**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 in email thread [102-e-NR-DSS-DC\_enh2-01]

* 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”

The email discussion is organized as follows

[102-e-NR-DSS-DC\_enh2-01] Email discussion/approval using the summary as a starting point, focusing on high-level aspects – Ravi (Ericsson) & Frank (Huawei)

* By 8/19 – Classification of high priority/medium priority items for this e-Meeting
* By 8/24 – high priority items
* By 8/27 - medium priority items

# 2. Discussion

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

### 2.1.1 1st Round discussion

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],[9]
   * For the SCell used for scheduling PCell/PSCell, only the UESS on that SCell can be used for scheduling the PCell/PSCell – [4],[9],[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)

|  |  |
| --- | --- |
| 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 impact  Since 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? |
| NTT DOCOMO | We agree with the moderator’s proposal on the discussion priority. |
| Apple | The first two issues can be prioritized.  I assume that we first need to discuss whether CCS can be configured in SCell for PCell scheduling, if yes, which CCS. |
| InterDigital | We agree with the moderator’s view on the prioritization of the first two topics in RAN1#102-e meeting. |
| Intel | We are supportive to prioritize the first two topics, i.e. prioritize the discussion from search space set point of view. On the other hand, since CSS/USS are related to fallback or non-fallback DCI formats, it may not be easy to hardly avoid the discussion on DCI format. For example, same or different handling on fallback or non-fallback DCI formats in USS. |
| ETRI | Agree with the moderator’s proposal to focus on high-level issues. Also share the view with QC and Intel that DCI format (at least fallback vs. non-fallback DCI) should be part of the discussion in this meeting. |
| Xiaomi | We agree with the moderator’s proposal on the prioritization. We should also discuss whether fallback monitoring mechanism is needed when SCell schedule P(S)Cell. |
| CATT | We agree with moderator’s suggestion that the first two bullets should have high priority and should be discussed in this meeting. |
| LG | We agree with moderator’s suggestion that the first two bullets are prioritized to be discussed first in this meeting.  In addition, we think that the last two bullets should also be discussed for the complete figure of the Scell-to-Pcell CCS. |

### 2.1.2 2nd Round discussion

Companies are requested to provide input on below questions preferably by 08/24 10AM UTC

#### Q1-1:

When cross-carrier scheduling from an SCell to PCell/PSCell is configured, should self-scheduling on PCell/PSCell be allowed?

