**3GPP TSG-RAN WG1 #104b-e R1-21xxxxx**

**eMeeting, Apr 12 – 20, 2021**

**Source: Moderator (Ericsson)**

**Title: Summary of Email discussion [104b-e-NR-DSS-01]**

**Agenda item:** **8.13.1**

**Document for:** **Discussion and Decision**

# 1 Introduction

This document summarizes the discussions for email thread [104b-e-NR-DSS-01] under agenda item 8.13.1 on Cross-carrier scheduling (from SCell to PCell) for the Rel17 WI on NR Dynamic spectrum sharing (DSS).

# 2. Discussion

## 2.1 Moderator Summary

Below is a short moderator summary based on tdocs [1-21] submitted for RAN1#104-e

### 2.1.1 PDCCH monitoring and BD/CCE limit handling

Following aspects were discussed related to PDCCH monitoring and BD/CCE limit handling when CCS from sSCell to PCell/PSCell is configured

1. In RAN1#103-e and RAN1#104-e, high level agreements on PDCCH monitoring on P(S)Cell and/or sSCell to support CCS from sSCell to P(S)Cell were made. For this meeting, below detailed alternatives were discussed in the tdocs (details of Alt 2-1 to 2-4 are in the RAN1#103-e agreement in the Annex)
   * Alt 2-1 -- [1],[4],[5],[7?][11],[16],[17],[19],[20]
   * Alt 2-2 – [2],[3],[10],[14],[18]
   * Alt 2-3 –[19 (for non-fallback DCI formats x\_2)]
   * Alt 2-4 – [6],[7?],[18],[19 (for non-fallback DCI formats x\_1)]
   * Modified Alt 2-4 (now called Alt 2-4a) – [15]
     + A UE does not expect to monitor PDCCH [including CSS and USS candidates for primary cell scheduling] on both the primary cell and the sSCell in a same slot
   * Modified Alt 2-2 (now called Alt 2-5) – [8]
     + Dynamic switching of PDCCH monitoring of DCI formats 0\_1,1\_1,0\_2,1\_2 between monitoring on PCell/PSCell USS sets and monitoring on sSCell USS sets is supported
       - FFS: Details of switching mechanism
     + UE may ~~does not~~ monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS sets simultaneously in certain scenarios, e.g. when the UE falls back to monitoring USS set on the PCell, it is not forbidden from monitoring the USS set on the sSCell.
   * Alt2-2+Alt 2-4 (now called Alt 2-6!) – [8]
     + The USS set(s) on PSCell/PCell and the USS set(s) on sSCell are configured such that UE does not monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS set(s) simultaneously
     + SS Group Swithcing is employed for dynamic switching mechanism
2. BD/CCE limit handling and overbooking discussed in [1],[3],[4],[5],[7],[9],[11],[13],[14],[15],[17],[20],[21].
   * As part of the discussions, it is beneficial to clarify the intended BD limit handling for a corresponding PDCCH monitoring option (i.e., the Alt 2-1,2-2, etc. discussed above). To initiate such discussion, it can be first clarified whether BD limits are according to Option A or Option B below (similar principle can be applied for CCE limits later)
     + Assuming below notation
       - USS(s) => USS(s) that can schedule PDSCH/PUSCH on P(S)Cell)
       - x1(m) is #BDs for PDCCH CSS(s) candidates monitored on P(S)Cell slot m
       - x2(m) is #BDs for PDCCH USS(s) candidates monitored on P(S)Cell slot m for USS(s)
       - y(m) is #BDs for PDCCH USS(s) candidates monitored on sSCell in sSCell slot(s) that overlap slot m of P(S)Cell
     + Option A
       - max of (x1(m1)+x2(m1))+max of y(m2) corresponding to any P(S)Cell slots m1 and m2 is less than or equal to BD limit Z1
         * FFS Z1 related details including value of Z1and any related signaling
     + Option B
       - For P(S)Cell slot m,
         * x1(m)+x2(m)+y(m) is less than or equal to BD limit Z2

FFS Z2 related details including value of Z2 and any related signaling

* + - * max of (x1(m1)+x2(m1)) + max of y(m2) corresponding to any P(S)Cell slots m1 and m2 can be larger than BD limit Z2
  + Whether to allow PDCCH overbooking on sSCell was discussed in
    - Not allow overbooking on sSCell – [1],[3],[5?],[6],[7?],[9],[13],[19],[20]
    - Allow overbooking on the sSCell – [4],[5?],[7?],[11],[14],[15],[17]

1. Handling of DCI formats 0\_0 and 1\_0 on USS for scheduling PCell/PSCell PDSCH/PUSCH (this was also discussed in RAN1#104-e)
   * only on PCell/PSCell as in Rel15/16 – [3],[4],[5],[11],[12],[15],[16],[19]
   * follows for non-fallback handling – [13]
   * FFS – [17],
2. DCI format 2-5 (also discussed in RAN1#104-e)
   * follows Rel16 – [4],[6],[10],[11],[12],[15],[17]
3. DCI format 2-6 (also discussed in RAN1#104-e)
   * Follows Rel16 handling – [3],[4],[6],[10],[12],[17]
   * Can be sent also on sSCell – [1?],[5],[11],[15],
4. Impact on DCI size budgets– [3],[4],
5. Impact on #DL and UL unicast DCI per monitoring occasion/span – [4],[7],[16],[19]
6. PDCCH in SS set provided by recoverySearchSpaceId can be monitored on the sSCell – [21]
7. Separate config of UL and DL DCI formats – [19]

### 2.1.2 Configuration details for CCS from sSCell to P(S)Cell

1. CIF handling, hashing function – [3],[4],[11],[13],
2. Search space ID linking and config of (PeriodicityAndOffset, SymbolsWithinSlot, and duration) for sSCell 🡪 PCell/PSCell scheduling and PCell/PSCell 🡪 PCell/PSCell scheduling – [3],[4],[13],[21]
3. RRC configuration details for CCS from sSCell to PCell/PSCell (How to indicate using CrossCarrierSchedulingConfig) – [3],[4],[5],[6],[9],[15],

