3GPP TSG-RAN WG2 Meeting #114 Electronic R2-210xxxx

Elbonia, 19 – 27 May 2021

**Agenda item: 6.5**

**Source: Nokia (Rapporteur)**

**Title: [Post113bis-e][222][R16 DCCA] Cell grouping for NR-DC (Nokia)**

**WID/SID: LTE\_NR\_DC\_CA\_enh-Core - Release 16**

**Document for: Discussion and Decision**

# 1 Introduction

This document is the report of the following email discussion:

* [Post113bis-e][222][R16 DCCA] Cell grouping for NR-DC (Nokia)

Scope: Discuss the signalling solutions for R16 NR-DC cell grouping based on the corresponding RAN4 LS.

      Intended outcome: Discussion report and CRs (if possible)

      Deadline:  Long

=> Long deadline equals to, May 10 23.59 PDT (same as submission deadline)

# 2 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

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| --- | --- | --- |
| Company | Name | Email Address |
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# 3 Discussion

In RAN2#113e we technically endorsed CRs regarding UE capability signaling for NR DC cell grouping. In RAN#91e concerns were raised regarding limiting the signaling to 5 bands and this resulted in following conclusion (RP-210880):

### *3.6 Summary from Final Round*

*Only further input was from Nokia indicating that they are fine with the moderators proposal but would also be ok to go with "The signalling should* ***aim*** *to support more than 5 bands". Given this the conclusion from the discussion is unchanged as follows:*

***Conclusion****:*

1. *The RAN2 endorsed CRs (*[*R2-2102210*](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113-e/Docs/R2-2102210.zip) *and* [*R2-2102211*](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113-e/Docs/R2-2102211.zip) *) are not approved at RAN#91e.*
2. *RAN4 are tasked to consider this topic (as described in RAN2 LS* [*R2-2102212*](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113-e/Docs/R2-2102212.zip) *) and provide input to RAN2 from their April meeting.*
3. *RAN2 are tasked to complete these CRs for RAN#92e, considering the input received from RAN4*

As a result of this RAN4 discussed the topic and provided a LS in [R2-2104652](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113bis-e/LSin/R2-2104652.zip). In the LS RAN4 indicates:

*RAN4 would like to thank RAN2 for the LS on introducing Cell Grouping UE capability for NR-DC. According to the LS, the change in signaling uses a bit in the bitmap to represent a single frequency band within the band combination. The consequence of this bitmap is that a limit of up to 5 frequency bands for NR-DC band combinations can be signaled. RAN4 also identified issues with the PUCCH grouping alternative approach.*

*It is RAN4’s view that the limit of 5 frequency bands is not fully future-proof. While combinations defined in the current RAN4 specifications are able to be represented by the per-frequency-band RAN2 bitmap, RAN4 envisions in the near future, NR-DC combinations with greater than 5 frequency bands may be specified. Moreover, granularity of per band in current RAN2 signalling can indicate cell grouping between different frequency bands, however it is not clear how to indicate cell grouping within one frequency band, e.g. NR-DC using two/more non-contiguous CCs within one frequency band. In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view. This can be a default UE capability which means no need to indicate the cell grouping capability explicitly.**RAN4 thinks the support of these cases may be needed in the future depending on the operator’s demands, and the UE capability signaling needs to be extended at that time.*

And RAN4 requests RAN2 to consider that future NR-DC combinations are expected to be specified with greater than 5 frequency bands.

**Question 1**: RAN4 indicated that they will NR-DC band combinations with > 5 frequency bands may be specified in near future and requests RAN2 to consider this in their work. Do you think that > 5 frequency bands need to be supported in NR DC cell grouping signaling?

