**3GPP TSG RAN WG2 Meeting #111-e R2-2008422  
E-Conference, 17th – 28th August 2020**

**Agenda item: 6.1.2**

**Source: Qualcomm Incorporated**

**Title: Summary of Offline discussion#021: UE cap NR-DC (Qualcomm)**

**Document for: Discussion and Decision**

1. Introduction

This is a summary of phase2 offline discussion:

* [AT111-e][021][NR16] UE cap NR-DC (Qualcomm)

Scope: Treat R2-2006558, R2-2007946, R2-2007605,

Deadlines: Short UE cap

In Thursday, it was discussed online, and updated scoping as captured in chair notes:

[R2-2008422](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_111-e\Docs\R2-2008422.zip)

P2

- Nokia think we cannot do anything until R4 has decided. Most companies think we follow R15 principle, cannot do anyting anything else until R4 decides differently.

- Huawei think we will anyway refer to R4 BC list, Huawei think we don’t need to do anything now.

- Intel think we can introduce new signalling for cases that cannot be handled by R15, or have completely new signalling. R4 has defined intra-FR1 and Intra-FR2 cases, but R1 and R4 are still discussing.

- Chair wonder if we can just postpone. Ericsson think we need to postpone anyway.

- QC think the main restriction that is needed is to restrict MCG/SCG roles.

- TMO UE think it is important to have all cases for R16, and the signalling should be flexible enough.

- MTK think asynch is ok with the old principle, and asks whether the issue is for synch only, and which exact proposal this relates to.

- Huawei think the UE is required to support sync NR DC without restriction. Ericsson agrees. QC has concerns about this, and it should be possible to do only R15 NR-DC also for R16 UEs.

- Apple think we need to agree something at this meeting and think it is dangerous to imply capability with absence of signalling. Samsung agrees that we should try to converge this meeting.

- Apple want to first make clear what would be the consequences of using the R15 signalling, and we should ask R4 and R1, and explain improvements

- CATT think we need to better understand for synch case and would be ok to send an LS.

- Intel think that we can also discuss, e.g. whether we need cell grouping for intra-FR1 intra FR2 cases.

* Agree by email the async parts (that seems agreeable), continue discussion on synch case, and clarify consequences of the signalling proposals on the table. Can work on a draft LS to R1 R4, will come back on-line next week to finally decide whether to send it.

2. Discussion

During online discussion of phase 1 [8], rapporteur think there is some confusions on whether the proposal is for async NR-DC or sync NR-DC. Thus, rapporteur will emphasize it for each question. Please note its definition in this discussion:

* **Sync NR-DC**: Rel-16 slot synchronous NR-DC where support of SFN misalignment is mandatory
* **Async NR-DC**: Rel-16 non-slot-synchronous NR-DC where support of SFN misalignment is also mandatory

## 2.1 Items for easy agreement

Based on company input, rapporteur believe the following 3 items should be easy agreements:

**Proposal 1: Based on company input, RAN2 agree:**

1. **For *sync NR-DC*, capture “The UE shall not report this UE capability from this release” in field description of *sfn-SyncNRDC***
2. **For sync NR-DC, the Rel-16 UE shall support Rel-15 grouping (i.e. MCG fully in FR1 and SCG fully in FR2), for backward compatibility with Rel-15 network**
3. **For async NR-DC, introduce LTE cell grouping capability signalling as the baseline (Note that enhancement proposed in phase 1 will be discussed in section 2.2).**

**Q1: Do you agree Proposal 1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Qualcomm | Yes | For 3), We are fine with it as baseline. We suggest enhancement in Q2/Q3 to be properly discussion in addition. |
| OPPO | Yes |  |
| Apple | Yes |  |
| vivo | Yes |  |

## 2.2 Items for enhancement of async NR-DC raised in phase-1

For **async NR-DC**, two enhancements for cell grouping signalling were raised in phase 1. However, few companies shared their views. Thus, we need to re-discuss the 2 issues here.