### 2.1.3 Remaining details on scheduling framework

Following aspects were discussed related to scheduling framework when CCS from sSCell to PCell/PSCell is configured

1. Dynamic activation/activation/switching of sSCell 🡪 PCell/PSCell scheduling
   * Support – [4],
   * Not support – [5],[6],[7]
   * FFS – [16]
   * Handling when sSCell is deactivated/dormant – [17],[[19],
2. Dormancy supported for sSCell?
   * Supported – [3],[4],
   * FFS –
3. DCI or MAC CE based switching of sSCell – [15]

### 2.1.4 Other aspects

1. SCell to PCell/PSCell scheduling has no impact on PUCCH or PUSCH/SRS for non-CA – [8]
2. Whether sSCell can be unlicensed band? – [19]
3. BFR on sSCell – [21]
4. SCell to PCell scheduling also supported for multi-cast broadcast PDSCH – [21]

Below are some proposals for discussion

## 2.2 Proposals

### Discussion point 1

* Companies are encouraged to indicate their preferred joint framework considering
  + the alternatives for PDCCH monitoring (i.e., Alt 2-1, 2-2, 2-3, 2-4, 2-4a, 2-5, 2-6 as discussed in section 2.1.1 above, point 1), and
  + the options for defining BD/CCE limits (i.e., a limit Z1 based on Option A, or Z2 based on Option B as discussed in section 2.1.1 above, point 2), and
  + whether PDCCH overbooking handling is needed or not for sSCell

