**3GPP TSG-RAN WG1 #102-e R1-20xxxxx**

**eMeeting, August 17th – 28nd, 2020**

**Source: Moderator (Ericsson)**

**Title: Summary of NR Dynamic spectrum sharing (DSS)**

**Agenda item:** **8.13**

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

# 1 Introduction

In this document, following contributions submitted for Rel17 WI on NR Dynamic spectrum sharing (DSS) are summarized, along with some suggestions for further discussion.

* A.I. 8.13.1 “Cross-carrier scheduling (from Scell to Pcell)” -- [1-18]
* A.I. 8.13.2 “Multi-cell PDSCH scheduling via a single DCI” – [19-35]

According to draft agenda for this meeting,

* for A.I. 8.13.1 the focus should be on “high level concepts”
* for A.I. 8.13.2 the focus should be on “study whether or not to support the feature first”

# 2. Discussion

## 2.1 Cross-carrier scheduling (from Scell to Pcell)

For “Cross-carrier scheduling (from Scell to Pcell)”, the following aspects were discussed in [1-18]

1. **Allowed scheduling combinations when CCS from an SCell to PCell/PSCell is configured**
	* Same cell scheduling on PCell/PSCell
		+ Allowed - [1],[2],[3],[4],[5],[6],[7],[9],[10],[11],[12],[13],[14],[15],[16],[18]
		+ Not allowed – [14] (only one scheduling cell for each scheduled cell)
		+ Study further – [8], [17]
	* CCS from PCell/PSCell to another SCell
		+ can be allowed – [7] (‘specific’ vs. ‘shared CIF’)
		+ not allowed - [15]
	* CCS from another cell to the SCell used for scheduling PCell/PSCell
		+ not allowed – [5]
2. **Search space handling**
	* Type 0/0A/1/2 CSS monitoring retained on PCell -- [1],[2],[3],[4],[5],[6],[7],[9],[10],[11],[12],[13],[14],[15],[16],[18]
	* Monitoring of UE specific RNTI (if provided) in Type 0/0A/1/2/3 CSS is retained on PCell/PSCell – [1],[3]
	* For the SCell used for scheduling PCell/PSCell, only the UESS on that SCell can be used for scheduling the PCell/PSCell – [4],[15],[16]
	* Type 3 CSS can be configured on either the PCell/PSCell or the SCell used for scheduling PCell/PSCell (at least some DCI formats) – [5],[6],[11],[12]
	* UESS for scheduling PCell/PSCell can be on a) both PCell/PSCell and the ‘SCell used for scheduling PCell/PSCell’ vs. b) only the ‘SCell used for scheduling PCell/PSCell’ – [11],[12],[13],[18]
	* Re-use existing SS set linking approach for CCS from SCell to PCell/PSCell – [1],[2]
3. **Handling of PDCCH BD/CCE limits, overbooking, DCI size alignment, allowed DCI formats**
	* Discussed in – [1],[2],[6],[8],[9],[11],[13],[15],[18]
4. **Handling of (de)activation/dormancy/BWP change for the SCell used for scheduling PCell/PSCell**
	* Discussed in – [1],[4],[6],[8],[9]
5. **Other aspects**
	* RRC configuration aspects – [1],[2],[3],[5],[10],[12]
	* Dynamic adaptation between same cell scheduling on PCell/PSCell and CCS from SCell to PCell/PSCell – [4],[10],[13],[16]
	* multiple vs. only one SCell used for CCS from SCell to PCell/PSCell – [5],[7],[18]
	* Multi-TRP handling – [6],[11]
	* Initial and retransmission scheduling DCIs on different serving cells – [7]
	* Out of order scheduling issues – [15]
	* Reuse preparation time from Rel16 – [18]
	* RLM retained on the PCell/PSCell – [18]

### Moderator Proposal 1 (1st round of discussion)

* Prioritize first two topics from below list for discussion in RAN1#102-e
	1. Allowed scheduling combinations when CCS from an SCell to PCell/PSCell is configured (discuss first)
	2. Search space handling when CCS from an SCell to PCell/PSCell is configured (discuss second)
	3. Handling of PDCCH BD/CCE limits, overbooking, DCI size alignment, allowed DCI formats
	4. Handling of deactivation/dormancy/BWP change for the SCell used for scheduling PCell/PSCell

Please provide comments if any for above proposal (preferably by 08/18 5PM PST)

