**3GPP TSG-RAN WG1 #105-e R1-21xxxxx**

**eMeeting, May 10 – 27, 2021**

**Source: Moderator (Ericsson)**

**Title: Summary of Email discussion [105-e-NR-DSS-01]**

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

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

# 1 Introduction

This document summarizes the discussions for email thread [105-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#105-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. PDCCH monitoring (definitions of Alt 2-1,2-2,2-4 are in the RAN1#103-e agreement in the Annex)
	* Alt 2-1
		+ [3],[4],[7],[10],[12],[15],[16],[19],[20]
		+ [13] –second preference as optional UE feature
	* Alt 2-2
		+ [5],[9],[18]
		+ [13] – first preference as optional UE feature
		+ [1] - Modified Alt 2-2 – [1]
			- 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 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.
		+ [1] - Alt 2-4 with SS Group Switching (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
			- SS Group Swithcing is employed for dynamic switching mechanism
	* Alt 2-4
		+ [7], [18], [6]
		+ [8] - Alt 2-4 with additional restrictions
			- Following search space sets are configured so that the UE does not monitor both of them in the same slot
				* USS set(s) for any DCI formats and Type3-CSS set(s) for DCI formats 1\_0/0\_0 with C-RNTI/CS-RNTI/MCS-C-RNTI configured on P(S)Cell
				* USS set(s) for P(S)Cell configured on sSCell
			- There is no restriction on Type-0/0A/1/2-CSS sets configurations
			- + BD limit handling as described in Proposal 4 of [8]
	* Alt 2-4a (as below based on [13])
		+ UE does not monitor PDCCH (including CSS and USS candidates) for P(S)Cell from both P(S)Cell and sSCell in a same slot (for smallest SCS)
	* No restrictions on PCell CSS monitoring slots due to CCS from sSCell to PCell -- [20]
2. BD/CCE limit handling
	* Discussion related to sSCell overbooking
		+ [3] – is “overbooking across PCell and sSCell for scheduling the PCell” supported? (also discussed in [12])
			- Not allowed per agreement from RAN1#104b-e? – “*PDCCH overbooking on sSCell USS set(s) is not allowed*”
	* Based on Option A discussed in RAN1#104b-e
		+ [4],[5],[8],[11],[12],[14],[15],[20]
	* Based on Option B discussed in RAN1#104b-e
		+ [3],[7],[11],[13],[16],[19] , [6]
	* Based on Option C discussed in RAN1#104b-e
		+ [3], [2],[4],[5],[9],[10],[19]
	* CA scaling
		+ Count sSCell as additional cell –[16],[19],[20], [6]
		+ Count sSCell as one cell – [3]
		+ Separate BDfactor (can be less than 1) for sSCell and P(S)Cell at least when they have different SCS – [2]
		+ Separate scaling factors [13]
		+ FFS – [9],[11]
	* SCS between P(S)Cell and sSCell for BD/CCE computation
		+ Use smaller SCS – [12], [13]
		+ Do not support P(S)Cell SCS > sSCell SCS – [8],[19]
3. Handling of DCI formats 0\_0 and 1\_0 on USS for scheduling PCell/PSCell PDSCH/PUSCH
	* Present only on P(S)Cell as in Rel15/16 – [3],[5],[6],[7],[8],[10],[11],[12],[19],[13] , [6]
	* Specs also allow UEs that cannot be configured to monitor DCI formats 0\_0/1\_0 on USS set(s) for scheduling PCell/PSCell PDSCH/PUSCH – [8]
	* follows for non-fallback handling – [4]
	* FFS – [16]
4. DCI format 2-5
	* follows Rel16 – [4],[6],[7],[11],[16],[17]
5. DCI format 2-6
	* Follows Rel16 handling – [3],[5],[6],[7],[11],[14],[16],[17]
	* Can be sent also on sSCell – [4]
6. SS handling when sSCell is deactivated – [3],[19]
7. Impact on DCI size budgets – [5],[8],[11]
8. Impact on #DL and UL unicast DCI per monitoring occasion/span – [3],[11],[14],[19]
9. Separate config of UL and DL DCI formats – [20]
10. PDCCH in SS set provided by recoverySearchSpaceId can be monitored on the sSCell – [21]

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

1. Use CIF for PCell non-fallback DCI – [3],8],[12?]
2. Search space linking configuration for CCS
	* Use SS linking as in Rel16
		+ [4],[9],[10],[17]
	* Use SS linking but PeriodicityAndOffset, SymbolsWithinSlot, and duration can be configured separately
		+ [7],[8],[14]
	* Separate search space config for sSCell to PCell scheduling
		+ [5],[13]
3. RRC configuration details for CCS from sSCell to PCell/PSCell (How to indicate using CrossCarrierSchedulingConfig) – [3], [4],[6],[7]