Companies are requested to indicate their view in the Table below

|  |  |  |
| --- | --- | --- |
| **Company Name** | **Preferred combination (PDCCH monitoring Alt, BD/CCE limit option, yes/no for ssCell overbooking handling)** | **Comments (Discussion point 1)** |
| Moderator notes |  | Intention is to identify joint framework considering PDCCH monitoring approach, corresponding BD/CCE limits and requirement for overbooking handling on sSCell.  In addition to clarifying Option A vs. Option B for BD/CCE limits, companies can also provide example limits for the corresponding Option. |
| Qualcomm |  | First of all, we would like to request to add a note that the discussion here is, for the time being, for UEs that can be configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 that schedule PDSCH/PUSCH on PCell/PSCell on PCell/PSCell USS set(s), and/or on sSCell USS set(s). The other type of UEs, i.e., (Alt.1) UEs that cannot be configured to monitor these DCI formats on the PCell/PSCell, will be discussed separately.  **PDCCH monitoring (sub-)Alternative**  With the above understanding, our preference is Alt.2-1, subject to appropriate solutions of BD/CCE determination and PDCCH overbooking.  **BD/CCE limit option for Alt.2-1**  Option A.  Z1 should be 44 PDCCH candidates for the PCell SCS 15kHz. This number comes from the fact that the PDCCH capability is dimensioned not from a scheduling cell perspective; but from a scheduled cell perspective. For PDSCH/PUSCH scheduling on the PCell with SCS 15kHz, 44 PDCCH candidates in 1ms slot should be sufficient.  **Yes/no for ssCell overbooking handling for Alt.2-1**  No.  PDCCH overbooking on the PCell has been supported since Rel.15 to address the issue where the number of PDCCH candidates on the PCell could vary across slots due to different monitoring periodicities for USSs and CSSs (for SI, paging, RA). For Rel.17 cross-carrier scheduling for DSS, since we have agreed to keep these CSSs on the PCell, it is not necessary to enable PDCCH overbooking on the sSCell.  In order to enable PDCCH overbooking on the PCell for Alt.2-1, we propose to introduce an RRC parameter that gives a BD limit for the PCell. The BD limit for the PCell should not be less than the maximum number of BDs required for CSSs across all the slots on the PCell (so that overbooking for CSSs is not required), and should not be more than Z1. Based on the configured BD limit for the PCell, PDCCH overbooking on USS sets on the PCell is enabled. For PDCCH monitored on the sSCell, no PDCCH overbooking shall be required. |
| Samsung |  | In resolving the FFS from the last meeting and considering Alt. 2-4, the baseline operation that enables DSS for Rel-16 UEs is for a UE to not monitor PDCCH in a same slot on both PCell and sSCell. There is no issue as the sSCell is TDD and Type3-CSS can be on either the PCell or the sSCell (DCI 2\_6 does not matter). SI updates may be received twice per frame on PCell as in LTE. Obviously there is no spec impact for BD/CCE partitioning.  Alt 2-1 and Alt 2-2 can be considered as enhancements. Alt 2-2 may be viewed as enhancement to Alt 2-4 but also applied to Alt 2-1. The spec impact includes the BD/CCE split/determination. Both Option A and Option B can work depending on particular alternative – e.g. Option A can work with Alt 2-1, Option B can work with Alt 2-2/2-4. Several more options can be considered, including introducing a virtual cell (e.g. x1(m)+x2(m) <= Z3 AND y(m) <= Z4, while Z3+Z4 <= Z5 or max of (x1(m1)+x2(m1))<= Z3 AND max of y(m2) <= Z4, while Z3+Z4 <= Z5, …). Instead of that, it would be better to discuss specific proposals for partitioning BDs/CCEs under Alt 2-1 – basically, the main question is how to determine /.  SS overbooking on sSCell should be supported. To clearly see this, consider Alt. 1 where all USS sets are moved to the sCell (in that sense, Alt. 1 is not DSS as there is no ‘D’ in it). With the exception of infrequent SI updates (CSS on PCell), the sSCell can/will also include the Type-3 CSS and is practically the Rel-16 PCell. |
| Huawei |  | **For PDCCH monitoring** there has been a working assumption that implies separate UE capabilities for whether or not simultaneously monitoring the PDCCH from both cells. From network point of view it is not desirable to have further finer granularity for restricted approach in between Alt 2-1 and Alt-2, thus Alt 2-1 is the preferred target for this objective of R17 DSS.  While to proceed it might be easier to discuss **the BD/CCE limit** first given the working assumption content, and in that case work based on Alt2-1 is proper. Our preference is not either Option A or Option B - either option is referring to Pcell while it was true in Rel16 X-carrier scheduling where Scell is not monitored, the need to keep the limit for each cell/SCS when sSCell scheduling PCell is raised, under Alt 2-1. So the determination needs to be extended considering the scheduling source numbers, as that happens in Multi-TRP operation. Our proposal is to add Option C (though Option B may still work if the SCS between two cells are same).   * Option C   + For P(S)Cell slot m1,     - max of (x1(m1)+x2(m1)) is less than or equal to BD limit Z3, and   + For sSCell slot m2,     - max of (y(m2)) is less than or equal to BD limit Z4   + FFS Z3/Z4 related details including value of Z3/Z4 and any related signaling   We don’t see strong need to support **overlooking on sScell**. |
| ZTE | 1) Alt.2-1  2) Option B  3) Overbook on across PCell + SCell | Based on our understanding, the potential UE implementation complexity mainly comes down to the BD/CCE budget split/sharing and/or overbooking between PCell and sSCell instead of these different alternatives.  For Alt.2-2, 2-5 and 2-6, RAN1 needs to define the switching command and switching mechanism. Besides, switching delay is required, which makes it impossible to perform frequent switching between PCell and sSCell scheduling to adapt to the dynamic channel condition.  For Alt.2-3, one DCI format is restricted on one carrier. This restricts the network scheduling flexibility. For example, if DCI format 1-2/0-2 is restricted on sSCell, it is impossible to switch PCell scheduling URLLC smoothly.  For Alt.2-4 and 2-4a, it is not clear what’s the benefit to stagger the CSS/USS on PCell and USS on SCell.  Regarding BD/CCE limit handling, Option A refers to separate limit for PCell and sSCell while Option B refers to a joint limit for PCell and sSCell. Based on our understanding, Option B can fully make use of the UE BD/CCE capability without any waste.  Regarding overbooking, legacy overbooking mechanism is for a particular scheduled cell. It is preferred to perform overbooking across PCell and SCell.  Thus, 1) Alt.2-1 + 2) Option B + 3) Overbook on across (PCell + SCell) would be our preferred solution. However, we understand that UE vendors may have concern on Option B and overbooking across PCell+SCell, we are also open to some compromised solutions for Alt.2-1. |
| vivo | 1. Alt. 2-1 2. Option A 3. Overbooking on Pcell CSS + Pcell USS only | As discussed in our contribution, the UE implementation complexity is evaluated by combining BD/CCE budget and overbooking options and provided below:    Note that Option A and Option B is Option 1/2 and Option 3 respectively in the above table. For UE complexity evaluation, it is determined based on how to allocate PDCCH blind decoding resource (i.e. no change, long term change, or dynamic) in terms of UE implementation. It is clearly observed that UE complexity depends on mainly the BD/CCE handling not on the various alternatives. Even for Alt. 1, if Option B is adopted, the PDCCH monitoring resource unit allocation is changed slot by slot. So, in our understanding, there is no need to have different UE capability on Alt. 1 and Alt. 2.1. Actually allowing Alt. 2.1 is the most flexible since Alt. 1 and Alt. 2.4 are special configuration case of Alt. 2.1. Then the question boils down to whether we need such configuration restriction as Alt. 1 and Alt. 2.4. However, according to UE complexity analysis, such restriction doesn’t bring any benefit on implementation complexity. In this sense, Alt. 2.1 is preferred to allow more configuration flexibility. To reduce the UE complexity, Option A and not support Scell overbooking is preferred.  For Alt. 2.2, it introduces SS switching mechanism and is beneficial to save some RRC re-configuration effort. We are open to discuss this switching mechanism and it could be configurable between Alt. 2.1 and Alt. 2.2. |
| MTK |  | As mentioned by HW and Samsung, Alt. 2.4 is the baseline according to previous working assumption on separate UE capabilities for whether or not simultaneously monitoring the PDCCH from both cells.  If UE is capable of simultaneously monitoring the PDCCH from both cells, then we prefer Alt. 2.1. For Alt 2.1, we prefer Option A and Z1 should be 44 PDCCH candidates for the PCell SCS 15kHz.  For overbooking, we prefer to not have overbooking on SCell. |
| CMCC | Alt. 2-1  Option B  Overbooking only on PCell/PSCell | As the working assumption in last meeting, the USS set(s) scheduling PCell/PSCell can be monitored on PCell/PSCell and/or on sSCell, there is no need to further restrict to dynamically or semi-statically split the USS set(s) monitoring on PCell/PSCell or sSCell. In addition, Alt 2-1 also gives NW more flexibility.  Regarding the BD/CCE limit, as the USS set(s) can be simultaneously monitored on PCell/PSCell and sSCell, it is much simple to take into count the total BD/CCE limits of PCell/PSCell and sSCell in Option B.  Regarding the PDCCH overbooking, following current framework i.e., only on PCell/PSCell is preferred. |
| CATT | 1. First preference is alt 2-4 but can compromise to alt 2-1. 2. Option B if alt 2-1 is adopted 3. No overbooking on the sSCell | 1. **For PDCCH monitoring**   From our perspective, the dynamic mechanisms are not preferred. They are too complicated to be applied to the real world. The configuration of USS on both sSCell and PCell/PSCell is in semi-static manner. The motivation of dynamic switching of PDCCH monitoring is unclear. Furthermore, there is a risk of miss detection for the dynamic signaling, which leads to the miss understanding between network and UE.  Considering the USSs configured on PCell and sSCell are both used to schedule PDSCH/PUSCH on the PCell, it is a bit abundant to mandate a UE to monitor USS on both cells. Hence alt 2-4 is our first preference.  Furthermore, both option A and option B will be unnecessary as the PCell and SCell are totally separate. We don’t need to further consider the partition of BD/CCE between PCell and SCell. Accordingly, the current mechanism can be fully reused.   1. **For the BD/CCE limit**   From our understanding, what really matters is how to calculate /. The current mechanism captured in the specification can be reused here, i.e.   1. Calculate the total number of BD and CCEs across the scheduling cell based on the *pdcch-BlindDetectionCA*, the number of configured cells, the per-CC limit for the target SCS, the number of CCs with the same SCS as the scheduling cell 2. Based on the total number of BD/CCE and the per-CC limit for the scheduled cell, determines the maximum number of BD/CCE for the scheduled cell   From this perspective, option B fit the current logic better if alt 2-1 is adopted.   1. **Overbooking on sSCell**   The overbooking operation is mainly used to protect the CSS. Considering there is no CSS configured on the sSCell, we don’t see the necessity to support overbooking on the sSCell. |