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| Answers to Question 1 |
| Company | Yes/No | Technical Arguments |
| Nokia | Yes | It seems very likely that band combinations with more than 5 bands will be specified soon as we generally aim to have band specific UE capabilities defined as release independent manner we think it is important to support > 5 bands in capability signaling for NR DC cell grouping. |
| Ericsson | Yes | The RAN4 LS clearly indicates that we can expect the need to support >5 bands in the near future. Our opinion from the start has been that we should select a signalling solution that scales beyond the current 5 band limitation. |
| MediaTek | No (for now) | RAN4 agreed that RAN2 endorsed CR is enough for current RAN4 SPEC and RAN4 **may** introduce NR-DC with more than 5 bands. The reply is not so clear that more than 5 bands NR-DC is definitely needed. If it does, is it going to be “FR1 bands in MCG and FR2 bands in SCG”? We think more than 5 band NR-DC is already supported for FR1+FR2 NR-DC. It is our preference to agree RAN2 endorsed CR and we could extend the capability in the future if necessary.  |
| ZTE | No (for now) | Similar view as MediaTek. In addition, as we know, there is no plan in RAN4 to support NR-DC with more than 5 bands at least in Rel-17. And as MTK indicated, more than 5 bands is already supported for FR1+FR2 NR-DC. So we prefer to agree RAN2 endorsed CR, and considering extension in the future. In our understanding, the LTE-style can be extendable with limited impact (see our response to Q3). |
| Qualcomm Incorporated | Yes | Future compatible solution is preferred. |
| Samsung | No | We share the view from MediaTek and ZTE. For >5 bands, FR1-FR2 NR-DC is already supported as they mentioned. We think endorsed CR by RAN2 is enough. Further enhancements of cell grouping can be made in future release (i.e., after RAN4 defines >5 bands for NR-DC.) |
| Intel  | Yes  | Considering that RAN4 BCs are defined later than signaling design, “in the near future” would be a good motivation that Rel-16 signaling should support more than 5 band NR-DC.   |
| OPPO | No (for now) | We also think RAN2 endorsed CR for Rel16 is sufficient considering BC with more than 5 bands will not introduced till Rel17. |
| SoftBank | Yes | Agree with Nokia. Increasing the refarming band from LTE, it would be important to use more than 5 bands NR-DC combination in the very near-term. Therefore, it is preferred the UE capability related to band combination should be defined as release independent manner. |
| Huawei, HiSilicon | See comments | According to RAN4 LS, RAN4 is not asking RAN2 to define the cell grouping capability for more than 5 bands in Rel-16, but only pointing out the possibility that a BC including more than 5 bands may be specified in future. Thus we also feel in Rel-16 it could be fine to only support FR1+FR2 NR-DC without limitation of band number and intra-FR NR-DC with up to 5 bands. Meanwhile, we should consider the case of more than 5 bands in the later release as well, so we agree with Qualcomm that the Rel-16 cell grouping capability (if any) should have the scalability. |
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**Summary 1**: TBD.

**Proposal 1**: TBD.

Regarding granularity of signaling RAN4 indicated:

*Moreover, granularity of per band in current RAN2 signalling can indicate cell grouping between different frequency bands, however it is not clear how to indicate cell grouping within one frequency band, e.g. NR-DC using two/more non-contiguous CCs within one frequency band. In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view. This can be a default UE capability which means no need to indicate the cell grouping capability explicitly.**RAN4 thinks the support of these cases may be needed in the future depending on the operator’s demands, and the UE capability signaling needs to be extended at that time*

So basically RAN4 indicates a concern regarding use case of supporting cell grouping between MCG on a band and SCG on same band but bit apart in frequency from MCG i.e. groups would be non-contiguous based on RAN4 input. RAN4 considers that this kind of case may need to be supported in future. Current technically endorsed RAN2 CRs do not support such a case as UE only indicates a band once in the NR DC cell grouping signaling. It should be noted that in LTE from which the basics of cell grouping was taken each entry of band combination is signalled in the cell grouping signaling and such a non-contiguous cell grouping as indicated by RAN4 would be supported.

**Question 2**: Do you think RAN2 needs to support above non-contiguous intra-band cell group signalling as indicated by RAN4?

