB and OD-SSB: (a) complete overlapping, (b) partial overlapping, and (c) non-overlapping cases, shown as Figure 1.

Figure 1 Possible time domain location between on-demand SSB and always-on SSB

As for Figure 1(a), when both the periodicity and the parameters of determining the time location (e.g., SFN offset and half frame index) of the on-demand SSB are equal to that of the always-on SSB, the on-demand SSB and the always-on SSB are completely overlapped. In this case, the transmission of the on-demand SSB does not provide any benefit, which is meaningless.

Observation 1: ***When the on-demand SSB and the always-on SSB are completely overlapped, the transmission of the on-demand SSB is meaningless.***

Figure 1(b) provides an example of partial overlap between on-demand SSB and always-on SSB. And the periodicity of the on-demand SSB is smaller than that of the always-on SSB, and the parameters to determine the time location (e.g., SFN offset and half frame index) of the on-demand SSB are equal to that of the always-on SSB. In this case, dense on-demand SSB bursts is transmitted. A UE can use a smaller periodicity of SSB to perform measurement to assist the UE in obtaining the measurement results of the SCell or speed up the SCell activation process.

Observation 2: ***Partially overlapping between on-demand SSB and always-on SSB can achieve the effect of dense SSB transmission.***

When the parameters to determine the time location (e.g., SFN offset and/or half frame index) of the on-demand SSB are different to that of the always-on SSB, the on-demand SSB will not overlapped with always-on SSB. In this case, the on-demand SSB and always-on SSB are distributed with equal or non-equal intervals in the time domain. As shown in Figure 1(c-1), the periodicity of on-demand SSB is equal to that of always-on SSB. With proper configurations of SSB, the on-demand SSB and always-on SSB with the same large-periodicity can be combined to achieve a SSB pattern with smaller periodicity. Moreover, as shown in Figure 1(c-2), with different time location configurations, the on-demand SSB will not overlapped with always-on SSB and the intervals between the on-demand SSB and always-on SSB are different. Then for the on-demand SSB with small periodicity as elaborated in Figure 1(c-3), it probably does not overlap with always-on SSB.

Observation 3: ***When on-demand SSB and always-on SSB do not overlap, the SSB density can be effectively increased to assist UE in performing measurement.***

Based on the above analysis, except that the on-demand SSB and always-on SSB are completely overlapped, the on-demand SSB in other cases is helpful for the UE to perform measurement. Therefore, for the time location

relationship between the on-demand SSB and the always-on SSB, complete overlapping should be excluded. And the other cases can be supported.

Proposal 2: For the time location between always-on SSB and OD SSB, except for complete overlapping, other cases are supported.

- **Q3: What is the relation in terms of frequency location between the always-on SSB and OD-SSB?**

It is agreed in RAN1 #119 meeting that 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.

For the case that always-on SSB is CD-SSB, some alternatives are provided as follows.

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.

When the always-on SSB is CD-SSB on a synchronization raster, the on-demand SSB can also be same as the frequency location of always-on SSB. Because if the frequency location of the always-on SSB and on-demand SSB is different, the on-demand SSB activation delay is longer due to the additional processing of the UE. What's more, if the always-on SSB and the on-demand SSB are not included in one active BWP, or even in different RF range, the BWP switching or RF returning operation may be needed, which is not beneficial for NES gain. Therefore, in this case, the frequency domain location of always-on SSB and on-demand SSB should be the same.

Regarding Alt A,B,C, the motivation to configure CD-SSB not on a synchronization raster is no clear. No benefit is observed by this configuration. Therefore, Alt C, i.e., do not support the case where always-on SSB is CD-SSB and not on a synchronization raster is preferred.

Proposal 3: 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) and Alt C (Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster) are supported.

- **Q4: What is the spatial relation between the always-on SSB and OD-SSB?**

The SSB positions within a SSB burst can be configured by the gNB. UE can perform the RRM measurement based on the always-on SSB and report the measurement results to the gNB. Based on this, the gNB can obtain the channel performance corresponding to each SSB index. For on-demand SSB transmission, there is no need to restrict the on-demand SSB positions within an on-demand SSB burst is same as that of always-on SSB.

What's more, reducing the number of transmitted SSBs in a SSB burst can achieve additional energy saving gain. As for the energy consumption model cat 2 agreed in R18, the transition time of light sleep and deep sleep is 640ms and 10s respectively. In this case, the NES gain from reducing the number of transmitted SSBs in a SSB burst is almost the same as extending the SSB periodicity since the sleep states of the gNB cannot be changed even if the SSB periodicity is increased. Therefore, reducing the number of transmitted SSBs in a SSB burst is beneficial to the cat 2 BS.