| Xiaomi | 1) Alt 2-2  2) Option A  3) Overbooking on PCell/PSCell only | 1) From the perspective of UE processing complexity, UE monitoring both on PCell/PSCell and sSCell in the same slot is not preferred. It should be a feature that can be activated/deactivated by network under the configuration of the feature, instead of always activating the feature when it is configured. By this way, network can have more scheduling flexibility on UE-specific search space, such as switch the scheduling cell back to the ‘PCell/PSCell’ in the case of beam failure on the sSCell, and switch the scheduling cell to only the sSCell for UE to reduce power consumption.  2) To reduce the UE complexity, Option A is preferred.  3) It is unnecessary to support overbooking on the sSCell. |
| ETRI | 1) Alt.2-1  2) Option B  3) Overbook on across PCell/PSCell + sSCell (i.e., overbooking on sSCell allowed) | We share the same view as ZTE. We basically think the existing BD/CCE limit and the overbooking rule can be applied the same over the union of PCell/PSCell and sSCell, without any split between them. We expect that the UE complexities of Option A and Option B are comparable, while Option B can reuse the existing mechanism as much as possible. |
| Apple | 1) Alt 2-4a | Regarding 1)  We have strong concern on the toggling of USS between SpCell and sSCell or even simultaneous monitoring. You either have DSS problem on SpCell or you do not. Pick one, and have a clean solution  Question 2 and 3 depends on the outcome of 1), so it should come after we resolve the first question |
| Nokia, NSB |  | **PDCCH Monitoring:**  As indicated in our contribution, as it has become evident over the past meetings that 2-1 cannot be adopted as the solution we can design the system around, we prefer Alt 2-5 or Alt 2-6, or in the end any other mechanism that allows for having USS configured on both cells and there is a controlled way to manage which cell USS is being monitored at any given time. The dynamic switching the mechanism needs to be further detailed if that direction is the one preferred by the group.  Alt 2-5(Modified Alt 2-2)   * Dynamic switching of PDCCH monitoring of DCI formats 0\_1,1\_1,0\_2,1\_2 between monitoring on PCell/PSCell USS sets and monitoring on sSCell USS sets is supported   OR Alt 2-6 (Alt2-2+Alt 2-4)   * The USS set(s) on PSCell/PCell and the USS set(s) on sSCell are configured such that UE does not monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS set(s) simultaneously   **BD/CCE limits :**  The BD/CCE limits are counted separately for each scheduled cell monitored on the active DL BWP of the scheduling cell. We somewhat prefer option A, as it provides flexibility, but we can accept option B as well.  **Overbooking on sScell :**  We can accept not to support overbooking on sScell to simplify the UE PDCCH reception burden if we can otherwise converge to a meaningful overall concept. |
| InterDigital | 1) Alt 2-2 or  Alt 2-1  2) Option B for Alt 2-2 and Option A for Alt2-1  3) Overbooking on SCell is supported | For PDCCH monitoring, our preference is Alt2-2 and Alt2-1. For BD limit, if simultaneous monitoring of USS sets on both PCell and SCell is supported, separate limit should be set per scheduling cell. If dynamic switching is supported (Alt2-2), a maximum limit can be set across PCell and SCell. We support overbooking on SCell. because different USS can have different periodicity/offset and instead of configuring the PDCCH candidates based on the worst case where all the USS occur in the same slot, overbooking can be used to maximize the usage of control resources on SCell. |
| Lenovo, Motorola Mobility | Alt 2-1+  option B +  no overbooking on sSCell | Option B for PDCCH monitoring seems to align with Rel-16 mechanisms for BD/CCE limits.   * For option A, we think it might quite limit scheduling flexibility in slots/spans wherein not all search spaces exist. * For both options A and B, wondering if Z1 and Z2 are considered to be larger than 44?   Regarding Alt 2\_x variants, in general, we prefer to allow URLLC scheduling (e.g., DCI format x\_2) for PCell to be possible from PCell and not only from sSCell as the sSCell may become unavailable, and hence may impact URLLC performance. |
| LG Electronics | Alt 2-1  Option B  Overbooking handling on PCell + sSCell | Our preference on PDCCH monitoring is Alt 2-1. More specifically, cross-carrier scheduling or self-carrier scheduling can be configured per each USS set.  Regarding Option A vs. Option B, Option B is preferred since slot-by-slot handling for BD/CCE limit can provide more flexibility to assign PDCCH monitoring occasions. |
| OPPO | 1). Alt 2-2  2). max of (x1(m1)+x2(m1)) over all m1 is no larger than Z3; and max of y(m2) over all m2 is no larger than Z4.  3). Overbooking on P(S)Cell only. | **PDCCH monitoring**  With Alt2-2, the configuration is flexible and the implementation complexity is not increased.  **BD/CCE limit option**  Z1/Z2 is the maximum number BD in a slot for PCell (as scheduled cell), similar with the BD limit for a single cell. The number of PDCCH candidates may differ in different slots, it is not necessary to limit the maximum number of PDCCH candidates cross slots to satisfy the maximum number of BD for a single slot. It seems Option B is more suitable than Option A. On the other hand, why not to define separate limitations for PCell and sSCell? The number of PDCCH candidates needs to be counted across PCell and sSCell when there is only one limitation (Z1/Z2). It is easier to count separately for each scheduling cell if they have their own BD limitation. BD limitation is calculated in a slot or a span. If the SCS is different between PCell and sSCell, the time interval for a slot or a span is different and it need to unify the reference time interval used for BD limitation. Separate BD limitations can avoid mismatching of slot or span with different SCS.  **yes/no for ssCell overbooking handling**  Because the CSS and USS have different monitoring period, the total number of PDCCH candidates changes with large variation cross slots. PDCCH overbooking for PCell is required. There is only USS in sSCell, no PDCCH overbooking is required.  The maximum of BD for PCell(M1), not larger than Z1 or Z2, is needed to handle overbooking for PCell, where M1 should be equal or larger than the maximum PDCCH candidates of CSS across all slots in order to ensure the monitoring capability for CSS. If the BD limitations are defined separately for PCell and sSCell, M1 is the limitation for PCell. |
| NTT DOCOMO | Alt 2-2  Option B | Considering UE complexity, it may be better to avoid monitoring both P(S)Cell and sSCell simultaneously. |
| Ericsson | Alt 2-1,  Option A or B,  no overbooking on sSCell | We support Alt 2-1.  Option B based BD limit provides more flexibility (i.e., Z2=X results in more constrained BD allocation than Z1=X for a given X). However, we are OK with Option A if it is paired with Alt 2-1. Our preference is to set Z1 based on counting sSCell (s-p) as an additional scheduling cell, subject to the BD budget given by e.g. pdcch-BlindDetectionCA.  We are not OK with limiting CSS slots on DSS PCell as proposed in 2-4a – it is very restrictive and impacts legacy UEs.  Regarding overbooking, if the (p-p) BD/CCE limit can be separated from (s-p) BD/CCE limit, additional PDCCH overbooking handling for sSCell can be avoided. |
| Intel | Alt 2-1  Option B  Overbooking on sSCell | Alt 2-1 is the most flexible without any real complexity  Option A is to hardly split maximum number of BD/CCE to PCell and sSCell. As a result, for the configured BD/CCE for CSS on PCell, thought CSS is not monitored in a MO or slot, the allowable number of BD/CCE on sSCell cannot be increased. This cause limitation on gNB scheduling flexibility. Option B can avoid such issue  For overbooking, if the total numbers of BD/CCE exceed the maximum numbers, a USS set on the sSCell can be dropped |
| Spreadtrum | 1) Alt 2-2  2) Option A, Z1 is 44.  3)No Overbooking on SCell | **PDCCH monitoring**  First, Alt2-2 has more flexibility and less complexity. Since UE does not monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS sets simultaneously, it is with less UE complexity. Furthermore, Alt 2-2 has the significant benefit when considering sSCell activation/deactivation and sSCell dormancy. Such as when sSCell is activation or in non-dormancy BWP, UE can monitoring USS sets in sSCell which can increase the PDCCH capacity on PCell/PSCell. Otherwise, when sScell is deactivated or switched into dormancy BWP, UE can monitoring USS sets on PCell/PSCell. Considering PDCCH capacity limits, these USS sets can with less PDCCH candidates or smaller aggregation levels. We do not think Alt 2-1 is necessary if considering the use case of sSCell scheduling P(S)Cell, due to the limitation of PDCCH capacity in NR cell.  **BD/CCE limit option**  Our first preference is Option A. And Z1 equals 44 when PCell SCS is 15kHz. |
| Moderator notes |  | Below is my reading of comments for discussion point   * Alt 2-1   + no overbooking on sSCell (different views on detailed design of BD/CCE limits)     - QC (clarify this is not for ‘Alt1 only UEs’), HW, [Samsung?], vivo, MTK (for UEs that are not ‘Alt1 only’), CMCC, CATT, Lenovo/MotM, Ericsson   + overbooking on sSCell     - ZTE, ETRI, Interdigital, LG, Intel * Alt 2-2   + no overbooking on sSCell (different views on detailed design of BD/CCE limits)     - OPPO, Docomo, Xiaomi, Docomo, Spreadtrum, Interdigital, OPPO, [Samsung?] * Alt 2-4   + no overbooking on sSCell     - CATT (1st preference), MTK? * Alt 2-4a   + overbooking on sSCell     - Samsung   + Apple (no view expressed on overbooking) * Alt 2-5 or 2-6   + no overbooking on sSCell     - Nokia (open to ‘*other mechanism that allows for having USS configured on both cells and there is a controlled way to manage which cell USS is being monitored at any given time’*) |