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| Company Name | Comments |
| Samsung | Agree to prioritize the first two topics. We do not expect any spec impact from the last 2. |
| Huawei, HiSilicon | It is worthwhile to look at the details listed in each of the summarized aspects provided in section 2.1 based on submitted contributions for this meeting.Then, we think Point 2(Search space handling) has higher priority than the last two issues of Point 1 (i.e. CCS from PCell/PSCell to another SCell, and CCS from another cell to the SCell used for scheduling PCell/PSCell), which can be discussed later.Some aspects should be considered for Point 2: - Scheduling flexibility impact including PDCCH blocking considering instantaneous load of the SCell and the PCell/PSCell- specification impact- UE complexity impact- UE power consumption impactSince Point 3(Handling of PDCCH BD/CCE limits etc.) may be the main contributor of specification impact, some issues in Point 2 may need to be discussed together with Point 3, e.g., UESS for scheduling PCell/PSCell can be on a) both PCell/PSCell and the ‘SCell used for scheduling PCell/PSCell’ vs. b) only the ‘SCell used for scheduling PCell/PSCell’ – [11],[12],[13],[18].Point 5 can include different numerologies between the SCell and the PCell/PSCel – [1] [11] [18]. |
| ZTE | First of all, one question for clarification regarding the Moderator Proposal 1. Do we intend to discuss only the first two issues in this meeting or discuss all the four issues in this meeting?If we are only to discuss the first two issues in this meeting, then we are fine with the Proposal 1. To us, the 1st and 2nd issues are high-level issues which need to be addressed first. While the 3rd and 4th issues are more detailed issues, which could be discussed later in next meeting, especially considering that these detailed issues may consume lots of discussion time.One clarification for the 3rd bullet, our assumption of the PDCCH BD/CCE limits is that it includes both M/C\_max and M/C\_total. But this details can be discussed in next meeting. |
| MediaTek | OK with the priority. |
| Nokia | Proposed priorities 1 and 2 form a reasonable starting point. We acknowledge the importance of topics 3 and 4, but they can be discussed in subsequent meetings after the first two are covered. |
| Qualcomm | We agree with the moderator’s view. As part of the second issue, we should also discuss whether fallback DCI formats or non-fallback DCI formats can be monitored in the search space set on the scheduling SCell (or on the PCell/PSCell). |
| vivo | In general, we agree with the moderator’s proposal on the prioritization. For the two prioritized topics, more details on sub-issue in each topic need to be further clarified.For topic 1, the following sub-topics should be considered as well in addition to the listed 3:* Whether to support semi-static PDSCH/PUSCH scheduling from Scell to Pcell? (Proposed in [1], seems not captured in the summary)
* How many Scells could be configured to schedule Pcell at the same time? (Discussed in [5] and [18] , seems not captured in the summary)

For topic 2, the listed proposal seems to be related with each other and we think they could be classified into 3 sub-topics:* How to monitor PDCCH in Scell for scheduling P(S)cell
* Whether and how to monitor PDCCH in P(S)cell when it is scheduled by Scell?

How to determine the search space in Scell for scheduling P(S)cell? |
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## 2.1 Multi-cell PDSCH scheduling via a single DCI

For the study on “Multi-cell PDSCH scheduling via a single DCI”, the following aspects were discussed in [19-35]

1. **High level design aspects to align for evaluation of whether or not to support single DCI scheduling PDSCH on two cells**
	1. Whether the single DCI is used for scheduling two PDSCHs for the two cells, or used for scheduling one PDSCH for the two cells – [19],[22],[27],[29],[33],[34]
	2. Number of bits required for the single DCI scheduling PDSCH on two cells (including any padding bits used for size matching) when compared to an existing DCI format providing similar functionality/flexibility – [19],[20],[21],[22],[23],[24],[25],[26],[28],[34]
	3. The DCI fields are supported by the DCI format used for scheduling PDSCH on two cells (including what fields are shared and what are separate)– [20],[22],[24],[28],[33],[34],[35]
	4. Characteristics of the two cells on which the PDSCH is scheduled including the following – [19],[33],[35]
		* Whether different numerologies/channel BW/HARQ processes/MCSs/FDRA/TDRA can be assumed for the two cells – [33]
		* intra-band and inter-band CA cases – [35]
	5. Impact on PDSCH scheduling using existing DCI formats – [26],[33],[34],[35]
	6. HARQ feedback handling – [19],[20],[22],[23]
	7. Two stage aggregated DCI structure – [21]
2. **Evaluation framework**
3. Aspects to consider for evaluation
	* PDCCH overhead impact
	* Scheduling flexibility impact including PDCCH blocking
	* System throughput impact
	* UE complexity impact
	* UE power consumption impact
4. Link-level and System-level simulation assumptions

### Moderator Proposal 2 (1st round of discussion)

* Discuss below topics in RAN1#102-e
1. Identify a common minimum set of high-level design aspects for the study of whether or not to support single DCI scheduling PDSCH on two cells (discuss first)
2. Identify common evaluation framework for the study of whether or not to support single DCI scheduling PDSCH on two cells (discuss second)