First, two companies (Huawei and Qualcomm) proposed to enhance cell grouping by introducing differentiation of MCG and SCG for cell grouping signalling. The justification is:

* Introduction of FR2 is fundamental difference in NR compared to LTE, and how FR1 bands and FR2 bands are grouped in MCG and SCG will have substantial impact to UE implementation. Some companies thought this over-declaring of UE capability is undesirable. Note that even for NR CA, we introduced a capability (*pCell-FR2*) to indicate whether the UE support PCell operation on FR2.

**Because no specific signalling design is illustrated yet, rapporteur think we can first discuss whether RAN2 can agree the requirement. RAN2 can have further email discussion for specific signalling if the requirement can be agreed.**

**Q2: For async NR-DC, do you agree to enhance cell grouping signalling by introducing differentiation of MCG and SCG for cell grouping signalling?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Qualcomm | Yes | Introduction of FR2 is fundamental difference in NR compared to LTE, and how FR1 bands and FR2 bands are grouped in MCG and SCG will have substantial impact to UE implementation. Furthermore, we think the same consideration should be given to sync NR-DC.  For signalling details, we don’t have strong opinion. Maybe we can further progress in post meeting email discussion with Huawei’s input as baseline. |
| OPPO | Yes |  |
| Apple | Yes |  |
| vivo | Yes |  |

For **async NR-DC**, one companies (Ericsson) proposed to enhance cell grouping by introducing one bit to indicate support of Rel-15 grouping (i.e. MCG fully in FR1 and SCG fully in FR2). The intention is to reduce reporting overhead:

* This additional bit allows to reduce the size of the signalled UE capability for the very common deployment of FR1-FR2 NR-DC. By including the bit, the UE can refrain from including the up to 15-bit long supportedCellGroupingAsyncNRDC-r16 for each band combination, significantly reducing the size of signalled UE capability, as the number of supported band combinations can grow very large even for systems with only a few available bands.
* Some company raised a question whether it is per-UE or per-BC, rapporteur believe the intention is per-BC according to Ericsson’s explanation on its intention (i.e. “By including the bit, the UE can refrain from including the up to 15-bit long supportedCellGroupingAsyncNRDC-r16 for each band combination”)

**Q3: For async NR-DC, do you agree to enhance cell grouping signalling by introducing one bit to indicate support of Rel-15 grouping (i.e. MCG fully in FR1 and SCG fully in FR2) for a given band combination?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Qualcomm | Yes | We don’t have strong opinion, but it is acceptable for us with intention to reduce signaling overhead. |
| OPPO | No | Some RAN4 input is needed since they are still discussing possible combination between FR1 and FR2. |
| Apple | Yes | We are ok with signalling optimization |
| vivo | No | Cell grouping capability bits can be used. |

## 2.3 Items for sync NR-DC cell grouping

As indicated by Qualcomm and Apple in phase 1, the Rel-16 UE may have to over-declare the support of all complex cell grouping before RAN4 finalized the feasible band combination for sync NR-DC. Because there is some confusion on what “over-declaring” is, rapporteur will use a concrete example with 3 bands for illustration of companies concerns.

Let’s say the Rel-16 UE supports NR-DC involving FR1-Band-a, FR1-Band-b and FR2-Band-c, which is a legitimate band combination. The lack of cell grouping UE capability signalling mandates the support for the following {MCG, SCG} combinations.

1) {FR1a+FR1b, FR2c}

2) {FR1a+FR2c, FR1b}

3) {FR1b+FR2c, FR1a}

4) {FR2c, FR1a+FR1b}

5) {FR1b, FR1a+FR2c}

6) {FR1a, FR1b+FR2c}

Case 1) is Rel-15 cell grouping. However, supporting cases 2)-6) will cause the following issues to **both UE and Network**:

**#Issue 1: support of FR1-FR2 CA is a pre-requisite**

Case 2)/3) requires the support of FR1-FR2 CA in MCG, and case 5)/6) requires the support of FR1-FR2 CA in SCG. For both UE and Network side, the support of FR1-FR2 CA is not an easy work.