### Proposal 1

* For UEs configured to monitor non-fallback USS set(s) on sSCell and/or P(S)Cell
  + Alt 2-1 is supported
  + PDCCH overbooking on sSCell USS set(s) is not allowed
  + BD/CCE limit handling is as follows
    - PDCCH monitoring candidates on P(S)Cell and/or sSCell are configured such that max of (x1(m1)+x2(m1))+max of y(m2) corresponding to any P(S)Cell slots m1 and m2 is less than or equal to Z1
      * At least the case of Z1 = 44 is supported for P(S)Cell SCS 15kHz
        + FFS if Z1 larger than above can also be supported based on UE capability (e.g. similar to *BDFactorR* in Rel16)
      * FFS signalling details on how the limit Z1 is realized
        + E.g. configure separate BD limits/scaling factors for #BDs for PDCCH USS(s) candidates monitored on P(S)Cell, #BDs for PDCCH USS(s) candidates monitored on sSCell, separate BDfactorR for P(S)Cell/sSCell etc.
      * Note
        + x1(m) is #BDs for PDCCH CSS(s) candidates monitored on P(S)Cell slot m
        + x2(m) is #BDs for PDCCH USS(s) candidates monitored on P(S)Cell slot m
        + y(m) is #BDs for PDCCH USS(s) candidates monitored on sSCell in sSCell slot(s) that overlap slot m of P(S)Cell
        + USS(s) => USS(s) that can schedule PDSCH/PUSCH on P(S)Cell)
    - Similar principle as BD handling is used for CCE limits
* For UEs supporting functionality of only Alt-1, and configured with non-fallback USS set(s) only on sSCell
  + FFS support of PDCCH overbooking on sSCell
  + FFS BD/CCE limit handling

Companies are requested to indicate their view about the above proposal in the Table below