|  |  |  |
| --- | --- | --- |
| **Company Name** | **Yes/No** | **Comments (Q1-1)** |
| LG | Yes | Self-scheduling on the Pcell/PScell need to be allowed at least for the case of scheduling with CSS DCI. |
| vivo | Yes | In NR Rel-15, Type 0/0a/1/2 CSS is only configured in P(S)cell, where UE monitors at least PDCCH scrambled by cell-specific RNTI (e.g. SI-RNTI, RA-RNTI, etc.) to receive fallback DCI scheduling control information on P(S)cell. When Scell is enabled to schedule P(S)cell, those CSS should be kept on P(S)cell for receiving the broadcast service, such as paging for ETWS/CMAS. Besides, moving the CSS to Scell does not bring many benefits but introduces more spec changes and unreliabilities. Therefore, Type 0/0a/1/2 CSS(s) should remain in P(S)cell and is used for self-scheduling of at least control information.  Furthermore, In NR Rel-15, if a UE is provided with CSS#0/0a/1/2 and a C-RNTI/MCS-C-RNTI/CS-RNTI, the UE also monitors PDCCH candidates for fallback DCI with CRC scrambled by these UE-specific RNTI(s) in the CSS(s) in a slot where the UE monitors PDCCH candidates for at least a fallback DCI with CRC scrambled by SI-RNTI, RA-RNTI or P-RNTI. This is very useful to avoid ambiguity and keep the service continuity during RRC reconfiguration. Therefore, even when Scell is enabled to schedule Pcell, this “fallback” operation should not be removed.  Generally, we support that self-scheduling on PCell/PSCell is allowed, including Fallback DCI in Type 0/0A/1/2 CSS scrambled by SI-RNTI/RA-RNTI/MsgB-RNTI/TC-RNTI/P-RNTI, and C-RNTI, MCS-C-RNTI, CS-RNTI(s) if provided |
| Qualcomm | Yes | When cross-carrier scheduling from an SCell to PCell/PSCell is configured, it is not desirable to stop monitoring any search spaces on the PCell/PSCell. At least some sort of fallback operation using PDCCH in the PCell/PSCell should be enabled. |
| Samsung | Yes | Yes, as in Rel-16 |
| Xiaomi | Yes | When cross-carrier scheduling from an SCell to PCell/PSCell is configured, self-scheduling on PCell/PSCell should be allowed at least for CSS DCIs. |
| CATT | Yes | The type 0/0a/1/2 PDCCH CSS can only configured on the P(S)Cell and fallback DCI format with CRC scrambled by C-RNTI/CS-RNTI/MCS-C-RNTI can be transmitted in the CSS for unicast data scheduling. It is straightforward to reuse the same mechanism in the current specification for self-scheduling on the P(s)Cell.  However, it should make it clear that where the self-scheduling comes from. We don’t see the motivation of configuring USS on the scheduled P(S)Cell for the unicast data scheduling purpose. It against the intention to offload the PDCCH to another non-DSS carrier and increase the UE complexity on PDCCH monitoring. |
| ZTE | Yes | Based on our understanding, at least the fallback DCIs should be kept in the PCell for self-scheduling, otherwise the initial access procedure will be impacted. Regarding which DCI formats/searchspaces should be kept on the PCell, we can discuss this issue further. |
| Mediatek | Yes | * CSS is kept in PCell/PSCell to prevent the change on initial access and system information reception procedure * Then same UE behavior on CSS (e.g. PDSCH/PUSCH scheduling for PCell/PSCell in CSS) should be kept to minimize the change   In addition, it also enable gNB’s flexibility to utilize the remaining DL control capacity in PCell/PSCell for better coverage, assuming PCell/PSCell for DSS is in lower frequency band. |
| Intel | Yes | For Type-0/0A/1/2 CSS, PDCCH and PDSCH are both on PCell, hence self-scheduling;  For Type-3 CSS, depending on RRC configuration, it could be on PCell  Further, gNB could configure some USS on PCell that schedules unicast PCell transmissions, i.e. self-scheduling. |
| NTT DOCOMO | Yes | The CCS from SCell to P(S)Cell targets the scenario where PDCCH capacity of P(S)Cell is limited. In the current specifications, scheduling cell for a serving cell is semi-statistically configured by *schedulingCellInfo*. Therefore, when PDCCH capacity of P(S)Cell becomes sufficient and NW would like to change from CCS to SCS for the P(S)Cell, RRC reconfiguration is necessary. In order to address this point, we can consider monitoring PDCCH on multiple scheduling cells such as SCell and P(S)Cell for the P(S)Cell. |
| ETRI | Yes | At least UE should monitor fallback DCI in PCell CSS set for fallback scheduling during PCell RRC reconfiguration. We can also consider including other search spaces for scheduling flexibility and fallback operation when SCell link quality is poor. |

#### Q1-2:

When cross-carrier scheduling from an SCell to PCell/PSCell is configured, should cross-carrier scheduling from PCell/PSCell to another SCell be allowed?