**#Issue 2: support of PCell in FR2 is a pre-requisite**

Case 4) requires the support of PCell in FR2 because its MCG is fully in FR2. As mentioned before, whether supporting PCell operation on FR2 is already another capability (i.e. *pCell-FR2*). Note that at this stage, rapporteur don’t know whether the enhancement in Q2 can be agreed.

**#Issue 3: support of intra-FR power sharing is a pre-requisite**

For case 2)/3)5)/6), although they are intended as a FR1-FR2 band combination, they have intra-FR serving cells across cell groups. Then, the support of intra-FR power sharing (i.e. *capability intraFR-NR-DC-PwrSharingMode1-r16* or *intraFR-NR-DC-PwrSharingMode2-r16*) is a must. This problem is severer in case if the UE also supports multiple FR2 bands in the band combination. The UE may support power sharing only for FR1 or FR2 and have to limit the cell grouping accordingly.

Meanwhile, RAN1 indicated earlier that the UE capability for power sharing is implicitly indicated by supported cell grouping (RAN1 LS R1-2003072):

|  |
| --- |
| * + RAN2 to discuss whether or not to introduce an optional FG that indicates supported cell-grouping configurations for a BC where the UE supports NR-DC operation     - If the UE reports a cell-grouping configuration in which MCG cell(s) and SCG cell(s) are in the same FR, the UE must support FG18-1 (FG18-1a/1b are optional). |

**#Issue 4: may block deployment of dual CDRX**

If dual CDRX is intended to be deployed for sync NR-DC for power saving, it actually requires UE and Network to support triple CDRX for case 2)/3)/5)/6). If it can’t be supported due to implementation complexity (3-4 parallel CDRX), dual CDRX may have to be dropped for NR-DC.

**Q4: For sync NR-DC, do you agree the 4 issues list above as the consequence of the lack of cell grouping UE capability signalling for a legitimate band combination (FR1-Band-a, FR1-Band-b and FR2-Band-c)?**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company | I1 | I2 | I3 | I4 | Comments (if no, please indicate the reason) |
| Qualcomm | Yes | Yes | Yes | Yes | We do have strong concern that NR-DC may become a paper work as LTE-DC, if we don’t introduce any cell grouping signalling (TBD signalling details):   1. The issue #1/#2#3 imply that the UE can only report its support for a legitimate sync NR-DC band combination (i.e. FR1-Band-a, FR1-Band-b and FR2-Band-c) after the UE supports all features of FR1-FR2 CA, PCell in FR2 and infra-FR power sharing (either FG18-1 or FG18-2). We think it is impossible in early deployment of Rel-16. Then, the UE may have no choice but have to drop the support of the whole feature of sync NR-DC in Rel-16. 2. We don’t think the issues indicated in 1) are only for UE/chipset vendor. We are not sure whether Network vendor can deploy FR1-FR2 CA, PCell in FR2 and infra-FR power sharing because we understand these features have NW impact and are also not easy for Network to deploy in early Rel-16.      1. The issue#4 is just an example to illustrate that some related Rel-16 feature may be impacted by the lack of cell grouping signalling for a FR1-FR2 BC. We believe there should be more examples. |
| OPPO | No | No | No | No | Issue1: not sure why suddenly CA between FR1 and FR2 is difficult. It exists in Rel15 from very beginning  Issue2: in case UE don’t want to support FR2 as PCell, it means UE can already indicated by capability *pCell-FR2.* And at last meeting per UE capability *CarrierAggregationVariant* is introduced to indicate whether FR2 carrier can configured as sPCell for CA between FR1 and FR2. So if UE wants FR1 carrier to be sPCell, it can also do it.  Issue3: that’s the consequence to split FRX carrier between MCG and SCG. If there is no such split, it means FRX can either in MCG or SCG. Since rapporteur has concern on FR2 as pcell, it seems rapporteur think Rel15 capability i.e. FR1 in MCG and FR2 in SCG is sufficient also in Rel16? If it is inevitable, then this should not be a concern.  Issue4: dual DRX is one way to save power. Rel16 has other power saving solution on the table, so we are not sure whether this concern is valid or not.  On the other hand we have sympathy to further discuss this issue and would like to come back after more input from RAN1 and RAN4 comes. |
| Apple | Yes | Yes | Yes | Yes |  |
| vivo | Maybe | Maybe | Maybe | Maybe | Same other capability, lots of capabilities have dependency, we do not sure how serious it is for introduction of sync NR-DC due to the capability dependency. |

