**3GPP TSG-RAN WG2 Meeting #121bis-e R2-23xxxx**

**e-meeting, April 17- 26, 2023**

**Source: Qualcomm Incorporated**

**Title: [Draft] Summary of email discussion [Post121][043][NR17] Intraband ENDC UE cap (QC)**

**Document for: Decision**

**Agenda Item: x.x**

# Introduction

This document provides a summary for the following email discussion.

* [Post121][043][NR17] Intraband ENDC UE cap (QC)

Scope: Starting point R2-121 agreement discussion R2-2300142. Take into account BW and FW compatibility, can consider R4 discussion aspect if needed. Discuss, allow review/check, Conclude agreeable solution and LS out, alt identify points for discussion / decision.

Intended outcome: Report, draft LS out (to R4)

Deadline: Long

Companies are invited to provide their contact information for this email discussion.

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| --- | --- | --- |
| **Company** | **Delegate name** | **Email address** |
| OPPO | Qianxi Lu | qianxi.lu@oppo.com |
| Huawei, HiSilicon | Tong Sha | shatong3@hisilicon.com |
| MediaTek | Mutai Lin | morton.lin@mediatek.com |
| CATT | Jie Shi | Shijie@catt.cn |
| Nokia | Shehzad Ali Ashraf | shehzad.ashraf@nokia.com |

# Discussion

This email discussion builds on top of the RAN2#121 discussion and agreement below.

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| [R2-2300142](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121/Docs/R2-2300142.zip) Discussion on UE capability ‘intraBandENDC-Support’ Qualcomm Incorporated discussion Rel-17 TEI17  [R2-2301611](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121/Docs/R2-2301611.zip) Discussion on intra-band EN-DC combination Huawei, HiSilicon discussion TEI17   * Both noted   DISCUSSION  - TMO support a new cap IE  - Apple think R4 has defined both for the current signalling. Think we can just follow the LS.  - MTK agree with P1, think that R4 proposal can be considered on top of current. Has concerns with new separation  - ZTE prefers proposal from QC to redefine current for DL and new for UL, think the new cap can be only  - Nokia think that introducing a new cap would make it easier. Wonder if we could avoid to support the mixed case. QC think it doesn’t exist.  - QC think that R4 solution is not forward compatible,  - Apple think R4 has analyzed and made the best solution. Nokia disagrees, think R4 didn’t have a good discussion on UE cap.  - MTK think that also FW compatibility is considered by RAN4.  - TMO think a non-backward change is risku but also think R4 are not the experts on UE cap signalling.  - ZTE think that with Huawei proposal we need two new capabilities.   * We introduce a new capability for UL *intraBandENDC-Support-UL,* and restrict the existing capability to DL. |

* 1. Definitions

In this document, we use the following definitions.

**Contiguous intra-band EN-DC**

* + Intra-band EN-DC band combination where one LTE band entry and one NR band entry within the EN-DC band combination are contiguous.
  + Some examples below. The UE uses the number of band entries and bandwidth class signalling to differentiate those cases.
    - DC\_48A\_(n)48AA
    - DC\_(n)48AA
    - DC\_(n)48AC\_n48A

**Non-contiguous intra-band EN-DC**

* + Intra-band EN-DC band combination where there is no pair of LTE band entry and NR band entry that is contiguous.

**NOTE:** Moderator ruled out the concept of “mixed” case as discussed in [2] based on offline comments from multiple companies.

* 1. New signalling solution

With the addition of new UE capability parameter for UL, say *intraBandENDC-Support****-UL***, the following combinations of UE capabilities can be indicated.

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| *intraBandENDC-Support* (for DL) | *intraBandENDC-Support****-UL*** (for UL, new) | UE supports in DL/UL |
| Absent (Contiguous) | Contiguous | * Contiguous/Contiguous |
| Absent (Contiguous) | Non-contiguous | * Contiguous/Non-contiguous |
| Non-contiguous | Contiguous | * Non-contiguous/Contiguous |
| Non-contiguous | Non-contiguous | * Non-contiguous/Non-contiguous |
| Both | Contiguous | * Contiguous/Contiguous * Non-contiguous/Contiguous |
| Both | Non-contiguous | * Contiguous/Non-contiguous * Non-contiguous/Non-contiguous |
| Absent (Contiguous) | Both | * Contiguous/Contiguous * Contiguous/Non-contiguous |
| Non-contiguous | Both | * Non-contiguous/Contiguous * Non-contiguous/Non-contiguous |
| Both | Both | *Further discussed below* |

RAN2 can discuss whether there is any missing case or whether there is any invalid combination, e.g. DL: Non-contiguous / UL: Contiguous, which can result in UL carrier without paired DL. One could have preference to keep the UE capability signalling generic to cover any potential cases.

