**3GPP TSG RAN WG2 Meeting #111-e R2-200xxxx
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 below offline discussion:

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

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

 Deadlines: Short UE cap

where the related CRs are list below:

[R2-2006558](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2006558.zip) Introduce capabilities on Async NR-DC and cell-grouping configuration Qualcomm Incorporated discussion Rel-16 LTE\_NR\_DC\_CA\_enh-Core

[R2-2007946](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2007946.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

Moved from 6.8.4

[R2-2007605](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2007605.zip) UE capabilities for NR-DC Ericsson discussion

2. Discussion

## 2.1 *sfn-SyncNRDC* support for Rel-16 UE

The capability *sfn-SyncNRDC* was introduced in Rel-15, and further discussed in RAN#88-e [5] for Rel-16 UE:

* For NR Rel-15, sync NR-DC was introduced to leverage CA implementation. The capability *sfn-SyncNRDC* can indicate whether the UE only supports **slot-aligned and frame-aligned NR-DC** with restriction that MCG is FR1 and SCG is in FR2 [4][7];

| **Definitions for parameters** | **Per** | **M** | **FDD-TDD****DIFF** | **FR1-FR2****DIFF** |
| --- | --- | --- | --- | --- |
| ***sfn-SyncNRDC***Indicates the UE supports NR-DC only with SFN and frame synchronization between PCell and PSCell. If not included by the UE supporting NR-DC, the UE supports NR-DC with slot-level synchronization without condition on SFN and frame synchronization. \*Note that in [7], it was clarified: “In this version of the standard, a UE indicating support for NR-DC supports only configuration where all serving cells of the MCG are in FR1 and all serving cells of the SCG are in FR2.” | UE | No | No | No |

* For NR Rel-16, RAN#88-e [5] endorsed the below proposal in RP-201284. It means Rel-16 UE mandatory supports **Rel-16 slot sync NR-DC (i.e. slot-aligned and non-frame-aligned NR-DC).**

**Updated proposal 2 for non-SFN-sync NR-DC support:**

**All Rel-16 UEs shall not be allowed to report *sfn-SyncNRDC*.**

**RAN WGs are tasked to prepare CRs addressing this issue in RAN#89-e.**

In contributions R2-2006558 [1] / R2-2007946 [2], it is proposed to capture the above highlighted conclusion in Rel-16 TS 38.306, e.g. capture “The UE shall not report this UE capability from this release” in field description of *sfn-SyncNRDC* in R2-2006558. Rapporteur think there is only small text difference between the two contributions, and thereby proposed to agree CR based on wording from R2-2006558.

**Q1: Do you agree to capture “The UE shall not report this UE capability from this release” in field description of *sfn-SyncNRDC*?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

## 2.2 Band combination for Rel-16 NR-DC

In Rel-15 NR-DC, it was clarified that only MCG fully in FR1 and SCG fully in FR2 is supported in the exception sheet of NR\_newRAT-Core WI, as approved in RP-181473:

For SA (Option 2) only:

* NR-NR Dual connectivity aspects
* synchronous mode from physical layer aspects;
* Band combination(s) for FR1 + FR2;
* MCG fully in FR1 and SCG fully in FR2
* Common radio protocols and network interfaces applicable to both synchronous and asynchronous mode of operations.

However, in Rel-16, it is possible to support infra-FR NR-DC (in FR1 or FR2) and mixed FR1+FR2 NR-DC. In R2-2007605 [3], it lists the below possible cases:

|  |
| --- |
| 1) intra-FR NR-DC;2) NR-DC with MCG in FR1+FR2 and SCG in FR1+FR2;2.1) NR-DC with MCG in FR1 and SCG in FR2;2.2) NR-DC with MCG in FR1 and SCG in FR1+FR2;2.3) NR-DC with MCG in FR1+FR2 and SCG in FR2;2.4) NR-DC with MCG in FR1+FR2 and SCG in FR1;2.5) NR-DC with MCG in FR2 and SCG in FR1+FR2;2.6) NR-DC with MCG in FR2 and SCG in FR1; |

**Table.1 Possible band combination of NR-DC in Rel-16**

Note that although original band combination possibilities in R2-2007605 is just for Async NR-DC, rapporteur think it is necessary to discuss whether they are feasible for Rel-16 slot synchronous NR-DC, e.g. maybe 2.6) (i.e. MCG in FR2 and SCG in FR1) is also questioned for Rel-16 slot synchronous NR-DC.