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| **Company Name** | **Yes/No** | **Comments (Q1-2)** |
| LG | No | The cell configured to be scheduled from a cell cannot schedule another cell so far even from LTE. It is quite not aligned with the motivation of cross-CC scheduling that a cell reliable for control signaling schedules another cell unreliable for control signaling. |
| vivo | No | PCell/PSCell is scheduled from an SCell due to PDCCH capacity limitation. There is no motivation for the PCell/PSCell to schedule another SCell. |
| Qualcomm | No | The motivation of this new setting for cross-carrier scheduling is to offload the PDCCH from a DSS carrier (= the PCell/PSCell for the UE) to another carrier (= likely non-DSS carrier, which is an SCell for the UE). For this scenario, there is no motivation to enable cross-carrier scheduling from the PCell/PSCell to another SCell. |
| Samsung | No | With this operation, the offloaded PDCCH for PCell would be overloaded on PCell again. That is against the motivation for DSS on PCell and the underlying assumptions |
| Xiaomi | No | It shouldn’t be allowed, otherwise UE monitoring burden is increased obviously. |
| CATT | No | Don’t see the necessity. |
| ZTE | No | We didn’t see the motivation to allow this kind of scheduling.  The motivation of this objective it to offload the PDCCH overhead on PCell. If we allow PCell to cross-carrier schedules another SCell, it seems to be again with the objective here. |
| MediaTek | No | Don’t see the necessity. Allowing this may increase UE PDCCH monitoring burden. |
| Intel | No | PCell, being a scheduled cell now, cannot be the scheduling cell for another SCell. Otherwise, the benefit of PDCCH offloading disappears. |
| NTT DOCOMO | No | The motivation for enabling CCS from an SCell to P(S)Cell is to improve limited PDCCH capacity of PCell/PSCell. We think the CCS from the PCell/PSCell to another SCell is not aligned with the motivation. |
| ETRI | No | Not aligned with the motivation of SCell-to-PCell/PSCell cross-carrier scheduling. |

#### Q1-3:

When cross-carrier scheduling from an SCell to PCell/PSCell is configured, should the following be allowed?

a) self-scheduling on the ‘SCell used for scheduling PCell/PSCell’

b) cross-carrier scheduling from the ‘SCell used for scheduling PCell/PSCell’ to another serving cell

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| **Company Name** | **Yes/No** | **Comments (Q1-3)** |
| LG | Yes | We think there is no reason not to allow both (a) and (b) since it doesn’t seem to be different and differentiated from the case where cell 1 is configured to schedule both cell 2 and cell 3 based on current cross-CC scheduling configuration. |
| vivo | Yes | In NR Rel-15, if one cell is scheduling another cell, this cell should be self-scheduling. So following Rel-15 logic, the ‘SCell used for scheduling PCell/PSCell’ should be self-scheduling and it could also schedule another Scell. |
| Qualcomm | Yes | The scheduling SCell should be able to schedule data on its own cell or on another cell. This should be based on the cross-carrier scheduling framework, i.e., using CIF to identify the scheduled cell. |
| Samsung | Yes | Yes, this is in line with Rel-16 cross carrier scheduling |
| Xiaomi | Yes | Both a) and b) should be allowed. |
| CATT | Yes | We support both a) and b). From our understanding, a) and b) are quite align with the configuration rules and behaviors for the current cross carrier scheduling. Currently, the scheduling cell can transmit DCI for self-scheduling and cross-carrier scheduling associated with multiple scheduled cells. |
| ZTE | Yes | For a), it is straightforward that the SCell configured for cross-carrier scheduling PCell can also be used for self-scheduling.  For b), if the SCell is configured for cross-carrier scheduling PCell, then this SCell is a scheduling cell, thus it is straightforward that it can also be used to schedule another serving cell. |
| MediaTek | Yes | Just reuse the design in Rel-16 cross-carrier scheduling and extend it to SCell scheduling PCell/PSCell case. |
| Intel | Yes | In our view, the SCell scheduling PCell/PSCell works just as a legacy scheduling cell, which could schedule up to 7 scheduled cell. The only difference is that PCell/PSCell is now being one scheduled cell. All other design on CCS can be reused unless a necessary adaption is found. |
| NTT DOCOMO | Yes | In order to maintain the scheduling flexibility of SCell, both a) and b) should be allowed. |
| ETRI | Yes | This is in line with Rel-15/16 cross-carrier scheduling. |

#### Q1-4:

When cross-carrier scheduling from an SCell to PCell/PSCell is configured, should cross-carrier scheduling from another serving cell to the ‘SCell used for scheduling PCell/PSCell’ be allowed?