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 1)** |
| Moderator notes |  | Thank you for the inputs for Discussion point 1. Majority views are in direction of Alt 2-1. There are diverse views on BD/CCE limit handling and hopefully a harmonized solution can be identified with the text in the Proposal as a starting point. Majority companies prefer to avoid PDCCH overbooking handling for sSCell but some prefer to support it. This has to be chosen one way or other. Comments welcome. |
| Qualcomm | Support | We think the FL proposal is a good starting point for UEs configured to monitor non-fallback USS set(s) on sSCell and/or P(S)Cell.  One missing piece is USS set(s) for fallback DCI formats that schedules PDSCH/PUSCH on the P(S)Cell. For the UEs supporting Alt.2-1, it is natural to enable monitoring the USS set(s) for fallback DCI formats on the P(S)Cell. For the UE only supporting Alt.1, this should be added as an FFS under the 2nd bullet. If it is difficult to get consensus on this, it is OK to leave it to the next opportunity of discussion. |
| Samsung | Not support | The starting point should be no specification impact so that a Rel-16 UE can support DSS without hardware change. That is Alt 2-4. The scheduling flexibility impact is minimal, especially since the sSCell is TDD (and Alt 2-4 results naturally). The scheduling flexibility is also improved as the maximum of x(m1) + y(m2) can be larger than 44 (non-overlapping slots) without requiring a new UE capability (BTW, there is no reason to use x1 and x2 – just x for the PCell suffices). Alt 2-1 can then be considered as an enhancement.  Also, we do not have an agreement that there will be UEs supporting functionality of only Alt-1. There are multiple reasons, but a basic one is that Alt-1 is not even DSS - scheduling is always on the sSCell and only when there is infrequent CSS on the PCell, an even more infrequent fallback scheduling can apply. For that reason, we do not support confirming the WA with the inclusion of Alt-1.  Overbooking on the sSCell should be supported – taking Alt-1 just for the sake of an example, everything can be moved to the sSCell (except the rare non-Type 3 CSS). How is that different from the PCell in Rel-15? |

### Proposal 2

* When CCS from sSCell to Pcell/PSCell is configured
  + CIF=0 used for sSCell self-scheduling, and CIF for sSCell to Pcell cross-carrier scheduling is explicitly configured using *CrossCarrierSchedulingConfig*

Above proposal already discussed during Monday GTW session and corresponding agreement is copied below

**Agreement**

* When CCS from sSCell to Pcell/PSCell is configured
  + CIF=0 used for sSCell self-scheduling, and CIF for sSCell to Pcell cross-carrier scheduling is explicitly configured using RRC signalling

### Proposal 3 (for conclusion)

* When CCS from an SCell (sSCell) to Pcell/PSCell is configured DCI format 2\_5 handling is same as in Rel16

Above proposal already discussed during Monday GTW session.

### Discussion point 4

* Companies are encouraged to provide comments on below search space linking framework for CCS from sSCell to P(S)Cell including preference between Alt1, Alt 2 or other alternative.
* When CCS from sSCell to Pcell/PSCell is configured
  + UE is configured with search space set Ssa on P(S)Cell with search space ID = X1
  + If UE is configured with a search space set SSb on sSCell with same search space ID = X1 (i.e., ‘linked SS sets’ approach as in Rel16)
    - DCI formats monitored by UE on SSb with n\_CI corresponding to CIF P(S)Cell are used for P(S)Cell PUSCH/PDSCH scheduling
    - For monitoring the DCI formats on SSb used for P(S)Cell PUSCH/PDSCH scheduling
      * Alt 1
        + *nrofCandidates* is derived from Ssa configuration
        + *monitoringSlotPeriodicityAndOffset, monitoringSymbolsWithinSlot, duration* are derived from SSb configuration and same parameters are also used for self-scheduling on sSCell (i.e., same approach as in Rel16)
      * Alt 2
        + *nrofCandidates* is derived from Ssa configuration
        + *monitoringSlotPeriodicityAndOffset, monitoringSymbolsWithinSlot, duration* are configured independently from the parameters used for self-scheduling on sSCell