In order to obtain the better energy saving gain, the SSB index corresponding to the SSB with better performance can be selected to be transmitted on-demand. Therefore, the actual transmitted on-demand SSB can be the same as the always-on SSB or a subset of the always-on SSB.

Proposal 4: Support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

3 Discussion on on-demand SSB SCell operation

3.1 Scenarios and cases for on-demand SSB SCell operation

During the 3GPP RAN1#116-bis meeting, several scenarios for the on-demand SSB SCell operation were identified, including scenarios #2, #2A, #3A, and #3B. Both scenario #2 and scenario #2A, in conjunction with cases #1 and case #2, have been supported.

Scenario determination is the prerequisite for solution design. Firstly, for different scenarios, UE has different requirements regarding synchronization, measurements and SCell activation facilitated by the SSB signal in SCell. For example, UE needs dense SSB for fast SCell activation, while UE only needs sparse SSB to maintain synchronization/AGC operation in scenario #3B. Secondly, across diverse scenarios, the appropriate method for signaling the triggering of on-demand SSB transmission may vary.

Proposal 5: Whether or not support scenario #3A, #3B should be discussed and concluded.

Regarding scenario #3A, the on-demand SSB is proposed to be triggered as part of the SCell activation procedure. However, since scenario #2A, which involves the on-demand SSB being triggered upon the UE receiving the SCell activation command, is already supported, the rationale for introducing an additional trigger for the on-demand SSB following the SCell activation command is not evident, irrespective of whether it is bound to case #1 or case #2. Consequently, there is no continued justification for supporting scenario #3A.

Proposal 6: There is no need to support Scenario #3A.

In Scenario #3B, the UE has the potential to be served by network for a long time period. The substantial network energy savings may be realized by reducing the majority, if not all, of SSB transmissions after SCell activation is completed.

It should be noted that the UE is capable of realizing synchronization/AGC adjustment during the SCell activation process. Consequently, once the SCell activation is completed, the system performance can be reliably maintained even in the absence of periodic SSB transmissions, as in Case #1. For scenarios requiring more precise synchronization or frequent ACG adjustment, an on-demand SSB transmission mechanism can be invoked to ensure the requirement in a flexible manner. This approach offers a superior balance between network energy saving gain and system performance. Hence, there is a necessity for supporting Scenario #3B, particularly in conjunction with Case #1.

Observation 4: ***Scenario #3B in conjunction with case #1 can achieve a good tradeoff between network energy saving and system performance.***

For case #2 in scenario #3B, the always-on SSB will be transmitted after the SCell activation is completed. It is noted that the always-on SSB is legacy SSB supported in Rel-18 specifications. The scenario #3B with case #2 is similar to adaptation of SSB in time domain as discussed in AI 9.5.3. To this end, this case can be de-prioritized in AI 9.5.1 and left to be discussed in AI 9.5.3.

Proposal 7: ***Scenario #3B in conjunction with case #1 should be supported.***

3.2 When does on-demand SSB transmission start/end in time domain

- **Time instance A for MAC CE**

It was confirmed that for SSB burst(s) indicated by on-demand SSB SCell operation via MAC CE, the time instance A is the beginning of the first slot containing the first actually transmitted SSB index 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.

In order to guarantee that the UE can successfully process the MAC CE before on-demand SSB reception, the minimum value of T is needed as concluded in last meeting. The time instance A should be the first half frame after T slots after the slot where UE receives a signalling from gNB to indicate on-demand SSB transmission. In details, T only needs to meet the time requirement for the UE to receive HARQ-ACK and process MAC CE. Therefore, the working assumption that T=T_min can be confirmed.

Proposal 8: ***Confirm the working assumption that T = T_min.***

- **Time instance A for RRC**

For RRC based indication signaling, the on-demand SSB transmission can be triggered when the SCell is configured or activated. To align the understanding of the SSB transmission time between the gNB and the UE and reduce the extra power consumption caused by unnecessary UE detection, it is necessary to determine a time instance A for RRC based indication signaling. Similar to the MAC CE indication signaling, the time instance A for the RRC signaling can be defined as the beginning of the first slot containing the first actually transmitted SSB index within the first "possible" on-demand SSB burst which is at least T_RRC slots after the last slot of the RRC message.

It is agreed in RAN1 #118 meeting that support RRC based signaling to indicate on-demand SSB transmission on the cell where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration. For the procedure that the RRC configures a SCell, activates a SCell, or provides on-demand SSB configuration, no HARQ-ACK is needed. So the T_RRC should be no less than the timeline required for UE's RRC processing.