Please provide comments if any for above proposal (preferably by 08/18 5PM PST)

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| Company Name | Comments |
| Samsung | Before considering spec impact/support/complexity or other specifics, a conclusion is needed for whether joint scheduling provides any benefit. Initial focus should be on evaluation assumptions to determine overhead savings, if any – LLS is sufficient for PDCCH, no need for SLS except possibly for geometry distributions (difficult to converge/calibrate SLS, LLS provides all necessary info for PDCCH). Conclude on DCI fields that can be common for scheduling over two cells. |
| Huawei, HiSilicon | Regarding the list of high-level design aspects, the FL’s summary is a good starting point. For the first item, we’d like to emphasize that the aim is to identify the minimum set of design aspects that are needed for the study phase, thus some of the details mentioned in several contributions may be left to a later phase and some of the issues should be part of evaluation assumptions for companies to report. For example, - Point 1a) is not needed to be concluded in this meeting, as it depends on the output of the study, including the gain and potential specification impact. Therefore, this can be reported as candidate techniques from proponents in their analysis;- Details of DCI formats (1b, 1c) cannot really be looked at separately, and should be provided by proponents for each candidate technique (1a, 1g), since some assumption on DCI size is needed for evaluations;- Point 1d) should be clarified early as this would set the requirements for the targeted scenarios and for the evaluations.- Point 1e) looks like it might be discussed as part of 1b/1c (“compared to an existing DCI format providing similar functionality/flexibility”)In order to provide response for the above aspects (cell characteristics and DCI format assumptions etc.) with a clear classification towards the goal of this study, it is necessary to first clarify during the email discussion that:**- targeted deployment scenarios****- candidate techniques to evaluate, including assumption on DCI sizes, and overall expected specification impact for each candidate technique**On the evaluation framework. Looking at the discussion in the various papers, we don’t think that meaningful conclusions could be derived from a separate analysis of PDCCH overhead and PDCCH blocking and from LLS in general. All these effects should be observed as part of the SLS, so SLS should be the primary means of evaluating single DCI scheduling PDSCH on two cells. UE complexity and UE power consumption can be analyzed separately. Therefore, we should**- agree on SLS evaluation assumptions, including reasonable assumptions for modeling PDCCH overhead and PDCCH blocking.** |
| ZTE | To us, it is more reasonable to first discuss the **potential scenarios** and **use cases** of this one-to-two scheduling instead of the detailed design. For all the items (a-g) listed under the first issue, most of them are too detailed design issues, which may consume lots of discussion time. Among them, we think we only need to discuss item (a) first. And after that, we can start discuss common evaluation framework.For the simulation, companies can do simulation to figure out what the potential gain is for each different DCI size. In that case, companies can determine whether there is any performance for one-to-two scheduling under different scenarios for different DCI sizes.Further, regarding the performance metrics for evaluation, as the motivation of this WI is to ensure sufficient scheduling capacity for NR UEs on the shared carriers under DSS scenario, it seems the “PDCCH overhead impact” and “Scheduling flexibility impact including PDCCH blocking” are more appropriate to applied as the metrics. We can further discuss the details in the second discussion phase. |
| MediaTek | To conclude the study, we only need to agree on the following two.* Evaluation assumptions & performance metrics
* DCI overhead assumptions of the enhanced schemes for evaluation

Detailed design (e.g. bullet 1(a)-1(g)) can be left to later RAN1 meetings after concluding the study phase. |
| Nokia | Would like to understand the 2.1 (discuss first) and 2.2 (discuss second), is the intent to ONLY discuss 2.1 in this meeting, or phase the email discussions in this meeting?Proposal 2.1 should clarify if high-level design aspects should be able to accommodate more than 2 CCs in the future.Explicitly clarify if the discussion proposed by 2.2 is intended to cover LL and SLS and prioritize accordingly if needed.We propose to use the identified common set of high-level design aspects as a basis and focus on the evaluation assumptions and key performance metrics. |
| Qualcomm | As ZTE commented, it is important to align the understanding of scenarios and use-cases first. Based on them, potential DCI designs (including rough range of necessary DCI payload size, impact on scheduling flexibility, etc) are identified. Without these, the simulation campaign would not be useful.For the simulation work, we tend to agree with Samsung – SLS would not be essential. |
| vivo | Before discussing the listed issues in the high-level design aspects, we think we should first **clarify what the scenario/use case and purpose** of multi-cell scheduling are. For example, is multi-cell scheduling used to increase the PDCCH capacity of Pcell only? Can a Scell schedule multiple cells with a multi-scheduling DCI?Regarding the multi-cell scheduling, **we think the evaluation framework should be the first priority**. We suggest identifying evaluation assumptions to assess the savings in PDCCH overhead that multi-cell scheduling can bring. Once the specific scenario and the performance gain have been identified, we can further discuss the technical aspects(e.g., 1-a~1-g) that need to be investigated. LLS and SLS can be considered in the evaluation. Besides, we also need to consider the proportion of single-cell scheduling UEs and multi-cell scheduling UEs in the simulation. On top of the SNR curve in SLS and the SNR required to reach 1% PDCCH BLER in LLS, we can calculate the average CCE required by multi-cell scheduling under different DCI size assumptions. Then, by comparing the average CCE of single-cell scheduling with that of multi-cell scheduling, we can derive the CCE saving of multi-cell scheduling with different DCI compression rates compared to single-cell scheduling. Furthermore, the metric reflecting the impact of CCE savings on system performance should also be clarified, e.g., the CCE saving can be converted into a PDCCH blocking reduction rate or a PDSCH throughput improvement.  |
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# 3 References