### 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 – [3],[12],[17],[13]
	* Not support – [4],[6],[14]
	* FFS –
	* Handling when sSCell is deactivated/dormant –
2. Dormancy supported for sSCell?
	* Supported – [5],[6],
	* FFS – [16]

### 2.1.4 Other aspects

1. SCell to PCell/PSCell scheduling has no impact on PUCCH or PUSCH/SRS for non-CA – [1]
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 – [13]

Below are some proposals for discussion

## 2.2 Proposals

### Proposal 1

* Confirm that “overbooking across PCell and sSCell for scheduling the PCell” is not allowed per previous RAN1#104b-e agreement (“PDCCH overbooking on sSCell USS set(s) is not allowed”)

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

|  |  |
| --- | --- |
| **Company Name** | **Comments (Proposal 1)** |
| Moderator notes | According to RAN1#104b-e agreement any kind of overbooking on sSCell USS set(s) is not allowed. However, two tdocs [3],[12] discussed whether “overbooking across PCell and sSCell for scheduling the PCell” is allowed and it may be good to clarify. |
| Qualcomm | Agree with the proposal |
| Apple | We are fine with the FL proposal to make progress. Strictly speaking, it spends on the SS pattern, especially if it is TDM for simultaneous.  |
| Samsung | We understand that the proposal from [3], [12] does not relate to “overbooking on sSCell USS sets is not allowed”. Rather that BD/CCE counting for scheduling on the P(S)Cell is across the PCell and the sSCell. That is a separate issue.Additionally, there are a few statements in the summary above that are incorrect:1. removing the link among search space sets for the scheduling cell (sSCell) and the scheduled cell has nothing to do with Alt. 2-4a.
2. Alt. 2-4a does not imply any change in the WA. The WA states “FFS: Whether the UE can monitor PDCCH from both cells in the same slot.”
3. Some revisions are made above for other clarifications.
 |
| Ericsson | OK to confirm. |
| CATT | Agree with the proposal. |
| ZTE | Firstly, in RAN1 #104b-e meeting, the agreement is “overbooking on sSCell USS sets is not allowed”. Then, there are still two potential options open1. Overbooking on PCell for self-scheduling is supported;2. Overbooking across PCell and sSCell for scheduling PCell is supported.Secondly, there are Option A/B/C for BD/CCE limits, if Option A/C is agreed, then we are fine with the proposal 1 because the “across case for overbooking” does not exist. If Option B is agreed, using overbooking across PCell and sSCell for scheduling PCell seems to be the valid scheme.From our perspective, if Option B is precluded, then it is fine to agree the Proposal 1 here. BTW: We updated some parts in Section 2.1 regarding our contribution ([3]) with change mark. |

### Proposal 2

* Down select from below alternatives for handling of PDCCH monitoring and BD/CCE limits when P(S)Cell SCS is less than or equal to sSCell SCS
	+ **(based on Alt 2-1)** When UE is configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 on P(S)Cell USS set(s), and on sSCell USS set(s), and for case when sSCell is activated
		- UE can monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both P(S)Cell USS set(s) and sSCell USS sets in overlapping [symbol/slot] of P(S)Cell and sSCell
		- Further discuss detailed BD/CCE handling based on Option A ~~or Option B~~ or Option C discussed in RAN1#104b-e
			* For Option C, at least the case where Z3 + Z4 ≤ $M\_{PDCCH}^{max,slot,μ}$ is supported where $μ$ is SCS configuration of the P(S)Cell
	+ **(based on Alt 2-2)** When UE is configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 on P(S)Cell USS set(s), and on sSCell USS set(s), and for case when sSCell is activated
		- Dynamic switching of PDCCH monitoring of DCI formats 0\_1,1\_1,0\_2,1\_2 between monitoring on P(S)Cell USS sets and monitoring on sSCell USS sets is supported using one of the following switching mechanism(s)
			* Search space set switching by unicast DCI formats/MAC CE/DCI format 2-0
			* SS Group Switching
		- Further discuss detailed BD/CCE handling
	+ **(based on Alt 2-4)** When UE is configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 on P(S)Cell USS set(s), and on sSCell USS set(s), and for case when sSCell is activated
		- 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) in overlapping [symbol/slot] of P(S)Cell and sSCell
		- Dynamic switching of PDCCH monitoring of DCI formats 0\_1,1\_1,0\_2,1\_2 between monitoring on P(S)Cell USS sets and monitoring on sSCell USS sets is not supported
		- Further discuss detailed BD/CCE handling based on Option A ~~or Option B~~ or Option C discussed in RAN1#104b-e
			* For Option C, at least the case where Z3 + Z4 ≤ $M\_{PDCCH}^{max,slot,μ}$ is supported where $μ$ is SCS configuration of the P(S)Cell