**Q1:** Any invalid or missing case in the tables above?

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| **Company** | **Any invalid or missing case? (Yes/No)** | **Comments / Additional explanation** |
| OPPO | See comment | In our understanding, since the old field is for DL only, it means absence of the new field (as in legacy) = no restriction on UL, which can be interpreted for some BC:s as ‘both’, e.g., case-4 in R2-2300060 – as clarified in R2-2300141    Figure 2 Possible configuration of DC\_48A\_(n)48AA+DC\_(n)48AA,DC\_48A\_n48A  So we wonder whether the final 3 rows of the table above are really needed.  Besides, we wonder if the combo of “DL = Non-contiguous, UL=Contiguous’ really exists? And due to the same reason, whether it is unnecessary to have ‘DL=both, UL=contiguous’ given ‘DL = contiguous, UL=contiguous’ is already there.  [Rap] Please see intermediate summary. |
| Huawei, HiSilicon | See comments | We understand the following cases are not valid:  1) DL: Non-contiguous / UL: Contiguous;  2) DL: Both / UL: Contiguous;  3) DL: Non-contiguous / UL: Both.  As mentioned by rapp, there will be a UL carrier without a paired DL carrier in these cases.  As for the legacy field, we have different understanding from OPPO. We think the legacy field indicates the same contiguity capability for both DL and UL if the new capability is not included. When the UE has a different UL capability from DL, the new capability will be included. That’s why the current signalling cannot support the case3 and case4, and new capability signalling is needed, as what we agreed in RAN2#119bis.   * RAN2 concludes that the discussed cases are not currently supported by signalling and new signalling is needed.   We understand there will be NBC issue if there is no restriction on UL for legacy field. To keep backward compatibility, we suggest to clarify the legacy field indicates the same contiguity for both DL and UL when the new capability is not included. If the new capability is included, the upgraded NW can know additional UL capability through the new field.  [Rap] Please see intermediate summary. |
| ZTE | Agree with all of above cases | We agree with all of the above cases.  For the 3 cases as below:  1) DL: Non-contiguous / UL: Contiguous;  2) DL: Both / UL: Contiguous;  3) DL: Non-contiguous / UL: Both.  We think they shall also be supported for the forward compatibility.  [Rap] Please see intermediate summary. The solution can be made simple only if we make the assumption that the support for non-contiguous in DL and contiguous in UL is not a valid case. |
| MediaTek | See comments | We understand that the UL part is now either a fallback or a lower order BC (with asymmetric spectrum continuity) of the DL part after Case 3 & 4 are introduced by RAN4. So we agree with Huawei’s comments for the invalid cases.  [Rap] Please see intermediate summary. |
| CATT | - | See our comment to Q5. |
| Nokia | See comments | We agree with Huawei on the list of invalid cases. However, at the same time, we wonder, why do we need to discuss which are valid and which are non-valid cases. In RAN2, we should define a new UE capability parameter for UL, intraBandENDC-Support-UL, with 2 possible field values (continuous, both) similar to existing intraBandENDC-Support which is repurposed for DL only.  Now for invalid cases, UE would not chose the corresponding combination for intraBandENDC-Support-DL and intraBandENDC-Support-UL.  We also agree with the proposal from Huawei to clarify on the meaning on legacy field. |
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When the UE indicates “both” for DL and UL, the following 4 cases are applicable. [2] discussed whether the UE may support only a subset of the cases; e.g. supports case 1 and case 2, but not others.

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| **Case1** | Contiguous/Contiguous |
| **Case2** | Non-contiguous/Non-contiguous |
| **Case3** | Contiguous/Non-contiguous |
| **Case4** | Non-contiguous/Contiguous |

**Q2:** Can the UE support only a subset of the cases; e.g. supports case 1 and case 2, but not others.

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| **Company** | **Yes/No** | **Comments / Additional explanation** |
| OPPO | See comment | Firstly, if DL = non-contiguous, we wonder if case-4 really exist?  Secondly, if DL = contiguous, considering the case-3 in R2-2300060 is for the case where UE support UL = non-contiguous but not UL = contiguous (since otherwise, if UE will always support both, there is no need to introduce a UL-specific field), it seems reasonable to assume a UE supporting case-3 but not supporting case-1.  Then in case we understand there exists UE support case-3 but not case-1, just wonder how to solve the NBC issue, since legacy NW would not see the new UL field, may assume the UE supporting both case-1 and 3.  [Rap] Please see intermediate summary. |
| Huawei, HiSilicon | See comments | The UE can support only case 1 and/or case 2, but not others (i.e. case3). By only including the legacy field, the same contiguity capability between DL and UL can be signalled as a subset capability. For example, if the UE supports case 1 and case 2, but not case3, the UE can set the legacy field to ‘both’ without the new capability included. If the UE supports case1, case2 and case3, the new capability can be set to ‘both’ additionally.  Besides, the UE may support case3 but not case1. To keep backward compatible, we understand the NW supporting corresponding EN-DC combination (e.g. band 48) can upgrade to identify the new capability. The new capability should be early implemented from Rel-15.  [Rap] Please see intermediate summary. |
| ZTE | See comments | We agree that “When the UE indicates “both” for DL and UL, the 4 cases (as listed by Rapp) are applicable.  We also agree with Huawei that if the UE only support case 1 and case 2, the UE can report “both” for the DL and absent for the UL.  [Rap] Please see intermediate summary. |
| MediaTek | See comments | All legacy UEs supporting intra-band ENDC BC of CBRS spectrum could be the case (i.e., supporting only Case1 and Case2 in the table.)  However, we think the way how the UE uses the codepoint ‘both’ shall remain unchanged even the new signalling is introduced for UL part. So the UE indicates ‘both’ for DL and UL ONLY WHEN it supports all possible combination permutations, to save capability signalling.  [Rap] Please see intermediate summary. |
| CATT | Yes | See our comment for Q5, we think the invalidity of case4 non-contiguous/Contiguous(DL/UL) needs to be confirmed by RAN4. |
| Nokia | See comment | As mentioned above, case 4 is invalid case.  Theoretically, a UE can support any combination of case1, case2, and case3.   1. UE support case 1 and case 2, but not case 3 🡪 This should be indicated by both/both. 2. UE support case 1 and case 3, but not case 2 🡪 This is already covered by Absent (contiguous)/both in Q1. 3. UE support case 2 and case 3, but not case 1 🡪 This is already covered by both/non-contiguous in Q1. |
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[2] concluded that it is indeed a possible UE implementation to support only a subset of the cases. One may argue that different cases can be signalled by different EN-DC band combination entries. However, RAN2 has been trying to avoid cases where duplicated band combination signalling is needed.