**Q2: Do you think which band combinations in Table 1 are feasible for Rel-16 slot synchronous NR-DC?**

|  |  |  |
| --- | --- | --- |
| Company | Support list | Comments |
|  |  |  |
|  |  |  |

**Q3: Do you think which band combinations in Table 1 are feasible for Rel-16 asynchronous NR-DC (i.e. non-slot-aligned NR-DC)?**

|  |  |  |
| --- | --- | --- |
| Company | Support list | Comments |
|  |  |  |
|  |  |  |

## 2.3 Async NR-DC indication and cell grouping

LTE supported below async LTE-DC capability and cell grouping, i.e. it includes two UE *capabilities asynchronous-r12 and supportedCellGrouping-r12* per band combination (detailed signalling can be found in Appendix A):

#### 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,

 ...

}

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |  |  |

**Table 2: cell group configuration in LTE-DC**

As indicated in R2-2006558[1] / R2-2007605[3], RAN1 has requested RAN2 to introduce similar signalling on asynchronous NR-DC and supported cell-grouping configurations. RAN2 has agreed to use LTE style cell grouping capability signalling with restriction to 5 bands, and RAN1 provided their response that “There is no additional suggestion from RAN1 for now.” in R1-2005096 (detailed status can be found in Appendix B).

Thus, in R2-2006558 [1] and R2-2007605 [2], it is proposed to introduce similar signalling on asynchronous NR-DC and supported cell-grouping configurations for Rel-16 Async NR-DC. In rapporteur understanding, this is per RAN1 request, and RAN2 has discussed this topic in last RAN2 meeting. Thus, it is proposed to agree the same signalling as LTE, to make progress.

**Q4: Per RAN1 request, do you agree to introduce async LTE-DC similar signalling for NR, i.e. *asyncNRDC-r16* and *supportedCellGroupingAsyncNRDC-r16* to indicate the support of asynchronous NR-DC, where:**

* ***asyncNRDC-r16* is ENUMERATED {supported}, same as LTE**
* ***supportedCellGroupingAsyncNRDC-r16* reuse the mapping table of LTE with up to 5 bands from ASN.1 perspective, as illustrated in table 2.**
* **If *asyncNRDC-r16* is present but *supportedCellGroupingAsyncNRDC-r16* is absent, the UE supports all possible mappings of serving cells to cell groups for the band combination**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

In R2-2007605, it is further proposed that the UE can additionally include one bit to indicate support of asynchronous NR-DC with MCG in FR1 and SCG in FR2.

**Q5: If you agree “Yes” for Q4, do you also agree that: if the bit to indicate support of asynchronous NR-DC is included, the UE can additionally include one bit to indicate support of asynchronous NR-DC with MCG fully in FR1 and SCG fully in FR2, i.e. 2.1) in table 1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

## 2.4 Cell grouping for Rel-16 sync NR-DC

In R2-2006558 [1], it is proposed to further introduce supported cell-grouping configurations for a band combination of Rel-16 slot sync NR-DC. It is different from LTE capability signalling. As indicated in R2-2006558 [1], the intention is to provide a better way to accommodate a trade-off between NW and UE complexities. And some examples of benefit are list below:

1. Cell Grouping signalling can indicate the grouping where the UE can support non-frame-aligned sync-DC
* Different from CA, Rel-16 sync NR-DC is non-frame-aligned. So, the UE implementation may have restrictions as to how the serving cells can be grouped to have different SFN timing, e.g. band A and band B can have different SFN timing, but band C needs to have the same SFN timing as band A.
1. Cell Grouping signalling can indicate bands that can share the same Timing Advance (TAG)
* For example, if the UE indicates that it supports only the same TAG across two bands, it should not be required to support Rel-16 sync-DC with these two bands being in different cell groups.
1. Reduce IoT efforts, i.e. there are some grouping cases in which sync-DC is very unlikely, so the UE should not be required to be tested for DC functionality.
* An example is intra-band contiguous CA. There should be no sync-DC case where two CCs in a band are in different cell groups
1. It is questioned whether Rel-16 UE needs to support NR-DC with some mixed FR1 and FR2 band combinations (e.g. FR2 fully in MCG and FR1 fully in SCG)

**Q6: Do you agree the benefits indicated in R2-2006558 to introduce cell-grouping configurations for a band combination of Rel-16 slot synchronous NR-DC?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

If you agree to introduce the signalling, then in R2-2006558 [1], it is proposed to reuse the same mapping table for async NR-DC.