Proposal 9: ***For the RRC based signaling, time instance A can be the first slot containing the first actually transmitted SSB index within the first "possible" on-demand SSB burst which is at least T_RRC slots after the last slot of the RRC message.***

- ***FFS values of T_RRC.***
- ***Note: The T_RRC should be no less than the timeline required for UE's RRC processing.***

- **Deactivation of the on-demand SSB**

For the deactivation of the on-demand SSB, the agreement was approved in RAN1 #119 meeting as follows.

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

As for option 1, the MAC CE for on-demand SSB transmission indication can also be used for indicating the deactivation of the on-demand SSB. Since it is supported to use MAC CE based signaling to indicate on-demand SSB transmission on the cell for both scenarios #2 and #2A. So, it is natural and feasible to deactivate the on-demand SSB transmission by the MAC CE signaling for both scenario #2 and scenario #2A. That is, Option 1 can be used at least for scenario #2 and scenario #2A.

Proposal 10: Option 1 can be used at least for scenario #2 and scenario #2A.

Option 2 can also be used to deactivate the on-demand SSB transmission. By this way, the on-demand SSB transmission can be stopped via the configuration/indication. And the value of N can be configured/indicated to meet different requirements under various scenarios.

The value of N can be flexibly configured or indicated to meet different requirement. So, the option 2 can also be used for scenario #2 and scenario #2A.

Proposal 11: Option 2 can be used for scenario #2 and scenario #2A.

Besides, according to the previous analysis, a large energy saving gain can be obtained by supporting on-demand SSB for scenario #3B. Therefore, the activation/deactivation of on-demand SSB in the scenario #3B should also be discussed. Considering the complexity of signaling design and the characteristics of scenarios, it is unnecessary to introduce a new activation/deactivation signaling in the scenario #3B. The same activation and/or deactivation scheme as that of scenario #2 or #2A can be applied to scenario #3B. Therefore, option1 and option2 can also be used for scenario #3B.

Proposal 12: Option 1 and option 2 can also be used for scenario #3B.

In addition, it should be noted that the deactivation of on-demand SSB transmission by option 1 and option 2 should not be mutually exclusive. For example, to meet the measurement requirements under the worst conditions, the value of N may be set to a large value. However, actually, the requirements can be satisfied by detecting some of the on-demand SSBs. In this case, unnecessary energy consumption is caused due to the remaining on-demand SSB transmission. Therefore, it is reasonable to terminate the on-demand SSB transmission in advance by the MAC CE signaling.

So, the combination of option 1 and option 2 should also be supported.

Proposal 13: Support the combination of option 1 and option 2.

As for the remaining FFS bullet, we don't think that option 4, 4a is needed in addition to Option 2. Basically there is no extra NES benefit over option 2. Besides, considering the flexibility of available values of N, we believe option 2 can achive the same duration of on-demand SSB transmission as what option 4,4a tries to implement.

Proposal 14: Option 4 and 4a are not needed.

For the second FFS bullet, according to the requirement description of RAN4, the number of SSB can better reflect the requirements of UEs for synchronization, measurement, and AGC in different scenarios. The periodicity of on-demand SSB is one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms, if the number of SSB required by a UE is fixed, the duration of the SSB to be transmitted varies with the different SSB periodicity. If N is implicitly indicated by a timer, different on-demand SSB periodicity correspond to different N values. To ensure the flexibility of the value of N, a large number of timer configurations are required, which increases the implementation complexity.

Observation 5: ***Using timer to implicitly indicate the value of N leads to a large overhead.***

Therefore there is no need to introduce the timer to implicitly determine the value of N.

Proposal 15: ***Introduce the timer to implicitly determine the value of N is not supported.***

The value of N that UE needed is related to the measurement requirement. For example, for scenario 2A, the number of SSBs for SCell activation for the SCell with different conditions (such as intra-band, inter-band, known, and unknown) are different, and the minimum number of SSB depends on the requirement specified by the RAN4. Therefore, there should be multiple candidate values for N, and the determination of the candidate values is up to RAN4.

Proposal 16: ***The determination of candidate values of N is up to RAN4.***

3.3 Configurations of on-demand SSB

In RAN1 #119 meeting, it is agreed that 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, the SFN offset and half frame index can be configured to the UE. For case #2, there are two alternatives are summarized to be down-selected.