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

|  |  |
| --- | --- |
| **Company Name** | **Comments (Proposal 2)** |
| Moderator notes | Please provide any comments/clarifications to above alternatives. Intention is to discuss the down selection in GTW session |
| Qualcomm | We would like to make sure that at least one type of UEs is allowed to implement monitoring unicast PDCCH on one of the scheduling cells in each P(S)Cell slot. * Our first preference for this is to fix this unicast PDCCH scheduling cell to the sSCell semi-statically – this is our original proposal; support UEs with Alt.1 only (with supporting UEs with Alt.2-1 with Option A as an advanced UE type).
* As a compromise, we have added an alternative proposal in R1-2105970, wherein one unicast PDCCH scheduling cell is determined based on higher-layer configurations (Alt.2-4 with hybrid b/w Option A and Option B) for each P(S)Cell slot.

We suggest companies to consider either of the above frameworks. Between the above two, the first preference is friendly to UE side while may cause scheduler restriction to NW side. The above compromised option could take a good balance between UE complexity and NW flexibility.Regarding the Proposal 2:For **the option based on Alt.2-1 (first sub-bullet)**, we are in general OK with this if the WA (UE is allowed to support only Alt.1 functionalities) is confirmed and if the following is added:* UE is allowed not to support monitoring USS for fallback DCI formats on the P(S)Cell

For **the option based on Alt.2-4 (third bullet)**, just limiting non-fallback DCI formats on only one of the scheduling cells per P(S)Cell slot just resolves part of the implementation concerns. We propose to rephrase the proposal as following. With this change, we do not need to agree “UE is allowed not to support monitoring USS set(s) for fallback DCI formats on the P(S)Cell”, which must be beneficial for NW side.* Following search space sets are configured so that the UE does not monitor both of them in the same slot
	+ USS set(s) for any DCI formats and Type3-CSS set(s) for DCI formats 1\_0/0\_0 with C-RNTI/CS-RNTI/MCS-C-RNTI configured on P(S)Cell
	+ USS set(s) for P(S)Cell configured on sSCell

In addition, for this solution, it is not reasonable to combine with Option A/C for all the slots as long as “one unicast PDCCH scheduling cell is determined based on higher-layer configurations for each P(S)Cell slot” is ensured. Therefore, we further propose (on top of the above changes) to add following:* For P(S)Cell slot m where the UE monitors PDCCH for P(S)Cell only on P(S)Cell,
	+ PDCCH monitoring candidates on P(S)Cell are configured such that x1(m)+x2(m) is less than or equal to BD limit Z4
* For other P(S)Cell slot(s) where the UE monitors PDCCH for P(S)Cell on both P(S)Cell and sSCell,
	+ PDCCH monitoring candidates on P(S)Cell and sSCell are configured such that max of x1(m1) + max of y(m2) corresponding to any P(S)Cell slots m1 and m2 that the UE monitors PDCCH for P(S)Cell on both P(S)Cell and sSCell is less than or equal to Z4
* At least the case of Z4 = 44 is supported for P(S)Cell SCS 15kHz