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| --- | --- | --- |
| **Company Name** | **Yes/No** | **Comments (Q1-4)** |
| LG | No | The answer is the same as in the above Q1-2. Such case had not been introduced so far, and it is not aligned with the motivation of cross-CC scheduling. |
| vivo | No | In NR Rel-15, if one cell is scheduling another cell, this cell should be self-scheduling. So following Rel-15 logic, the ‘SCell used for scheduling PCell/PSCell’ should be self-scheduling. |
| Qualcomm | No | The motivation of this is not justified. |
| Samsung | No | From a RAN1 perspective, there may not be additional spec impact (e.g. only care about “scheduling cell” and “scheduled cell” – don’t care whether it is primary or secondary) but that is not totally clear yet and there may be RAN2 impact. Can deprioritize for now and revisit towards the end of the WI. |
| Xiaomi | No | It shouldn’t be allowed, otherwise UE monitoring burden is increased obviously. |
| CATT | No | Don’t see the motivation. |
| ZTE | No | We didn’t see any motivation to do this.  For example, for PCell A + SCell B + SCell C, if SCell B is used for cross-carrier scheduling PCell A while SCell C is used for cross-carrier scheduling B, in this case, why don’t we just configure SCell C to cross-carrier schedule both SCell B and PCell A. |
| MediaTek | No | Don’t see the necessity. Allowing this may increase UE PDCCH monitoring burden. |
| Intel | No | We don’t see any motivation to allow such operation. |
| NTT DOCOMO | No | The motivation of CCS from another serving cell to SCell scheduling P(S)Cell is not clear. |
| ETRI | No | Don’t see the motivation. |

## 2.2 Multi-cell PDSCH scheduling via a single DCI

### 2.2.1 1st Round discussion

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. |
| NTT DOCOMO | We think multi-cell scheduling applicable scenarios and use cases should be clear first in order to discuss the detail design of single DCI. Regarding evaluation, the detail design of single DCI (e.g. whether support some indication fields in the DCI or not) and the DCI size should be aligned. |
| Apple | Support FL proposal |
| InterDigital | We also think that we should discuss first the scenarios and the use cases for multi-PDSCH using a single PDCCH. The design aspects and the evaluation framework can be then discussed to consider only the high priority scenarios. |
| Intel | We think the first thing is to check whether multi-cell scheduling can be beneficial. The target scenario should be identified, evaluation assumptions, especially size of the DCI for single-cell scheduling and multi-cell scheduling should be derived. |
| ETRI | We also think that scenarios and use cases should be first decided. After that, we can discuss evaluation assumptions including DCI overhead proper to target use cases. |
| Xiaomi | We agree with the moderator’s proposals. |
| CATT | Support FL proposal. We should achieve a common understanding on the benefits and use case for the multi-cell scheduling via a single DCI. After that, we can jump into more detail designs. Regarding the simulation methodology, we think either SLS or LLS can be used to prove the potential benefits, which can depend on companies’ report. |
| LG | We share the same view with other companies that before going to the design for the multi-cell scheduling directly, target scenarios, use cases, and technical motivation/benefits to introduce this multi-cell scheduling, should be identified and justified first.  After the above, we can discuss and decide on the relevant evaluation assumptions. |

### 2.2.2 2nd Round discussion

Companies are requested to provide input on below questions preferably by 08/24 10AM UTC

#### Q2-1:

What use cases and scenarios should be considered for evaluating the potential benefits of single DCI scheduling PDSCH on two cells?