FFS Details

* + - * Alt 3
        + other

Companies are requested to provide comments in the Table below

|  |  |
| --- | --- |
| **Company Name** | **Comments (Discussion point 4)** |
| Qualcomm | We think it is natural to re-use “linked SS sets” approach as in Rel.15/16. This is also friendly to enable mixed operation of cross-carrier scheduling from sSCell to Pcell/PSCell and sSCell to another SCell(s).  Among the alternatives, we think Alt.2 is a flexible solution especially when the SCSs of Pcell/PSCell and sSCell are different. This flexibility is also good to address the restriction comes from the BD budget Z1 – e.g., suppose 44 PDCCH candidates have to be distributed across a slot of Pcell with SCS 15kHz and overlapping two slots of sSCell with SCS 30kHz. With Alt.2, a UE can be configured to monitor sSCell USS for Pcell scheduling only on the first slot of the two sSCell slots with keeping monitoring sSCell USS for sSCell scheduling on both sSCell slots. |
| Samsung | Alt. 2 – provides better functionality for DSS and in general. But we can take this opportunity and fix the RAN2 bug from Rel-15 and generalize Alt. 2 as follows  Alt. 2.1: separate SS configuration and SS ID for scheduling cell (sSCell) and scheduled cell (Pcell) |
| Huawei | Alt 2 seems good. But can also be determined in RAN2 later. |
| ZTE | Based on our understanding, Alt.1 is the legacy mechanism, which is preferred by us.  Alt.2 seems to offer more flexibility, we can also accept Alt.2 if it is favored by most companies. But we may also need to clarify that Alt.2 is only for sSCell scheduling Pcell, or can also be applied to legacy cross-carrier scheduling, e.g., sSCell scheduling other SCell. |
| Vivo | Reusing “linked SS sets” approach as in Rel.15/16 is preferred by us. Alt. 1 is slightly preferred by us since it is the same as Rel.15/16. We are also open to Alt. 2 if it is beneficial.  Another related issue is how to differentiate USS configuration for Pcell self-scheduling and cross carrier scheduling from sScell. For example, only the USS with non-complete SS configuration could be linked to cross carrier scheduling from sScell. Otherwise, it is used for Pcell self-scheduling. |
| MTK | We prefer Alt. 2 for the better flexibility as mentioned by Qualcomm and agree with ZTE to clarify Alt.2 is only for sSCell scheduling Pcell, or can also be applied to legacy cross-carrier scheduling, e.g., sSCell scheduling other SCell. |
| CMCC | Alt 1 can re-use current cross-carrier linked search space configuration framework. But we are also open to Alt 2 to give NW more flexibility. |
| CATT | Alt-2 provides more flexibility which is preferred from our perspective. |
| Xiaomi | Alt. 1 is slightly preferred since it is the same as Rel.15/16. We are also open to Alt. 2 if benefits are observed. |
| ETRI | We slightly prefer Alt. 1 as it is the legacy approach. Alt. 2 seems a general enhancement for cross-carrier scheduling rather than a DSS-specific one. But we are also open to discuss Alt. 2. |
| Apple | Alt 1 is preferred  Alt 2 does provide some configuration flexibility, we need some example about what this can be used since we need to access the potential impact on UE implementation. |
| Nokia, NSB | Would prefer Alt-2 as it provides more flexibilility in configuration when the SCS of P(S)cell and sScell are different. |
| InterDigital | Alt 2 provides more flexibility and it is our preference. |
| Lenovo, Motorola Mobility | We are fine in principle with Alt1/2, however, would slightly prefer to discuss it (e.g., decide between Alt-1 and Alt-2) after decision on other high-level aspects (e.g., dormancy procedure of sSCell). |
| LG Electronics | Alt 1, prefer to keep current rule as is. |
| OPPO | Alt-1 is preferred.  In R16, both *searchSpaceId* and *nrofCandidates* are indicated in the RRC signaling *SearchSpace* on scheduled cell and other configuration is derived from the associated SS on scheduling cell. It can help to meet the capability budget for PCell by configuring a suitable PDCCH candidate number for SS on sSCell. Furthermore, the SS configured with only *searchSpaceId* and *nrofCandidates* on PCell is used only for cross-carrier scheduling from sSCell. There is no problem for R17 to have the same approach for cross-carrier scheduling from sSCell to PCell. |
| Ericsson | We are OK to discuss improvements of existing SS configuration.  If modifications are done to the Rel-15/16 SS-linking, then rather than Alt 2, configuring a separate search space for sSCell-to-PCell seems like a cleaner approach, e.g. configure *nrofCandidates, monitoringSlotPeriodicityAndOffset, monitoringSymbolsWithinSlot, duration* independently for s-p in that search space set configuration.  Additionally, it should also be possible to separately configure BDs for uplink and downlink DCI formats, i.e. configuration of individual DCI format(s) (e.g. only DCI format 0-1, only DCI format 1-1) should be supported as part of the corresponding search space set configuration. |
| Intel | Alt 1 is preferred to maximize reusing existing CCS framework. |
| Qualcomm2 | We do not prefer to re-design the framework of cross-carrier scheduling configuration (i.e., “linked SS sets” approach as in Rel.15/16). This would cause different versions of general cross-carrier scheduling frameworks.  Alt.2 basically does not change the framework, except the 38.331 description of RRC IE *SearchSpace*, highlighted by red below.  “The IE *SearchSpace* defines how/where to search for PDCCH candidates. Each search space is associated with one *ControlResourceSet*. For a scheduled cell in the case of cross carrier scheduling, except for *nrofCandidates*, all the optional fields are absent (regardless of their presence conditions)”  If majority wants Alt.1, it is fine for us. However, we think Alt.2 offers benefits with minimal impact. |

# 3 Conclusions

TBD

# 4 References

1. R1-2102309 Discussion on SCell PDCCH scheduling P(S)Cell PDSCH or PUSCH Huawei, HiSilicon
2. R1-2102416 Discussion on cross-carrier scheduling from SCell to PCell OPPO
3. R1-2102471 Discussion on cross-carrier scheduling from SCell to Pcell Spreadtrum Communications
4. R1-2102503 Discussion on Cross-Carrier Scheduling from SCell to PCell ZTE
5. R1-2102544 Discussion on Scell scheduling Pcell vivo
6. R1-2102611 Discussion on cross-carrier scheduling from Scell to Pcell CATT
7. R1-2102684 On Cross-Carrier Scheduling from SCell to PCell/PSCell MediaTek Inc.
8. R1-2102803 Om cross-carrier scheduling from SCell to Pcell Nokia, Nokia Shanghai Bell
9. R1-2102902 Discussion on cross-carrier scheduling from SCell to Pcell CMCC
10. R1-2102968 Discussion on Cross-carrier scheduling from SCell to PCell Xiaomi
11. R1-2103052 On SCell scheduling PCell transmissions Intel Corporation
12. R1-2103126 Views on Rel-17 DSS SCell scheduling PCell Apple
13. R1-2103188 Cross-carrier scheduling from an SCell to the PCell/PSCell Qualcomm Incorporated
14. R1-2103202 Search space monitoring in sSCell and PCell InterDigital, Inc.
15. R1-2103262 Cross-carrier scheduling from SCell to PCell Samsung
16. R1-2103333 Cross-carrier scheduling from SCell to Pcell ETRI
17. R1-2103359 Discussion on cross-carrier scheduling from SCell to Pcell LG Electronics
18. R1-2103596 Discussion on cross-carrier scheduling enhancements for NR DSS NTT DOCOMO, INC.
19. R1-2103609 Cross-carrier scheduling (from Scell to Pcell) Lenovo, Motorola Mobility
20. R1-2103645 Enhanced cross-carrier scheduling for DSS Ericsson
21. R1-2103659 Discussion on cross-carrier scheduling from sSCell to PCell/PSCell ASUSTeK

# 5 Annex A – Agreements from previous meetings

## Agreements from RAN1#102-e

Agreements:

* Following scheduling combinations are allowed/not allowed when cross-carrier scheduling from an SCell to PCell/PSCell is configured  
  1. self-scheduling on PCell/PSCell is allowed
  2. cross-carrier scheduling from PCell/PSCell to another SCell is not allowed
  3. self-scheduling on the ‘SCell used for scheduling PCell/PSCell’ is allowed
  4. cross-carrier scheduling from the ‘SCell used for scheduling PCell/PSCell’ to another serving cell is allowed
  5. cross-carrier scheduling from another serving cell to the ‘SCell used for scheduling PCell/PSCell’ is not allowed
* FFS: Search space and DCI format handling for the allowed cases above

Agreements:

* Configuring 2 or more Scells to schedule the PCell/PSCell is not allowed

## Agreements from RAN1#103-e

**Conclusion**

* When CCS from sSCell to PCell/PSCell is configured, the configuration of Type 3 CSS set for DCI formats 2\_0, 2\_1, 2\_2, 2\_3, 2\_4 and applicability of the information in the DCI formats are the same as in Rel-15/Rel-16
  + FFS: DCI format 2\_5 and DCI Format 2\_6 handling
* Note: The SCell configured with CCS to Pcell/PSCell is referred to as ‘sSCell’

**Conclusion**

* When the PCell/PSCell and sSCell use different numerologies, the PDSCH reception preparation time between the PDCCH on the sSCell and the PDSCH on the PCell/PSCell is applied (i.e., as specified in TS38.214 Section 5.5).