The outlook of this solution is like following.For **the option based on Alt.2-2 (second bullet)**, this is a significant enhancement from Rel.16 NR-U features. Mandating this for Rel.17 DSS with cross-carrier scheduling even without unlicensed/shared spectrum is questionable. Besides, the benefit compared to the above our proposed modified option based on Alt.2-4 is not clear. |
| Apple | We prefer Alt 2-4We are also open to discuss the new proposal from QC which is USS + Type3-CSS based partition  |
| Samsung | Do not support any of the proposals. No changes to UE implementation or additional specifications are needed to support DSS.Alt. 2-1 should be optional for DSS and should be combined with option B, not option C (why is Option B crossed out when it has a large support?) – same for Alt. 2-4.Under the current wording, Alt. 2-2 and Alt. 2-4 limit the non-simultaneous monitoring only to USS (non-fallback DCIs) and also unnecessarily exclude DCI 0\_0/1\_0 from USS. That has practically no effect on reducing UE complexity over Alt. 2-1 and will lead to similar additional specification requirements. There is also no technical reason to support Alt.1 or any of its variants. We first support doing nothing (which is Alt.2-4a – resolve the FFS of the WA as “UE cannot monitor PDCCH from both cells in the same slot.”). The NW ensures that the UE does not simultaneously (same slot) monitor PDCCH on both P(S)Cell and sSCell based on SS set configuration and there is zero spec impact. That also has no impact on legacy UEs, no impact on CSS monitoring (Type-3 can be either on P(S)Cell or sSCell at any slot for both legacy and non-legacy UEs and non-Type-3 is anyway not monitored more often than 20 msec), and nothing is ‘friendlier’ to UE implementation. Alt. 2-2 can be an enhancement to Alt.2-4a under the same conditions (PDCCH monitoring only on one scheduling cell per slot). In summary, none of the proposals needs to be agreed to support DSS and we therefore do not agree to any of them. A modified Alt. 2-2 can be considered as an enhancement under the framework of no “simultaneous” (same slot) PDCCH monitoring on 2 scheduling cells and Alt. 2-1 may be considered as an optional most complex enhancement. |
| Ericsson | We support the described approach based on Alt 2-1, as it provides good balance between UE complexity (when paired with Option A and/or Option C) and NW scheduling flexibility. This has least impact on primary cell self-scheduling, and in general, we do not support alternatives that lead to undesirable scheduling restrictions for primary cell self-scheduling case.Regarding the proposed approach from QC – our preference is to support the described approach based on Alt 2-1, and consider the modifications to Alt 2-4 proposed by QC in R1-2105970 as a solution that could potentially replace the Alt1 UEs in the WA. |
| CATT | Our first preference is alt 2-4 with adding option B back. We don’t think option B should be precluded. From our understanding, it is the exactly same way as the current specification to handle BD/CCE, i.e. counting the BD/CCE per-slot or per-span.For sake of progress, we suggest to split the discussion between USS monitoring and BD/CCE handling. It is much friendly to discussion step by step.We can also live with option 2-4a. |
| ZTE | Our first preference is Option B + Alt 2-1 (same view as Samsung for Alt 2-1) which is the most flexible than other solutions. And the Z1 or Z2 is preferred to be determined by larger SCS of the two scheduling cells or both SCS of the two scheduling cells which are all aligned with the intention in Rel-16 CA to determine the BD/CCE limit for the scheduled cell according to the SCS of the scheduling cell.Comparing Option A/B/C in Table 1. With same total BD limits, Option B has more BD opportunities due to shared BD between two scheduling cells per PCell slot, while Option A and C are similar but Option A is more flexible than option C due to shared BD between two consecutive slots overlapped with one PCell slot.Table 1 Examples of Option A/B/C

|  |  |  |
| --- | --- | --- |
| Option A | Option B | Option C |
| Z1=44 per slot with μ1=0 | Z2=44 per slot with μ1=0 | Z3=22 per slot with μ1=0 and Z4=11 per slot with μ2=1 |

To make some progress, we can also support the alternative based on Alt 2-1 above with following changes.* + **(based on Alt 2-1)** When UE is configured to monitor DCI formats 0\_1/1\_1/0\_2/1\_2 on P(S)Cell USS set(s), and on sSCell USS set(s), and for case when sSCell is activated
		- UE can monitor DCI formats 0\_1,1\_1,0\_2,1\_2 on both P(S)Cell USS set(s) and sSCell USS sets in overlapping [symbol/slot] of P(S)Cell and sSCell
		- Further discuss detailed BD/CCE handling based on ~~Option A or Option B or~~ Option C discussed in RAN1#104b-e
			* For Option C, Z4 is per slot of sSCell, at least the case where Z3 + 2μ1-μZ4 ≤ $M\_{PDCCH}^{max,slot,μ}$ is supported where $μ$ is SCS configuration of the P(S)Cell, where μ1 is SCS of the sSCell.

The difference between Option A and Option C is that, Option A defines BD limit for sSCell-schedule-PCell per two sSCell slots overlapped with one PCell slot and Option C defines the BS limit per sSCell slot. Option C is preferred because it is similar as normal BD limit definition and can be used for the case that SCS of scheduling cell is larger or smaller than the SCS of the scheduled cell.@Qualcomm, maybe your concern for USS Alt 1 can be discussed in UE feature discussion at a late stage. For your new Alt 2-4, the main drawback is same as original Alt 2-4, i.e., the USS scheduling opportunities are semi-statically limited on certain slots, where the scheduling opportunities can’t be flexibility chosen between PCell and sSCell.  |

### Proposal 3

* At least the following is supported for BD/CCE limit handling when P(S)Cell SCS is less than or equal to sSCell SCS
	+ PDCCH monitoring candidates on P(S)Cell and/or sSCell are configured such that total of (x1(m)+x2(m))+ y(m) ≤ $M\_{PDCCH}^{max,slot,μ}$ ,where $μ$ is SCS configuration of the P(S)Cell
* FFS: whether/how (x1(m)+x2(m))+ y(m) > $M\_{PDCCH}^{max,slot,μ}$ is also supported
* Discuss further detailed BD/CCE limit handling e.g. based on Options A/B/C from RAN1#104b-e
* 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 all sSCell slot(s) that overlap slot m of P(S)Cell
	+ USS(s) => USS(s) that can schedule PDSCH/PUSCH on P(S)Cell