|  |  |
| --- | --- |
| **Company Name** | **Comments (Q2-1)** |
| LG | The scenarios for evaluations should not be limited to only 2 CC case where all the UEs have same Pcell and same Scell. The case with more than 2 CCs where Pcell is the same for all the UEs but different UE has different Scell (for example, cell1 is Pcell for both UE1 and UE2 but cell2 is Scell for UE1 and cell3 is Scell for UE2), should be included in the scenarios. |
| vivo | The WID is to ensure sufficient scheduling capacity for LTE-NR shared carrier. Since the LTE-NR shared carrier is usually used for NR Pcell deployment, at least the scheduling capacity of Pcell sharing the same frequency with LTE should be studied. So we can consider evaluating the following scenarios:   * **Scenario1: Pcell schedules two cells with multi-cell scheduling**   Compared with using two DCIs on Pcell to schedule two cells separately, jointly scheduling on Pcell allows gNB to use fewer DCI to schedule the same number of transmissions, which could reduce the amount of control signaling required on Pcell and possibly increases the capacity.   * **Scenario2: Scell#1 schedules a Scell and Pcell with multi-cell scheduling**   In this case, Scell#1 schedules Pcell and a Scell(e.g., Scell#1 itself or other Scell) through a single DCI. It can offload to the Scell#1 some of the PDCCH for scheduling Pcell that was originally required to be transmitted on Pcell. This case can be seen as a combination of Scell scheduling Pcell and multi-cell scheduling.  If multi-cell scheduling in the above scenarios is identified to be beneficial, we can further generally apply it to other scenarios, e.g., **a Scell schedules two Scells with multi-cell scheduling**. |
| Qualcomm | The first scenario can be a typical DSS scenario where a DSS carrier (SCS 15kHz, narrower bandwidth) and a non-DSS carrier (SCS 30kHz, wider bandwidth) in different frequency bands are aggregated for downlink. Some more possible details are found in the following table.   |  |  |  | | --- | --- | --- | |  | PCell/PSCell | SCell | | Duplex | FDD | TDD | | SCS | 15kHz | 30kHz | | Bandwidth | 5, 10, or 20MHz | 20, 40, or 100MHz | | Deployment | Different bands and may or may not be co-located | | | PUCCH transmission | Yes | No | | No. of TBs per cell | 1 | 1 | | Baseline size of the non-fallback DL DCI | [60] bits + 24-bit CRC | [70] bits + 24-bit CRC | | Notes | Cross-carrier scheduling from one of the cells is configured | |   The second scenario is a wideband operation using intra-band CA. The multi-cell PDSCH scheduling, if supported, should be useful not only for a particular DSS scenario (as above), but also for general CA operations that can be benefit from the feature. In the first scenario described above, various aspects (e.g., propagation channels, antenna configurations, data traffic profiles, scheduling policies, etc) maybe uncorrelated/independent between the scheduled cells. In this sense, this is a kind of worst scenario for DCI size compression, whereas the second scenario would be the best case. We should study both cases, to see how much the multi-cell PDSCH scheduling is useful in various scenarios.   |  |  |  | | --- | --- | --- | |  | PCell/PSCell | SCell | | Duplex | TDD | TDD | | SCS | 30kHz | 30kHz | | Bandwidth | 20, 40, or 100MHz | 20, 40, or 100MHz | | Deployment | Same band and co-located | | | PUCCH transmission | Yes | No | | No. of TBs per cell | 1 | 1 | | Baseline size for non-fallback DL DCI | [70] bits + 24-bit CRC | [70] bits + 24-bit CRC | | Notes | Cross-carrier scheduling from one of the cells is configured | |   With the scenarios, we can identify how DCI fields/size/format for multi-cell PDSCH scheduling should look like. Based on this, it is possible to further analyze how multi-cell PDSCH scheduling is useful for these scenarios. |
| Samsung | Start with DSS as use case and LTE-NR as scenario. Additional scenarios can be considered depending on relevance/importance |
| Xiaomi | Both intra-band CA and inter-band CA should be evaluated. |
| CATT | Single DCI scheduling can further reduce the PDCCH overhead on both DSS serving cell and the scheduling cell other than the DSS cell. Consequently, the PDCCH blocking possibility can be reduced and higher spectrum efficiency can be achieved. It is beneficial to pursue high PDCCH capacity and throughput. The system performance will be improved. Any scenarios may benefit from the multiple-cell scheduling via a single DCI should not be precluded, e.g.   1. Pcell scheduling SCell and PCell 2. PCell scheduling SCell and SCell 3. SCell scheduling PCell and SCell   SCell scheduling SCell and SCell |
| ZTE | The motivation of this WI is to mitigate the PDCCH blockage issue on PCell under DSS scenario. Thus, the most typical scenario for one-to-two scheduling should be DSS scenario with one carrier/band shared with LTE and another NR carrier/band. **Thus, we agree with Samsung that we can start with DSS and additional scenarios can be considered depending on relevance/importance.**  To compare the potential performance of one-to-two scheduling, the following scenarios can be simulated.  1. Legacy Rel-15/Rel-16 mechanism, one DCI schedules one PDSCH on one carrier;  2. One DCI with PDCCH on shared carrier schedules two PDSCHs on two carriers;  3. One DCI with PDCCH on NR carrier schedules two PDSCHs on two carriers.  Regarding whether single DCI is used for scheduling two PDSCHs for the two cells, or used for scheduling one PDSCH for the two cells, our preference is that the single DCI is used for scheduling two PDSCHs for the two cells.  Regarding whether LLS or SLS should be adopted, we feel like LLS together with the geometry should be sufficient. |
| MediaTek | * An FR1 TDD carrier using 30KHz SCS to schedule an FR1 FDD carrier using 15KHz SCS   + Inter-band CA between two carriers * An FR1 TDD carrier using 30KHz SCS to schedule another FR1 TDD carrier using 30KHz SCS   + Intra-band CA between two carriers * An FR1 TDD carrier using 30KHz SCS to schedule an FR2 TDD carrier using 120KHz SCS   + Inter-band CA between two carriers   However, it would be very beneficial to include the case with more than 2 carriers for evaluation to have a unified design. |
| Intel | DSS related scenario should be the focus in the evaluation. It should be enough to evaluation CA of one PCell (shared with LTE cell) and one NR SCell. Additional SCell if existed, that is scheduled by the scheduling SCell, is an existing feature in NR. |
| NTT DOCOMO | The target is to improve NR PDCCH capacity on the serving cell operating DSS where only 1 or 2 symbols per slot may be available for NR PDCCH. Hence, we can consider at least DSS case as scenario. Regarding other cases (e.g. intra-band CA), since multi-cell scheduling using a single DCI may be beneficial to improve PDCCH capacity, we think it can be considered as scenario in addition to DSS case. |
| ETRI | The evaluation can focus on DSS scenario with same or different SCSs between SCell and PCell/PSCell, both TDD and FDD carriers. |