- 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*)

Both Alt A and Alt B can determine the time domain location of the on-demand SSB. As we discussed before, the on-demand SSB can be applied to multiple scenarios/cases. In order to simplify the design of on-demand SSB configuration, a unified framework of on-demand SSB configuration which can be applicable to multiple scenarios and can be used for both Case #1 and Case #2 is preferred.

For option 2, a new parameter is introduced, which will lead to additional and unnecessary workload. And no additional benefits are observed. Therefore, for case #2, the determination of the time domain location of the on-demand SSB can be the same as that of case #1.

Proposal 17: ***For the determination of the time domain location, Alt A is supported.***

In addition to the time domain position, the on-demand SSB transmission power, the number N of on-demand SSB bursts to be transmitted, the SSB positions within an on-demand SSB burst, and the periodicity of the on-demand SSB also need to be configured for the UE. And the above one or more parameters may be differently for different scenarios.

For instance, in Scenario #2, the measurement cycle for SSBs on deactivated SCells is extended compared to that of activated SCells, allowing for the transmission of sparse SSBs. In contrast, for Scenario #2A, to minimize the SCell activation delay, a denser transmission periodicity of SSBs may be employed.

In addition to the on-demand SSB transmission periodicity, the required number of on-demand SSB bursts also varies in different scenarios. In that respect, multiple candidate periodicity values of the on-demand SSB can be configured by RRC and the applicable value can be indicated by MAC CE. However, when multiple variable

parameters can be configured by RRC, and each of them is updated by MAC CE, the signaling overhead will be increased. To reduce the overhead of these UE specific signaling (MAC CE), one parameter e.g., on-demand SSB transmission pattern can be configured. And each on-demand SSB transmission pattern contains/associates more than one on-demand SSB parameters.

Proposal 18: One parameter e.g., on-demand SSB transmission pattern can be configured for the SCell to UE, to reduce the overhead of indication the UE specific signalling.

3.4 Triggering signaling for on-demand SSB

■ On demand SSB triggered by RRC

As agreed in 3GPP RAN1 #108 meeting, there is one case that the RRC based signaling can be used to indicate on-demand SSB transmission on the SCell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration.

As discussed in the chapter 2.3, the on-demand SSB pattern associated with one or more on-demand SSB related parameters can be configured to the UE. If multiple on-demand SSB transmission patterns/configurations are configured by the RRC signaling, it is advantageous to clearly indicate the specific SSB transmission pattern index to be employed.

Therefore, for above case, a target on-demand SSB transmission pattern index can be configured by the RRC signaling.

Proposal 19: For the case that the RRC based signaling can be used to indicate on-demand SSB transmission on the SCell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration:

- ***A target on-demand SSB transmission pattern index can be configured by RRC signaling.***

For other cases except for the RRC signaling also configures the SCell, activates the SCell, and provides on-demand SSB configuration, the RRC based signaling has no advantage compared other signaling, for example the MAC CE based signaling, because RRC signaling causes a long and ambiguous signaling delay. Therefore, there is no need to support RRC based signaling for other cases.

Proposal 20: Do not support RRC based signaling for other cases.

■ On demand SSB triggered by MAC CE

For the on-demand SSB triggered by the MAC CE, it is agreed in RAN 2 that the NW should be able to send on-demand indication for multiple SCells simultaneously by a MAC CE. Therefore, the target Cell ID and the on-demand SSB transmission pattern corresponding to the target SCell index should be known to the UE, which can be indicated by the MAC CE.

Proposal 21: The target Physical Cell ID of the on-demand SSB and target on-demand SSB transmission pattern index can be indicated by the MAC CE.

■ On demand SSB triggered by DCI

In addition, whether to support DCI based signaling to indicate on-demand SSB transmission on the cell is still controversial.

For scenario #2 and scenario #2A, the RRC based signaling and the MAC CE based signaling is already supported. The motivation for introducing additional DCI based signaling needs to be discussed. But for scenario #3B, DCI based signaling can be further considered.

Proposal 22: Discuss whether the DCI based signaling is applicable to scenario #3B.

3.5 L1 measurement and LTM based on on-demand SSB/always-on SSB

- **L1 measurement**

L1 measurement based on on-demand SSB are discussed in previous meetings, and it is agreed that for L1 measurement based on on-demand SSB, periodic, semi-persistent, and aperiodic L1 measurement reports based on existing CSI framework are supported.

In last meeting, two options for UE to perform L1 measurement for Case #2 are provided as follows.

- 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

Firstly, in order to ensure the configuration flexibility, there is no need to restrict the OD-SSB and always on SSB have same beams.

Proposal 23: There is no need to restrict the OD-SSB and always on SSB have same beams.