During online discussion, more than 1 companies commented that Rel-16 UEs should be allowed to support only Rel-15 cell grouping for sync-DC in early Rel-16 deployment. Otherwise, the Rel-16 UE may have to drop the support of NR-DC before it can support new Rel-16 NR-DC cases 2)-6) (e.g. support of FR1-FR2 CA, and support of PCell in FR2)

**Q5: For sync NR-DC, do you also agree that Rel-16 UEs should be allowed to support only Rel-15 cell grouping (i.e. MCG fully in FR1 and SCG fully in FR2) in early Rel-16 deployment?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (if no, please indicate the reason) |
| Qualcomm | Yes | As indicated in our comment in Q4, it is questioned that NR-DC in all kind of band combination can be supported in early deployment of Rel-16, if we don’t introduce any cell grouping signalling. Then since UE and NW had supported NR-DC where MCG fully in FR1 and SCG fully in FR2, it is important to allow Rel-16 UE to still enjoy the benefit of Rel-15 NR-DC without further UE/NW update grade in early deployment of Rel-16. This is a benefit with almost no cost.  One response for companies’ comment that “RAN#88e agreement removes all restriction on sync NR-DC in Rel-16”. We have different understanding: RAN#88e agreement is just intended to mandate SFN synchronization in NR-DC in Rel-16. We do not think RAN plenary make any conclusion to mandate UE to support all cell groupings with various mixed FR1-FR2 bands.  Note that we think we just need to address this in this meeting because it is related to the existing NR-DC band combination defined by RAN4. We can discuss design of signaling details for new NR-DC band combinations which require the release-16 mechanisms, either in post-meeting email discussion or after getting RAN1/RAN4 response. |
| OPPO |  | Not sure this email is right place to discuss this |
| Apple | Yes |  |
| vivo | Yes | We are ok with this. We think that supporting only Rel-15 cell grouping (i.e. MCG fully in FR1 and SCG fully in FR2) for R16 UE may help NR-DC quick deployment. |

Although there is no consensus on whether to introduce cell grouping for sync NR-DC in phase 1, rapporteur would like to ask the same question after the illustration with the concrete example.

**Q6: For sync NR-DC, do you agree to introduce cell grouping capability signalling similar to async NR-DC? (signalling details can be discussed further in email discussion)**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (if no, please indicate the reason) |
| Qualcomm | Yes | To address the issues in Q4, we think it is simplest way to have cell grouping signalling similar to LTE-DC and async NR-DC (assuming it can be agreed in Q1).  Since enhancements to async NR-DC are being discussed in Q2/Q3, we think maybe signaling details can be discussed in post-meeting email discussion. |
| OPPO |  | Please see comment to Q4 |
| Apple | Yes |  |
| vivo | maybe | We would like to postpone this part until get RAN1/RAN4 feedback. |

In Q2, we discussed whether to introduce differentiation of MCG and SCG for cell grouping for async NR-DC. The rapporteur think the same question exists in sync NR-DC no matter whether LTE cell grouping like signalling will be introduced or not. For instance, the UE wanting to support FR1-MCG + FR2-SCG will also have to support FR2-MCG and FR1-SCG. During phase-1 discussion, some companies thought this over-declaring of UE capability is undesirable.

**Q7: For sync NR-DC, do you agree to introduce differentiation of MCG and SCG for cell grouping? (note that signalling details can be discussed further in email discussion)**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (if no, please indicate the reason) |
| Qualcomm | Yes | Same comment in Q2. We think differentiation of MCG and SCG for cell grouping is the same requirement for async and sync NR-DC because it is mainly related to issue caused by MCG FR2 deployment. |
| OPPO |  | Please see comment to Q4 |
| Intel Yes |  |  |
| vivo | maybe | We would like to postpone this part until get RAN1/RAN4 feedback. |

## 2.4 LS to RAN1 / RAN4

[Rapporteur’s node] During online discussion, multiple companies commented that RAN2 may not do anything until RAN4 provided band combination list. Meanwhile, they also commented that we should ask RAN4 and RAN1 to explain the issue and ask for guidance of capability design.