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

|  |  |
| --- | --- |
| **Company Name** | **Comments (Proposal 3)** |
| Moderator notes | Almost all companies seem to be OK with at least supporting case where the PDCCH BDs across P(S)Cell and sSCell is less than 44 per 1ms (i.e., $M\_{PDCCH}^{max,slot,μ}$, when P(S)cell is 15kHz SCS ) and intention of Proposal 3 is to capture this. There are different opinions on how to further adjust complexity/flexibility (e.g. according to the BD Options) and this will be discussed further.  |
| Qualcomm | Intention is OK. On the main bullet, “at least if a UE does not report *pdcch-BlindDectectionCA*” should be added. Or alternatively, adding one sub-bullet “FFS: if the UE reports *pdcch-BlindDetectionCA*” is also OK. |
| Apple | We should like to also limit themax (x1(m) + x2(m))max(y(m))Imagine if UE has to use two CC to handle this PDCCH monitoring, for example, in the case that SpCell and sSCell has different SCS. We would want to limit the BD/CCE per CC, it is not enough to simply have a total limitation since it will allow (44, 0) and (0, 44).  |
| Samsung | OK with the proposal in principle but not OK with the current wording. The proposal can be simply worded as a UE not having to exceed its Rel-16 PDCCH monitoring capability for the scheduled P(S)Cell at any given slot of the P(S)Cell.There is no reason for x1(m) and x2(m) – can be a single x(m). That may relate (not necessarily) to the previous discussion of not mandating to have CSS in every slot on the P(S)Cell – no reason for that and contrary to the objectives of DSS. |
| Ericsson | OK with the proposal.In addition to above starting point, as discussed in our tdoc we are also OK to introducing additional limits on individual components (x1(m)+x2(m), and y(m). For this our preference is to use an RRC configured scaling factor on $M\_{PDCCH}^{max,slot,μ} $for determining P(S)Cell BD/CCE limit, and use the remaining BD/CCEs for the sSCell.Regarding the proposed modification from QC – regardless on number of configured cells, we think the upper limit for BDs across P(S)Cell and sSCell should be of 44/1ms. Then, the individual P(S)Cell/sSCell limits due to CA scaling do still apply and this ‘upper limit of 44/1ms for BDs across P(S)Cell and sSCell’ is applied as an additional constraint. |
| CATT | OK with the proposal. We share the same views as Ericsson that the BD/CCE limit should be identical despite of the reporting of *pdcch-BlindDetectionCA*. Furthermore, we don’t see the necessity of introducing separate limit for PCell and SCell. Considering there is only one scheduled cell, i.e. PCell, the limit should be defined from the scheduled cell perspective. How to allocate the BD between PCell and sSCell is totally gNB work. It also aligns with the motivation of DSS that offload part of PDCCH monitoring from PCell to sSCell. |
| ZTE | Not support. We are not sure about the intention here. The similar restriction has been included in Proposal 2, not sure why we need a separate proposal here. If we really want to have some high level proposal here, we share similar view as Samsung, i.e., a UE is not required to exceed its Rel-16 PDCCH monitoring capability for the scheduled P(S)Cell at any given slot of the P(S)Cell.Besides, regarding the y(m) that #BDs for PDCCH USS(s) candidates monitored on sSCell in all sSCell slot(s) that overlap slot m of P(S)Cell, it seems y(m) is determined by the numerology of PCell, which has to be further discussed. This will end up with defining a BD/CCE limit (M\_max) on sSCell for s-p scheduling per multi-slots of sSCell. However, the M\_total during CA scaling is performed via the numerology of the SCell based on our understanding, it is not clear how to calculate min{M\_max, M\_total} on sSCell for s-p scheduling if different numerologies are applied for M\_max and M\_total.  |

### Discussion Point 4

* BD/CCE limits to account for CA are specified according to following conditions in 38.213
	+ $\sum\_{μ=0}^{3}\left(N\_{cells,0}^{DL,μ}+γ∙N\_{cells,1}^{DL,μ}\right)\leq N\_{cells}^{cap}$
		- $M\_{PDCCH}^{total,slot,μ}=M\_{PDCCH}^{max,slot,μ}$ or $γ∙M\_{PDCCH}^{max,slot,μ}$
	+ $\sum\_{μ=0}^{3}\left(N\_{cells,0}^{DL,μ}+γ∙N\_{cells,1}^{DL,μ}\right)>N\_{cells}^{cap}$
		- $M\_{PDCCH}^{total,slot,μ}=\left⌊N\_{cells}^{cap}⋅M\_{PDCCH}^{max,slot,μ}⋅{\left(N\_{cells,0}^{DL,μ}+γ∙N\_{cells,1}^{DL,μ}\right)}/{\sum\_{j=0}^{3}\left(N\_{cells,0}^{DL,j}+γ∙N\_{cells,1}^{DL,j}\right)}\right⌋$
* When CCS from sSCell to P(S)Cell is configured for the UE, how should the ‘CA scaling calculation’ be specified to derive $M\_{PDCCH}^{total,slot,μ}$ ?
	+ Alt1
		- P(S)Cell is counted once
		- sSCell is counted once
	+ Alt 2
		- P(S)Cell is counted once
		- sSCell is counted twice (with same SCS as sSCell)
	+ Alt 3
		- Use scaling factors $γ\_{μ1} $and $γ\_{μ2}$ $ $with SCS configuration $μ1$ and $μ2$ respectively for P(S)Cell and sScell (the scaling factors may be less than 1)