1. R1-2005409 Discussion on Scell scheduling Pcell vivo
2. R1-2005440 Discussion on Cross-Carrier Scheduling from SCell to PCell ZTE
3. R1-2005696 Disucssion on cross-carrier scheduling from Scell to Pcell CATT
4. R1-2005900 On SCell scheduling PCell transmissions Intel Corporation
5. R1-2006063 Cross-carrier scheduling OPPO
6. R1-2006176 Cross-carrier scheduling from SCell to Pcell Samsung
7. R1-2006281 Discussion on cross-carrier scheduling from Scell to Pcell Spreadtrum Communications
8. R1-2006318 Discussion on cross-carrier scheduling from SCell to Pcell LG Electronics
9. R1-2006362 Discussion on cross-carrier scheduling for NR DSS ETRI
10. R1-2006366 Discussion on Cross-carrier scheduling from SCell to PCell Beijing Xiaomi Mobile Software
11. R1-2006405 Discussion on the PDCCH of SCell scheduling PDSCH or PUSCH on P(S)Cell Huawei, HiSilicon
12. R1-2006469 Cross-carrier scheduling from SCell to Pcell Nokia, Nokia Shanghai Bell
13. R1-2006473 SCell scheduling PCell InterDigital, Inc.
14. R1-2006509 Views on Rel-17 DSS SCell scheduling PCell Apple
15. R1-2006671 Enhanced cross-carrier scheduling for DSS Ericsson
16. R1-2006749 Discussion on cross-carrier scheduling enhancements for NR DSS NTT DOCOMO, INC.
17. R1-2006756 Discussion on PDCCH of SCell scheduling PDSCH or PUSCH on PCell ASUSTeK
18. R1-2006833 Views on cross-carrier scheduling from an SCell to the PCell/PSCell Qualcomm Incorporated
19. R1-2006987 Discussion on joint scheduling vivo
20. R1-2005441 Discussion on Multi-cell PDSCH Scheduling via a Single DCI ZTE
21. R1-2005628 On Multi-cell PDSCH scheduling via a single DCI MediaTek Inc.
22. R1-2005697 Discussion on multi-cell PDSCH scheduling via a single DCI CATT
23. R1-2005901 On 2-cell scheduling via single DCI Intel Corporation
24. R1-2005909 On support of Single DCI scheduling two cells Nokia, Nokia Shanghai Bell
25. R1-2006064 Multi-cell PDSCH scheduling via a single DCI OPPO
26. R1-2006177 On the use of one DCI format for scheduling on two cells Samsung
27. R1-2006282 Discussion on multi-cell PDSCH scheduling via a single DCI Spreadtrum Communications
28. R1-2006319 Discussion on multi-cell PDSCH scheduling via a single DCI LG Electronics
29. R1-2006413 Discussion on the PDCCH of P(S)Cell/SCell scheduling PDSCH on mulitple cells using a single DCI Huawei, HiSilicon
30. R1-2006474 A single DCI scheduling multi-cell InterDigital, Inc.
31. R1-2006510 Views on Rel-17 DSS Multi-cell PDSCH scheduling via a single DCI Apple
32. R1-2006583 Discussion on multi-cell PDSCH scheduling via a single DCI ASUSTeK
33. R1-2006672 Discussion on single DCI scheduling PDSCH on multiple cells Ericsson
34. R1-2006750 Discussion on multi-cell PDSCH scheduling via a single DCI for NR DSS NTT DOCOMO, INC.
35. R1-2006834 Views on multi-cell PDSCH scheduling via a single DCI Qualcomm Incorporated