Agreements:

* When CCS from an SCell (sSCell) to PCell/PSCell is configured, UE monitors Type 0/0A/1/2 CSS sets (for the DCI formats associated with those SS sets) only on the PCell/PSCell and not on the sSCell
  + Note: UE monitors Type 0/0A/2 CSS only on PCell while Type 1 CSS can be monitored on PCell/PSCell

Agreements:

* Discuss in RAN1#104-e how to handle ‘DCI formats 0\_1,1\_1,0\_2,1\_2 scheduling PDSCH/PUSCH on PCell/PSCell’ from USS set(s), when CCS from sSCell to PCell/PSCell is configured.. Below alternatives can be considered in the discussion (other alternatives are not precluded)
* ~~Below alternatives can be considered in the discussion (other alternatives are not precluded)~~
  + Alt 1: ~~When CCS from sSCell to PCell/PSCell is configured,~~ UE cannot be configured to monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on PCell/PSCell USS set(s), and can be configured to monitor them only on the sSCell USS set(s)
  + Alt 2: ~~When CCS from sSCell to PCell/PSCell is configured,~~ UE can be configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 on PCell/PSCell USS set(s), and/or on sSCell USS set(s). The PDCCH monitoring is based on following alternatives (other alternatives are not precluded)
    - Alt 2-1:
      * UE can monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS sets simultaneously
        + ~~FFS activation/deactivation of scheduling from sSCell to PCell/PSCell~~
    - Alt 2-2:
      * Dynamic switching of PDCCH monitoring of DCI formats 0\_1,1\_1,0\_2,1\_2 between monitoring on PCell/PSCell USS sets and monitoring on sSCell USS sets is supported
        + FFS: Details of switching mechanism (~~e.g. based on SS group switching, based on BWP switching,…~~)
      * UE does not monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS sets simultaneously
    - Alt 2-3:
      * UE does not monitor the same DCI format on both PCell USS set(s) and sSCell USS sets simultaneously. UE can monitor some DCI formats on sSCell USS sets and other DCI formats on PCell/PSCell USS sets simultaneously
    - Alt 2-4:
      * The USS set(s) on PSCell/PCell and the USS set(s) on sSCell are configured such that UE does not monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both PCell USS set(s) and sSCell USS set(s) simultaneously
* FFS following aspects
  + Impact of sSCell activation/deactivation and sSCell dormancy
  + Impact on BD/CCE limit handling ~~including considering PDCCH monitoring on CSS sets and PDCCH monitoring of ‘DCI formats 0\_0, 1\_0 scheduling PUSCH/PDSCH on PCell/PSCell’~~
  + Whether PDCCH overbooking on sSCell is supported or not supported and impact (if any) on overbooking handling on PCell/PSCell
  + Impact from different numerologies between PDCCH on the PCell/PSCell and that on the sSCell
  + Whether or not to have mechanism for activation/deactivation of scheduling from sSCell to PCell/PSCell
  + USS configuration details (e.g. handling of USS type (self-scheduling, cross carrier scheduling) for a ~~configured~~ USS set configured for scheduling of ~~in~~ PCell/PSCell)

## Agreements from RAN1#104-e

**Agreement**

When CCS from sSCell to PCell/PSCell is configured,

* Out of order scheduling is not allowed between a) PDSCH on PCell/PSCell scheduled by PDCCH on PCell/PSCell and b) PDSCH on PCell/PSCell scheduled by PDCCH on sSCell
* Out of order scheduling is not allowed between a) PUSCH on PCell/PSCell scheduled by PDCCH on PCell/PSCell and b) PUSCH on PCell/PSCell scheduled by PDCCH on sSCell

FFS: Whether this agreement requires RAN1 specification impact.

**Agreement**

When CCS from sSCell to PCell/PSCell is configured,

* Simultaneous reception of a) unicast PDSCH on PCell/PSCell scheduled from PCell/PSCell and b) unicast PDSCH on PCell/PSCell scheduled from sSCell is not allowed
* Simultaneous transmission of a) PUSCH on PCell/PSCell scheduled from PCell/PSCell and b) PUSCH on PCell/PSCell scheduled from sSCell is not allowed
* Note: Simultaneous implies full/partial time overlapping

FFS: Whether this agreement requires RAN1 specification impact.

**Agreement**

* When CCS from sSCell to PCell/PSCell is configured, CA activation/deactivation operation for the sSCell is supported

**Working Assumption**

* When CCS from sSCell to PCell/PSCell is configured, UE can be configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 that schedule PDSCH/PUSCH on PCell/PSCell on PCell/PSCell USS set(s), and/or on sSCell USS set(s)
* The WA to be confirmed after agreements are made on PDCCH BD/CCE handling and PDCCH overbooking handling for CCS from sSCell to PCell/PSCell
* Specs also allow UEs supporting functionality of only Alt-1. Capability signaling details, if any, can be handled during the UE capability discussion for Rel17
* FFS: Whether the UE can monitor PDCCH from both cells in the same slot.

**Agreement**

* When CCS from sSCell to PCell/PSCell is configured, UE monitors ‘DCI formats 0\_0 and 1\_0 in CSS that schedule PDSCH/PUSCH on PCell/PSCell’ only on the PCell/PSCell and not on the sSCell