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| Answers to Question 2 |
| Company | Yes/No | Technical Arguments |
| Nokia | Maybe | It is not 100% clear if this intra-band DC support is critical to have. Based on RAN4 input this case is not yet actually to be done in near future unlike > 5 bands NR DC cases. But of course if signaling can support this in feasible manner then it would be good to avoid impacts in near future. We wonder also regarding PUCCH group signaling agreed in release 16 that it does not support such intra-band PUCCH grouping. Probably as that does not support this it is not critical to support this in this release as PUCCH group signaling would need also revision.. |
| Ericsson | No | The information in the RAN4 LS in this respect seems a bit contradicting. On one hand, the LS states that “it is not clear how to indicate cell grouping within one frequency band, e.g. NR-DC using two/more non-contiguous CCs within one frequency band”.On the other hand, the LS also states that “In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view. This can be a default UE capability which means no need to indicate the cell grouping capability explicitly.”, which seems to indicate such intra-band cell grouping signalling is not needed. Before defining any signalling for this we need at least to clarify with RAN4 the requirements. |
| MediaTek | No (for now) | RAN4 indicates that for intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view. So, if indeed this intra-band NR-DC is introduced, maybe just one more capability bit is needed per BC. One thing unclear to us is how to identify the cell group support for intra-band NR-DC with inter-band components. But maybe we don’t need to discuss this for Rel-16.  |
| ZTE | No | Based on “*the UE can support* ***any*** *cell grouping options from RAN4 point of view. This can be a default UE capability which means* ***no need*** *to indicate the cell grouping capability explicitly.*”We think RAN4 already made it clear that we don’t have to consider this aspect in current capability signalling design.  |
| Qualcomm Incorporated | Yes | We believe RAN4’s concern on RAN2 technically endorsed CRs is valid in case the band combination is an inter-band NR-DC which includes intra-band non-contiguous CCs. In this case, the RAN2 solution can assign the band entries of intra-band non-contiguous part only to one cell group.If the band combination includes only one frequency band with non-contiguous components, then the UE can signal it supports all possible combinations by omitting cellGroupingSync-r16 and cellGroupingAsync-r16. This satisfies RAN4 requirement in their LS ““In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view”. |
| Samsung | No | LS states: *RAN4 thinks the support of these cases may be needed in the future depending on the operator’s demands, and the UE capability signaling needs to be extended at that time*From this, we understand RAN4 has no clear concern yet. When they clearly send their concern in future, RAN2 can address this issue (e.g., by defining any cell grouping as UE's default capability). No need to handle this now. |
| Intel  | Maybe  | We think that it is not so essential to support at this moment. On the other hand, original LTE cell grouping approach supports intra-band non-contiguous NR-DC by using band entry instead of frequency band. With this approach, intra-band non-contiguous NR-DC is the same as inter-band NR-DC from signaling point of view.    |
| OPPO | No | We agree with E/// the information in the LS is not so clear.  |
| SoftBank | Yes | RAN4 clearly requests to support any cell grouping in a case of the intra-band non-contiguous NR-DC as indicated in “In this intra-band non-contiguous NR-DC case, the UE can support any cell grouping options from RAN4 point of view”. This intra-band NR-DC combination is already proposed in R4-2100940.  |
| Huawei, HiSilicon | See comments | In RAN4 LS, the intra-band non-contiguous NR-DC case may be needed in the future depending on operator’s demands. Thus there is no clear need to report the capability in Rel-16. Furthermore, RAN4 also indicates the UE can support any cell grouping options, which could be a default UE capability and explicit signaling is not needed in this case. Based on this RAN4 view, the default UE capability could be easily indicated by adding some clarifications to the description of the Rel-16 cell grouping parameter (if any).  |
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**Summary 2**: TBD.

**Proposal 2**: TBD.

If you answered Yes to question 1 and/or question 2 please provide possible solution how to solve those aspects

**Question 3**:Please provide high level description how would you solve RAN4 input – especially if you answered yes to questions 1 and/or 2?

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| Answers to Question 3 |
| Company | High level description of proposed solution(s) |
| Nokia | Based on RAN4 input they seem to want maximum freedom for capability signaling at least at some point of time. In order to support that kind of flexibility having any sort of optimizations seems quite difficult to do. Basically, it seems that based on RAN4 input we would even need to remove NR optimization from current CRs referring to band but one should refer to band combination entry instead in order to support intra-band NR DC case. If intra-band NR-DC signaling is not needed to be supported then though it seems that PUCCH grouping signaling based approach would seem to be feasible alternative supporting basically almost unlimited amount of bands. Thus we would think we have basic two approaches possible depending whether intra-band DC cell grouping is required:1. Revise existing CRs to allow NR DC intra-band cell grouping – Then one needs to consider how to enable (if enabled) > 5 bands support with this signaling. It seems bit challenging to do >5 bands support with this signaling as the bitmap size increases exponentially.
2. Use PUCCH Cell grouping principle (e.g. as described in [R2-2103273](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113bis-e/Docs/R2-2103273.zip)) which would allow indefinite amount of bands to be supported but may not support intra-band DC.
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| Ericsson | The RAN4 LS confirms the requirement to go beyond 5 bands. With this, we need to revisit the decision to go for LTE-DC style signalling, which was taken under the assumption that max 5 bands would be sufficient. LTE-DC style signalling does not scale beyond 5 bands due to exponential increase of the signalling overhead. This becomes apparent especially if there is also a need to support intra-band NR-DC cell grouping. To make matters worse the decision to explicitly indicate MCG/SCG caused a doubling of the signalling overhead compared to LTE-DC.Given the requirement to support >5 bands, we see two main alternative development tracks for the RAN2 signalling:1. Network filtering (as described in [R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip)). In short, instead of the UE indicating all supported cell grouping alternatives into MCG and SCG per supported band combination, the network could indicate to the UE in the filtered capability request how it intends to group the requested bands into MCG and SCG.
2. Carrier type grouping (as described in [R2-2103273](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113bis-e/Docs/R2-2103273.zip)). Instead of listing individual bands, the UE would list what carrier types are supported in MCG and SCG. It is similar as was used for PUCCH grouping, but since RAN4 indicated issues with PUCCH grouping, it is not clear whether this approach is feasible? If this track is selected, an LS needs to be sent to RAN4 to confirm feasibility.