# 3 Conclusions

## 3.1 1st Round discussion

The following is topics are proposed for further discussion in RAN1#102-e [102-e-NR-DSS-DC\_enh2-01] email thread, based comments received in 1st round of the discussion.

**Moderator Proposal 1v2**

* For Cross-carrier scheduling from SCell to PCell discuss below two topics in RAN1#102-e

1. Allowed scheduling combinations when CCS from an SCell to PCell/PSCell is configured (discuss in 2nd round, 20th – 24th)
2. Search space and DCI format handling when CCS from an SCell to PCell/PSCell is configured (discuss in 3rd round, 25th – 27th)

**Moderator Proposal 2v2**

* For study on multi-cell PDSCH scheduling via a single DCI discuss below two topics in RAN1#102-e

1. Identify relevant scenarios and use cases applicable for single DCI scheduling PDSCH on two cells (discuss in 2nd round, 20th – 24th)
2. Identify evaluation framework including the following (discuss in 3rd round, 25th – 27th)
   * 1. type of evaluations (e.g. link-level, system level,..), associated simulation assumptions and performance metrics
     2. any high-level design aspects that should be considered in the evaluations (e.g. one vs. two PDSCHs for the two cells, DCI payload size, supported DCI fields, impact on existing DCI formats…)

# 4 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