**Q8: Companies are requested to comment on possible LS to RAN1 / RAN4, e.g. the need of it. What the content should be.**

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | We prefer to conclude in this RAN2 meeting. However, we are also fine to send LS to RAN1 / RAN4 if people can’t achieve consensus on whether cell grouping for sync NR-DC is required.  If it is needed, we prefer to include below contents:   * Confirm the understanding of issue #1-#4 in Q4 * Whether differentiation of MCG and SCG for (sync and async) NR-DC cell grouping signaling is requirement * Any further requirement / restriction on sync NR-DC cell grouping from RAN1 / RAN4 perspectve |
| OPPO | Yes. At least RAN2 need know what typical synchronous band combinations are. And what is their opinion not to support Rel15 signalling etc. |
| Apple | We also prefer to conclude in RAN2 and in the LS explain the RAN2 agreements and the reasoning behind these (potential NBC etc). We are not very keen on asking input in the LS, but rather provide the agreements and request RAN1/4 to take these into consideration. |
| vivo | Confirm the understanding of issue #1-#4 in Q4.  Do capability dependency of issue #1-#4 in Q4 will give high restriction for sync-NR DC deployment? |

# 3. Conclusion

**TBD**

# References

[1] [R2-2006558](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_111-e\Docs\R2-2006558.zip), Introduce capabilities on Async NR-DC and cell-grouping configuration Qualcomm Incorporated discussion Rel-16 LTE\_NR\_DC\_CA\_enh-Core

[2] [R2-2007946](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_111-e\Docs\R2-2007946.zip), Correction on non-SFN-sync NR-DC support Huawei, HiSilicon CR Rel-16 38.306 16.1.0 0398 - F LTE\_NR\_DC\_CA\_enh-Core

[3] [R2-2007605](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_111-e\Docs\R2-2007605.zip) UE capabilities for NR-DC Ericsson discussion

[4] TS 36.306

[5] RAN#88-e, Chair Notes

[6] TS 38.101-3

[7] R2-2004437, Clarification on supported NR-DC cell grouping, Qualcomm Incorporated

[8] R2-2008422, Summary of Offline discussion#021: UE cap NR-DC (Qualcomm), Qualcomm Incorporated

# Appendix A (LTE cell grouping signalling)

The related signalling is captured in TS 36.306 [3] and TS 36.331 [4]. It includes two UE capabilities *asynchronous-r12* and *supportedCellGrouping-r12* per band combination.

#### Copy from TS 36.306

##### 4.3.5.9.1 *asynchronous-r12*

In addition to the UE capability indicated by *dc-Support*, this field defines whether asynchronous DC and power control mode 2 is supported by the UE which is capable of *simultaneousRx-Tx*. If the band combination is comprised of a single band entry for more than two carriers, the UE shall support any permutations of carriers to CGs. If the concerning band combination is comprised of more than two band entries, the carriers corresponding to a band entry shall belong to one cell group. For this band combination, the UE may indicate the supported carrier permutations to CGs.

##### 4.3.5.9.2 *supportedCellGrouping-r12*

In addition to the UE capability indicated by *asynchronous*, this field defines for which mapping of serving cells to cell groups (i.e. MCG or SCG) the UE supports asynchronous DC.

Copy from TS 36.331

BandCombinationParameters-v1250::= SEQUENCE {

dc-Support-r12 SEQUENCE {

asynchronous-r12 ENUMERATED {supported} OPTIONAL,

supportedCellGrouping-r12 CHOICE {

threeEntries-r12 BIT STRING (SIZE(3)),

fourEntries-r12 BIT STRING (SIZE(7)),

fiveEntries-r12 BIT STRING (SIZE(15))

} OPTIONAL

} OPTIONAL,

supportedNAICS-2CRS-AP-r12 BIT STRING (SIZE (1..maxNAICS-Entries-r12)) OPTIONAL,

commSupportedBandsPerBC-r12 BIT STRING (SIZE (1.. maxBands)) OPTIONAL,

...