Besides, if on-demand SSB and always-on SSB are located on different frequencies and/or have different beams, the CSI report configuration associated with both of on-demand SSB and always-on SSB (Option 1) may cause multiple measurement results for one cell, which may increase overhead of CSI report and complexity of implementation. Therefore, Option 2, a CSI report configuration is associated with one of always-on SSB and on-demand SSB, is preferred.

Proposal 24: At least for Case #2, Option 2, a CSI report configuration is associated with one of always-on SSB and on-demand SSB, is supported.

- **LTM based on on-demand SSB**

A UE can be indicated, by *LTM-Config*, candidate cells and SS/PBCH blocks per candidate cell for the UE to obtain synchronization and measure corresponding L1-RSRPs. When certain conditions are met, the UE can be indicated to switch to an LTM target cell belonging to the candidate cells. While the LTM target cell can only be a SpCell.

To reduce the impact on legacy UE, on-demand SSB SCells do not support to be a SpCell for UE. If the LTM is supported, necessary standardization work to change the state of the on-demand SSB SCell is required. In addition, there is no obvious benefits or strong motivation to trigger SSB transmission on the on-demand SSB cell for LTM. Therefore, for Rel-19, support LTM for on-demand SSB SCells should be deprioritized.

Proposal 25: For Rel-19, support LTM for on-demand SSB SCells should be deprioritized.

4 Conclusion

In this contribution, we have the following observations and proposals:

Observation 1: When the on-demand SSB and the always-on SSB are completely overlapped, the transmission of the on-demand SSB is meaningless.

Observation 2: Partially overlapping between on-demand SSB and always-on SSB can achieve the effect of dense SSB transmission.

Observation 3: When on-demand SSB and always-on SSB do not overlap, the SSB density can be effectively increased to assist UE in performing measurement.

Observation 4: Scenario #3B in conjunction with case #1 can achieve a good tradeoff between network energy saving and system performance.

Observation 5: Using timer to implicitly indicate the value of N leads to a large overhead.

Proposal 1: The periodicity of on-demand SSB can be smaller than or equal to that of the always-on SSB, and can be one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms.

Proposal 2: For the time location between always-on SSB and OD SSB, except for complete overlapping, other cases are supported.

Proposal 3: 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) and Alt C (Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster) are supported.

Proposal 4: Support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

Proposal 5: Whether or not support scenario #3A, #3B should be discussed and concluded.

Proposal 6: There is no need to support Scenario #3A.

Proposal 7: Scenario #3B in conjunction with case #1 should be supported.

Proposal 8: Confirm the working assumption that T = T_min.

Proposal 9: For the RRC based signaling, time instance A can be the first slot containing the first actually transmitted SSB index within the first "possible" on-demand SSB burst which is at least T_RRC slots after the last slot of the RRC message.

- ***FFS values of T_RRC.***
- ***Note: The T_RRC should be no less than the timeline required for UE's RRC processing.***

Proposal 10: Option 1 can be used at least for scenario #2 and scenario #2A.

Proposal 11: Option 2 can be used for scenario #2 and scenario #2A.

Proposal 12: Option 1 and option 2 can also be used for scenario #3B.

Proposal 13: Support the combination of option 1 and option 2.

Proposal 14: Option 4 and 4a are not needed.

Proposal 15: Introduce the timer to implicitly determine the value of N is not supported.

Proposal 16: The determination of candidate values of N is up to RAN4.

Proposal 17: For the determination of the time domain location, Alt A is supported.

Proposal 18: One parameter e.g., on-demand SSB transmission pattern can be configured for the SCell to UE, to reduce the overhead of indication the UE specific signalling.

Proposal 19: For the case that the RRC based signaling can be used to indicate on-demand SSB transmission on the SCell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration:

- ***A target on-demand SSB transmission pattern index can be configured by RRC signaling.***

Proposal 20: Do not support RRC based signaling for other cases.

Proposal 21: The target Physical Cell ID of the on-demand SSB and target on-demand SSB transmission pattern index can be indicated by the MAC CE.

Proposal 22: Discuss whether the DCI based signaling is applicable to scenario #3B.

Proposal 23: There is no need to restrict the OD-SSB and always on SSB have same beams.

Proposal 24: At least for Case #2, Option 2, a CSI report configuration is associated with one of always-on SSB and on-demand SSB, is supported.

Proposal 25: For Rel-19, support LTM for on-demand SSB SCells should be deprioritized.

5 References

[1] Chair notes RAN1#119, 3GPP TSG RAN1 #119, November, 2024.