Companies are requested to provide comments on above alternatives (or additional alternatives) in the Table below

|  |  |
| --- | --- |
| **Company Name** | **Comments (Discussion point 4)** |
| Qualcomm | We are not sure what the discussion here is. For cross-carrier scheduling from sSCell to P(S)Cell, part of the BD capability, that was originally implemented for P(S)Cell PDCCH monitoring, is taken by sSCell to enable P(S)Cell scheduling. An example is following.So, the sSCell is not counted as a scheduling cell to P(S)Cell (is this Alt.1 or something else?). |
| Apple | We think it depends on whether total BD/CCE will be relaxed or it stays the same, and, whether we introduce per SpCell/sSCell maximum BD/CCE |
| Samsung | Alt. 3 as an optional configuration with further clarification on the sum of $γ\_{μ1} $and $γ\_{μ2}$ (should be less than one). Alt. 1 if the configuration is not provided. |
| Ericsson | For the case where limit of up to 44 BDs per 1ms is used, we do not see much difference between the different alternatives.For the case of “FFS: if (x1(m)+x2(m))+ y(m) > $M\_{PDCCH}^{max,slot,μ}$ is also supported”, we see Alt 2 providing benefit without increasing the total BD budget*.* |
| CATT | The proposal highly depends on whether the SCS between PCell and sSCell is same or not. If same SCS is configured for PCell and sSCell, we don’t see the necessity to change anything from the current mechanism.For difference SCS case, it is valid to discuss how to count PCell and sSCell. For alt.2, it can almost reuse the current mechanism to calculate BD/CCE number across configured serving cells which is slightly preferred. Accordingly, we propose the following update for the main bullet:‘When CCS from sSCell to P(S)Cell is configured for the UE and different numerologies are configured for P(S)Cell and sSCell, how should the ‘CA scaling calculation’ be specified to derive $M\_{PDCCH}^{total,slot,μ}$ ?’ |
| ZTE | Maybe more clarification is needed. Based on our understanding, the scheduled cell (PCell) can be counted once or twice. It has nothing to do with whether the sSCell is counted once or twice.In Rel-17 DSS case that PDCCH of SCell scheduling PDSCH or PUSCH on P(S)Cell is supported, PDCCH blind decoding will be performed on two cells for this P(S)Cell. In this case, how to calculate the number of P(S)Cell in parameter  is a new issue. So we think for CA scaling, the first issue should be whether PCell is counted as one or two cells for the two scheduling cells. That means two alt is sufficient. * ZTE-A) PCell is counted as one cell for the two scheduling cells.
* A-1). The number of PCell is still count as 1 for only one of the scheduling cells, i.e., PCell.This can be used combined with Option B.
	+ A-2): The number of PCell is counted as N1 < 1 and N2 < 1 for the two scheduling cells (PCell and sSCell) respectively, wherein, N1 + N2 = 1. This can be used combined with Option A/C. (This is similar to Alt.3 listed above by the moderator)
* ZTE-B) PCell is counted as two cell for the two scheduling cells. And counted as one for each scheduling cell (how to reflect this in the spec can be discussed later, i.e. like BDfactorR). This can be used combined with Option A/C. (This is similar to Alt.1 listed above by the moderator)

For example, assume 6 cells are configured for a UE shown in Figure 3, wherein the SCS = 15kHz for PCell #1 and the SCS = 30kHz for sSCell #2. In Rel-15/Rel-16 case PCell cannot be scheduled by sSCell (the red arrow in Figure 3 is not presented), M\_total\_15khz = floor(4\*44\*1/6) = 29; M\_total\_30khz = floor(4\*36\*5/6) = 120. In case PCell can be scheduled by sSCell (the red arrow in Figure 3 is presented), whether PCell is counted as one or two cells for the two scheduling cells are analyzed below.Figure 3 CA with SCell-schedule-PCellComparing the two cases (ZTE-A and ZTE-B) above in Table 2, the common part of the two cases is M\_total\_15khz is reduced and M\_total\_30khz is increased compared with the Rel-15/Rel-16 case. The difference of two cases is that the total blind detection capability for the PCell may be increased and it may occupy the blind detection capability of other SCells in ZTE-B, otherwise the blind detection capability of the PCell scheduled by sSCell is very limited if keep the blind detection capability for other SCells unchanged. While only partial blind detection capability of the PCell is transferred to the sSCell in ZTE-A and the blind detection capability for other SCells is not impacted. Since there is a restriction that the total PDCCH blind decoding budget should not be changed as a result of this work, it is preferred to count PCell as 1 cell for the two scheduling cells.Table 2 blind detection capability for different cases |