These tracks need to be discussed further in next meeting based on contributions. |
| MediaTek | It is our understanding that the PUCCH group style is not preferred by RAN4 as they indicated that “*RAN4 also identified issues with the PUCCH grouping alternative approach*”. There is simply no feasible signalling to support fine granularity and unlimited band number. One possible way forward is to agree the RAN2 endorsed CR for NR-DC BC with no more than 5 bands and introduce PUCCH group style for NR-DC with more than 5 bands.In addition, we would like to point out the network filtering solution ([R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip)) could not be a complete solution for cell grouping capability. For example, considering a 3 band BC, there are 6 possible cell grouping as indicated in endorsed CR R2-2102211. The NW filtering may be able to filter out 3 of the combinations. However, it is still not possible for UE to indicate which cell group it support among the remaining 3 combinations. So, network filtering could only be further optimization once we have basic cell group capability. [Ericsson] Just a comment on the mentioned limitation to 3 combinations. As pointed out in [R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip), network filtering could be either cell group agnostic or cell group specific (i.e. MCG/SCG explicit). With cell group specific filtering, network can filter out all 6 combinations as shown below:Network filter UE Cell groupingrequestedCellGrouping    SEQUENCE { 001    MCG                                {n3, n7}    SCG                                 {n78}requestedCellGrouping    SEQUENCE { 010    MCG                                {n3, n78}    SCG                                 {n7}requestedCellGrouping    SEQUENCE { 011    MCG                                {n3}    SCG                                 {n7, n78}requestedCellGrouping    SEQUENCE { 100    MCG                                {n7, n78}    SCG                                 {n3}requestedCellGrouping    SEQUENCE { 101    MCG                                {n7}    SCG                                 {n3, n78}requestedCellGrouping    SEQUENCE { 110    MCG                                {n78}    SCG                                 {n3, n7} |
| ZTE | Our interpretation of RAN4 LS is PUCCH based solution is already excluded by RAN4. (Based on “*RAN4 also* ***identified issues*** *with the PUCCH grouping alternative approach.*”) Although RAN4 shows interests and possibilities of supporting more than 5 bands in the future, as we replied to Q1, at least this will not happen in Rel-17. And we are now discussing **Rel-16** capabilities. We don’t agree to the comments that LTE-style in RAN2 endorsed CR has huge problem. We understand simply scaling beyond 5 bands will exponentially increase the signalling overhead. But we think it is feasible to consider another way of extension (if needed in the future). For instance: * Instead of associating each bit with a single NR band, we can associate each bit with “more than one bands (band group)”, and UE can indicate the band group explicitly. For example, for BC band A+B+C+D+E+F, if “A+B” are always supported in one cell group, then UE can indicates a BC group of A+B for this band combination. Then the first bit will be associated with band A+B, instead of only band A. In this case, there is no need to extend the bit-string (the maximum length is still 30).
* Since the band group can be signalled as per-BC level, so UE only needs to indicate the band group when a BC has more than 5 bands, there is no significant signaling overhead. In addition, although it may loose some flexibility (e.g. band A and B only be MCG or SCG), but it is much more flexible compared to PUCCH-group option. And if UE can support any MCG/SCG options, it can anyway indicate “*anyGrouping*”.
* Since band group is only need for >5 bands BC, those BCs are newly introduced in the future, so from ASN.1 point of view, there is no backward compatible issues.