**Q7: If you agree Q6, do you also agree the signalling introduced in R2-2006558, i.e. introduce *supportedCellGroupingSyncNRDC-r16* with the same mapping table of *supportedCellGroupingAsyncNRDC-r16*?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

In R2-2006558 [1], it is further discussed how to understand the case that the UE doesn’t report asyncNRDC-r16. It is proposed: if a Rel-16 UE doesn’t report asyncNRDC-r16, it means the UE supports only Rel-16 slot sync NR-DC. And the UE can further report its supported cell grouping.

**Q8: If you agree Q7, do you also agree the proposal in R2-2006558:**

* **if a Rel-16 UE doesn’t report *asyncNRDC-r16*, the UE supports only Rel-16 slot sync NR-DC, and the UE can further report its supported cell grouping?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

In R2-2006558 [1], it is further discussed how to address legacy issue if the UE doesn’t report any supported cell grouping for a band combination of Rel-16 sync NR-DC for the below 2 cases:

* Case 1: for a band combination with intra-FR bands (i.e. FR1 only or FR2 only)
	+ Case 1 is not possible for Rel-15 UE, and thereby there is no legacy issue. Then it is straight forward to follow similar signaling in LTE cell grouping to reduce reporting overhead (i.e. signaling absence means supporting all cell grouping).
* Case 2: for a band combination with both FR1 and FR2 bands
	+ It has legacy issue: a Rel-15 UE may report a NR-DC band combination with FR1 and FR2 to a Rel-16 gNB. In this case, it is important for Rel-16 gNB to only configure Rel-15 NR-DC (i.e. slot synchronous FR1+FR2 NR-DC) to this Rel-15 UE. Otherwise, it is possible from signaling perspective that Rel-16 gNB may configure a NR-DC with MCG@FR2 and SCG@FR1 which Rel-15 UE can’t support. Note that this is an important issue which needs spec change even if cell grouping signaling is not agreed

**Q8: If you agree Q7, do you agree the proposal in R2-2006558:**

**when a Rel-16 UE doesn’t report *supportedCellGroupingSyncNRDC-r16*:**

1. **If the band combination includes intra-FR bands (either FR1 only or FR2 only), the UE supports any cell-grouping configurations in the band combination.**
2. **If the band combination includes both FR1 and FR2 bands, the UE supports only slot synchronous NR-DC configuration where all serving cells of the MCG are in FR1 and all serving cells of the SCG are in FR2.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

In R2-2006558, it is further discussed one more legacy issue: if the Rel-16 UE reports slot sync DC cell grouping for a band combination with FR1 and FR2 bands, it shall include the support of FR1+FR2 slot synchronous NR-DC in the cell grouping signalling, to provide compatibility with Rel-15 NR-DC.

Let us take an example for illustration of this proposal: if a Rel-16 UE reports a band combination with 3 bands where band A/B in FR1 and band C in FR2:

* Case 1: the Rel-16 UE only supports slot-synchronous FR1+FR2 NR-DC
	+ The UE will not report any supported cell grouping, following Proposal 8 of R2-2006558.
* Case 2: besides slot-synchronous FR1+FR2 NR-DC, the Rel-16 UE also supports other cell groupings (the case for this proposal):
	+ This Rel-16 UE needs to at least report its supporting on ‘001’ (i.e. band A/B in first cell group and band C in secondary cell group). This is because if the supported cell grouping is reported to a Rel-15 gNB, the Rel-15 gNB will ignore the cell grouping signaling because it can’t understand that. However, Rel-15 gNB should be still allowed to configure slot-synchronous FR1+FR2 NR-DC to this UE, following RAN plenary conclusion.

**Q9: If you agree Q7, do you agree the below proposal in R2-2006558:**

* **If the Rel-16 UE reports slot sync DC cell grouping for a band combination with both FR1 and FR2 bands, it shall include the support of FR1+FR2 slot synchronous NR-DC in the cell grouping signalling?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

Finally, in R2-2006558, it has below proposal for a small issue:

Proposal 6: For either *supportedCellGroupingAsyncNRDC-r16* or *supportedCellGroupingSyncNRDC-r16,* if the UE reports one supported cell-grouping configuration in which MCG and SCG are in the same FR, the UE shall support NR-DC power sharing FG18-1.

**Q10: If you agree Q7, do you agree the below proposal in R2-2006558:**

* **For either *supportedCellGroupingAsyncNRDC-r16* or *supportedCellGroupingSyncNRDC-r16,* if the UE reports one supported cell-grouping configuration in which MCG and SCG are in the same FR, the UE shall support NR-DC power sharing FG18-1**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |
|  |  |  |

# 3. Conclusion

Will provide based on companies’ inputs.

# References

[1] [R2-2006558](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2006558.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%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2007946.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%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_111-e%5CDocs%5CR2-2007605.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

# 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*