}

Note that the capability *supportedCellGrouping-r12* provides a mapping from bands to (one or more than one feasible) cell grouping configuration, as indicated in Note5 under *UE-EUTRA-Capability* in 36.331:

===================Extract from TS 36.331================

NOTE 5: The grouping of the cells to the first and second cell group, as indicated by *supportedCellGrouping*, is shown in the table below. The leading / leftmost bit of *supportedCellGrouping* corresponds to the Bit String Position 1.

|  |  |  |  |
| --- | --- | --- | --- |
| Nr of Band Entries: | 5 | 4 | 3 |
| Length of Bit-String: | 15 | 7 | 3 |
| Bit String Position | Cell grouping option (0= first cell group, 1= second cell group) | | |
| 1 | 00001 | 0001 | 001 |
| 2 | 00010 | 0010 | 010 |
| 3 | 00011 | 0011 | 011 |
| 4 | 00100 | 0100 |  |
| 5 | 00101 | 0101 |  |
| 6 | 00110 | 0110 |  |
| 7 | 00111 | 0111 |  |
| 8 | 01000 |  |  |
| 9 | 01001 |  |  |
| 10 | 01010 |  |  |
| 11 | 01011 |  |  |
| 12 | 01100 |  |  |
| 13 | 01101 |  |  |
| 14 | 01110 |  |  |
| 15 | 01111 |  |  |

=========================================================

The table seems to be complex. We take a simple example for illustration: Assume that the given band combination includes 4 bands (e.g. band A, B, C, D) the UE supports simultaneously. Then if the UE reports ‘0001’ and ‘0110’, it means the UE supports two Async cell grouping: 1) band ABC in first cell group and band D in secondary cell group; 2) band AD in first cell group and band BC in secondary cell group.

# Appendix B (Status of RAN1/RAN2 interaction)

In RAN1 LS on Rel-16 RAN1 UE features lists, RAN1 has requested RAN2 to introduce similar signalling to LTE, as illustrated in their agreement:

|  |
| --- |
| * RAN1 lists NR-DC power-sharing features as FG18-1/1a/1b. Apart from them, RAN1 see the need of following:   + RAN2 to introduce an FG that indicates support of asynchronous operation     - RAN1 will discuss whether this FG is mandatory or optional   + RAN2 to discuss whether or not to introduce an optional FG that indicates supported cell-grouping configurations for a BC where the UE supports NR-DC operation     - If the UE reports a cell-grouping configuration in which MCG cell(s) and SCG cell(s) are in the same FR, the UE must support FG18-1 (FG18-1a/1b are optional). * The capability signalling structure is up to RAN2. * The requirements for sync-DC and async-DC are up to RAN4. |

In RAN2#110-e, RAN2 agreed to use LTE style cell grouping capability signalling with restriction to 5 bands, which was included in reply LS to RAN1:

*Omit part*

1. **NR-DC cell grouping capability4:**

RAN2 has agreed to design the NR-DC cell grouping capability for the UE using the LTE style of capability signaling. RAN2 intends to restrict the NR-DC cell grouping signaling to NR DC combinations with up to 5 bands and for NR DC combinations with more than 5 bands in the combination, the UE cannot signal NR-DC cell grouping. The motivation for the above is that in LTE, there were no DC combinations defined with more than 5 bands, and RAN2 views the same with NR.

*Omit part*

By the end of RAN2#110-e, RAN1 response that “There is no additional suggestion from RAN1 for now.” in R1-2005096.

*Omit part*

|  |
| --- |
| **4.1 Further restrictions that are applicable to NR -DC combinations**  RAN2 would like to request RAN1 and RAN4 if they see any additional restrictions in the definition of NR-DC combinations that can help reduce the NR-DC cell grouping capability reporting at the UE. |

**RAN1 view:** There is no additional suggestion from RAN1 for now.

*Omit part*