Regarding the network filter solution (R2-2101091), it works if operator has deployed no more than 5 NR bands. However, we understand the scenario we are discussing is that operator may deploy more than 5 NR bands, and they hope UE will be configured with more than 5 bands NR-DC, so network filter solution still cannot solve this problem. [Ericsson] Just a comment on the mentioned limitation to max 5 bands. As pointed out in [[R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip)], there is no 5 band limit for network based filtering, since there is no exponential signalling increase based on the number of supported bands, as in LTE-DC type signalling. The below example illustrates how network filtering can be used in a network deployment with more than 5 bands. In this example, the network is interested in the following three alternative cell groupings:Network filter UE Cell groupingrequestedCellGrouping    SEQUENCE { 0111111    MCG                                {n3}     SCG                                 {n7, n78, n257, n258, n260, n261}requestedCellGrouping    SEQUENCE { 0011111    MCG                                {n3, n7}     SCG                                 {n78, n257, n258, n260, n261}requestedCellGrouping    SEQUENCE { 0001111    MCG                                {n3, n7, n78}     SCG                                 {n257, n258, n260, n261}For each reported band combination supporting NR-DC, the UE then indicates which of the requestedCellGroupings that are supported for that BC, as illustrated in Annex A of [R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip). This overhead grows proportional to the number of network supported cell groupings, but not proportional to the number of UE supported bands or band entries. In summary, we think RAN2’s endorsed CR is sufficient for Rel-16/17, above extension solution or other optimization can be considered only if needed in the future.  |
| Qualcomm Incorporated | We support a solution based on PUCCH grouping as recommended by RAN1. |
| Samsung | Alike ZTE, we think the RAN2 endorsed CRs are sufficient, at least for R16. We furthermore think that there is no good solution available for the cases that may need to be supported in future. Hence we think we should only introduce no changes as covered by the RAN2 endorsed CRs and make sure the signalling is extensible in future.We also would like RAN2 to inform RAN4 of the followings via reply LS.1) The endorsed CR by RAN2 already supports FR1-FR2 NR-DC for >5 bands, 2) RAN2 will address intra-band non-contiguous issue in future release, if RAN4 confirms this issue clearly (e.g., based on operator's demand) |
| Intel  | As usual, there is no perfect solution to meet two contradicting conditions i.e. granularity/flexibility and signaling overhead. One thing to note is that we understand that RAN4’s response (more than 5 frequency bands) does not mean that there will be more than 5 frequency bands having both downlink and uplink part. Even in the near future, it is unlikely to support more than 3 uplink frequency band in CA/NR-DC. Based on this observation, we suggest an alternative that LTE cell grouping based signalling is limited to the frequency bands having both DL and UL. For DL only bands, either we allow to include it in any CG or limited to the same carrier type with a CG. |
| OPPO | We think for Rel16 and Rel17 current RAN2 endorsed CR are sufficient. In future when BC with more than 5 bands will be introduced, RAN2 can develop a new solution to address these new band combination i.e. for the BC with less or equal to 5 bands, current solution still works. Some comments on potential alternatives on the table:1, PUCCH group option: RAN4 indicates there are issues with it, we don’t think RAN2 should carry on this way2, network filtering: well, this solution can help reduce reported number of group, but like Mediatek point it out, UE still need report detail grouping information. From signalling point of view solution should get ready for the worst case i.e. without any filtering. So this approach doesn’t resolve the problem as such that it doesn’t remove the limitation.[Ericsson] As we commented above, with network filtering, UE does not need to report detail grouping information. It just needs to indicate which of the network filtered groupings that are supported for each BC, see Annex A in [R2-2101091](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_113-e/Docs//R2-2101091.zip). Prerequisite for this to work is of course that the network provides the filtering information.3, band group approach: it could be one alternative to address BC with more than 5 bands, we are open to discuss it in future but not now. |
| SoftBank | We think NR-DC with more than 5 bands and intra-band non-contiguous NR-DC may be introduced from Rel-16 because it is up to RAN4 decision whether the feature is the release independent or not. So, it is not preferred to have such a limitation for the NR-DC band combinations currently predicted. RAN2 needs to support such NR-DC BCs in UE capability. If it is not introduced now, we think it is important to have extendibility with minimum change.  |
| Huawei, HiSilicon | First of all, according to the RAN4 LS, the cases of indicating more than 5 band or intra-frequency band NR-DC are not specified in Rel-16 and may be specified in future. RAN4 also identified issues with PUCCH grouping alternative. Thus PUCCH grouping like approach cannot address the above concerns without any further extension when such cases are specified in future.In our understanding, for Rel-16 * One possible way is to adopt the CRs of LTE approach, and make corresponding extension in future release when the BCs with more than 5 bands are specified.
* Another way is to support UE capability indications of **MCG(fully in FR1)+SCG(fully in FR2)** and **all options** in Rel-16, while leave the finer-granularity (per-band/others) cell grouping capability in the future release. For example, in Rel-16 for a given FR1+FR2 BC the UE will support MCG (fully on FR1) +SCG (fully on FR2) by default, and can optionally indicate the support of any cell grouping options, while for a given BC including only FR1/FR2 bands, the UE can indicate the support of any cell grouping, otherwise it should not report this BC for NR-DC. In this way there is no band number limitation.
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**Summary 3**: TBD.

**Proposal 3**: TBD.

# 4 Conclusion

TBD.