### Proposal 5

* Down select from below alternatives for SS set linking (or not) for case when CCS from sSCell to P(S)Cell is configured
	+ Alt1
		- Linking between P(S)Cell and sSCell SS sets is configured as in Rel16
	+ Alt 2
		- at least *nrofCandidates* is derived using the SS set linking as in Rel16
		- at least *monitoringSlotPeriodicityAndOffset, monitoringSymbolsWithinSlot, duration* can be separate for sSCell self-scheduling and sSCell to P(S)Cell scheduling
			* Details FFS
	+ Alt 3
		- SS set linking is not used and a separate SS set is explicitly configured for sSCell to P(S)Cell scheduling
			* Details FFS

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

|  |  |
| --- | --- |
| **Company Name** | **Comments (Proposal 5)** |
| Qualcomm | First preference is Alt.2 only for the search space set configurations involved in cross-carrier scheduling from sSCell to P(S)Cell – for search space set configurations for self- and legacy cross-carrier scheduling, their configuration should remain the same as in Rel.16 (i.e, Alt.1). This does not require a change of ASN.1 structures of *SearchSpace* and *crossCarrierSchedulingConfig*.Second preference is Alt.1 for all the search space set configurations including cross-carrier scheduling from sSCell to P(S)Cell. |
| Apple | We think Alt1 and Alt2 might be talking about two different things Regarding the SS linkage between scheduled cell and scheduling cell, in terms of *nrofCandidates* configuration and other configurations, we can reuse the existing design which might be the intention of Alt2. For *CrossCarrierSchedulingConfig*, we can also largely reuse the existing RRC. It is just that there might be two things (1) now SpCell can be scheduled by sSCell (others), so the note needs to be modified (2) SpCell can also be self-scheduled, so it is not “CHOICE”. But those should be easy to change  |
| Samsung | Alt.3 - if a change is to be made, links should be removed (they were only introduced because RAN2 did not properly implement the RRC parameters provided by RAN1 in Rel-15 that assumed Alt. 3). |
| Ericsson | From our perspective, it is feasible to reuse the SS set linking principles for sSCell scheduling P(S)Cell and still have separate monitoring for sSCell self-scheduling (s-s) and sSCell to P(S)Cell scheduling (s-p) by using multiple search space sets. Alt 2 is a superset that also includes Alt 1, and hence it could be considered as an enhancement. If number of search space sets on sSCell are limited, then sharing the same search space id on the sSCell (s-s, s-p) may be needed and in which case Alt2 allows more flexibility. We are also OK to take a shorter list of alternatives and agree to reuse the SS set linking as the basis for sSCell scheduling P(S)Cell.  |
| CATT | Alt-2 is our first preference considering the flexibility. Totally reuse the current linkage rule, i.e. alt 1, is also OK to us if it is majority view.Considering dynamic BWP switching may happen on either PCell or sSCell, alt-3 would definitely require more efforts. The configuration would be very complicated in order to maintain the same understanding between network and UE. |
| ZTE | Based on our understanding, Alt.1 is the legacy mechanism, which is preferred by us. Alt.2 seems to offer more flexibility which had been discussed during Rel-15/Rel-16 for legacy cross-carrier scheduling, we can also accept Alt.2 if this is the majority view. But we may also need to clarify whether Alt.2 is only for sSCell scheduling PCell, or can also be applied to legacy cross-carrier scheduling, e.g., sSCell scheduling other SCell.For Alt.3, it seems more flexible than alt.2 because the linkage is not used. More clarification is needed for Alt.3 to figure out the detailed mechanism. |

# 3 Conclusions

TBD

# 4 References

1. R1-2104185 On cross-carrier scheduling from SCell to Pcell Nokia, Nokia Shanghai Bell
2. R1-2104232 Discussion on SCell PDCCH scheduling P(S)Cell PDSCH or PUSCH Huawei, HiSilicon
3. R1-2104340 Discussion on Cross-Carrier Scheduling from SCell to PCell ZTE
4. R1-2104391 Discussion on Scell scheduling Pcell vivo
5. R1-2104445 Discussion on cross-carrier scheduling from SCell to Pcell Spreadtrum Communications
6. R1-2104495 Discussion on cross-carrier scheduling from Scell to Pcell CATT
7. R1-2104635 Discussion on cross-carrier scheduling from SCell to Pcell CMCC
8. R1-2105970 (R1-2104698) Cross-carrier scheduling from an SCell to the PCell/PSCell Qualcomm Incorporated
9. R1-2104806 Discussion on cross-carrier scheduling from Scell to Pcell OPPO
10. R1-2104931 On SCell scheduling PCell transmissions Intel Corporation
11. R1-2105131 Views on Rel-17 DSS SCell scheduling PCell Apple
12. R1-2105230 Cross-carrier scheduling from SCell to Pcell ETRI
13. R1-2105339 Cross-carrier scheduling from SCell to PCell Samsung
14. R1-2105378 On Cross-Carrier Scheduling from SCell to PCell/PSCell MediaTek Inc.
15. R1-2105401 Search space monitoring in sSCell and PCell InterDigital, Inc.
16. R1-2105441 Discussion on cross-carrier scheduling from SCell to Pcell LG Electronics
17. R1-2105546 Discussion on Cross-carrier scheduling from SCell to PCell Xiaomi
18. R1-2105723 Discussion on cross-carrier scheduling enhancements for NR DSS NTT DOCOMO, INC.
19. R1-2105765 Cross-carrier scheduling (from Scell to Pcell) Lenovo, Motorola Mobility
20. R1-2105796 Enhanced cross-carrier scheduling for DSS Ericsson
21. R1-2105847 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

## Agreements from RAN1#104b-e

**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

**Agreement**

PDCCH overbooking on sSCell USS set(s) is not allowed

Following was captured in RAN1 Chairman notes

**For RAN1#105-e, companies are encouraged to consider:**

* Further discuss PDCCH monitoring and BD/CCE limit handling in RAN1#105e considering below BD/CCE limit handling options
	+ Option A
		- At least when P(S)Cell SCS is not higher than sSCell SCS, 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.
			* RRC configured BD limit/scaling factor-based limit for max(x1(m)+x2(m))
			* Separate RRC configured BD limits/scaling factor-based limits for max(x1(m)+x2(m)) and max(y(m))
			* separate BdfactorR for P(S)Cell and sSCell
			* SS configuration-based BD limit for max(x1(m)+x2(m)) and max(y(m))
			* RRC configured BD limit/scaling factor-based limit for max(x1(m)+x2(m))+ max(y(m))
			* Counting ‘sSCell-to-P(S)Cell’ scheduling as an additional scheduling cell with numerology given by sSCell numerology in determining the BD/CCE limits
		- FFS reference SCS to use when P(S)Cell has higher SCS than sSCell (if supported)
		- For sSCell scheduling P(S)Cell, the UE is not required to monitor on the active DL BWP with SCS configuration $μ$ of the sSCell more than$M\_{PDCCH}^{max,slot,μ}$ PDCCH candidates per slot of sSCell.
			* FFS how limit$M\_{PDCCH}^{total,slot,μ}$ is computed and applied when CCS from sSCell to P(S)Cell is configured
	+ Option B
		- At least when P(S)Cell SCS is not higher than sSCell SCS, For P(S)Cell slot m, PDCCH monitoring candidates on P(S)Cell and/or sSCell are configured such that x1(m)+x2(m)+y(m) is less than or equal to BD limit Z2
		- At least the case of Z2 = 44 is supported for P(S)Cell SCS 15kHz
			* FFS if Z2 larger than above can also be supported based on UE capability (e.g. similar to *BDFactorR* in Rel16)
		- max of (x1(m1)+x2(m1)) + max of y(m2) corresponding to any P(S)Cell slots m1 and m2 ~~can~~ is allowed to be larger than BD limit Z2
		- FFS signalling details on how the limit Z2 is realized
		- FFS reference SCS to use when P(S)Cell has higher SCS than sSCell (if supported)
		- For sSCell scheduling P(S)Cell, the UE is not required to monitor on the active DL BWP with SCS configuration $μ$ of the sSCell more than$M\_{PDCCH}^{max,slot,μ}$ PDCCH candidates per slot of sSCell.
			* FFS how limit$M\_{PDCCH}^{total,slot,μ}$ is computed and applied when CCS from sSCell to P(S)Cell is configured
	+ Option C
		- PDCCH monitoring candidates on P(S)Cell are configured such that max of (x1(m1)+x2(m1)) is less than or equal to Z3
			* Z3 is derived by the PDCCH monitoring capability of PCell
		- PDCCH monitoring candidates on sSCell are configured such that max of y(m2) is less than or equal to Z4
			* Z4 is derived by the PDCCH monitoring capability of sSCell
		- FFS details to define Z3 and Z4, e.g.
			* Separate RRC configured BD limits/scaling factor-based limits for max(x1(m)+x2(m)) and max(y(m))
		- For sSCell scheduling P(S)Cell, the UE is not required to monitor on the active DL BWP with SCS configuration $μ$ of the sSCell more than Z4 PDCCH candidates per slot of sSCell
	+ 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 all sSCell slot(s) that overlap slot m of P(S)Cell
		- USS(s) => USS(s) that can schedule PDSCH/PUSCH on P(S)Cell)