[2] further proposed to introduce a UE capability parameter of bitmap format to indicate the support for those 4 cases individually. The use of the bitmap parameter by the UE should be limited to the case where the UE indicates “both” for DL and UL.

**Q3:** Do companies agree to introduce a UE capability parameter of bitmap format to indicate the support for those 4 cases individually?

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| **Company** | **Yes/No** | **Comments / Alternative solutions** |
| OPPO | No | In practice, we understand typically either DL = contiguous or DL = non-contiguous for a BC, so not see it as a critical issue to optimize signaling overhead.  [Rap] Please see intermediate summary. |
| Huawei, HiSilicon | No | We don’t see the necessity to introduce other capability since the subset cases can be indicated clearly by the legacy field and the agreed new field for UL.  [Rap] Please see intermediate summary. |
| ZTE | No | Share the same view as Huawei  [Rap] Please see intermediate summary. |
| MediaTek | No | We share the same view as Huawei.  [Rap] Please see intermediate summary. |
| CATT | No strong view. | This bit map way seems flexible and reduce the complexity to describe all case or their combination clearly in the new UE capability filed, but may consume more bits. See our further comment for Q5. |
| Nokia | No | We don’t see the need of it as explained as an answer to Q2. |
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* 1. Other discussion points

**Q4:** Companies are invited to raise other discussion points.

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| **Company** | **Comments** |
| MediaTek | [We understand the legacy field indicates the same capability for both DL and UL.]  We would like to confirm if Contiguous/Contiguous shall be deemed supported in the following capability advertisement, and corresponding UE behaviour:   |  |  |  | | --- | --- | --- | | Both | Non-contiguous | * Contiguous/Non-contiguous * Non-contiguous/Non-contiguous |   The answer shall be Yes in the legacy network but clearly contradictory to the literal signalling itself in the new network. Same concern for other cases such as:   |  |  |  | | --- | --- | --- | | Absent (Contiguous) | Non-contiguous | * Contiguous/Non-contiguous |   It seems that the UE is required to advertise additional Contiguous/Contiguous ENDC BC while reporting above cases in the new network. Is that the intent of this solution?  [Rap] Please see intermediate summary. |
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* 1. Intermediate summary

From the company comments captured in the previous sections, moderator observed that despite the RAN2#121 agreement to go with in [2], a different proposal in [3] is getting more momentum.

The key principles of solution in [3] can be summarized as follows.

1. The new UE capability parameter *intraBandENDC-Support****-UL*** is only signalled when UL capability is different from the one indicated by the existing parameter *intraBandENDC-Support*.
2. If the new parameter *intraBandENDC-Support****-UL***is not signalled. the existing UE capability parameter *intraBandENDC-Suppor* indicates:

either

* + - the UE capability for DL-only (when the UE supports intra-band EN-DC only in DL)

or

* + - the same capability for DL and UL (when the UE supports intra-band EN-DC in DL and UL)

1. Support for non-contiguous in DL and contiguous in UL is not a valid case.

Then different cases can be summarized as follows.

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| **Cases** | ***intraBandENDC-Support*** | ***intraBandENDC-Support-UL***  **(for UL, new)** | **UE supports in DL / UL (if applicable)** |
| 1 | Absent (Contiguous) | Absent | * Contiguous/Contiguous |
| 2 | Absent (Contiguous) | Non-contiguous | * Contiguous/Non-contiguous |
| 3 | Non-contiguous | Absent | * Non-contiguous/Non-contiguous |
| 4 | Non-contiguous | Contiguous | * N/A   NOTE:  “Non-contiguous/Contiguous” is not valid. |
| 5 | Both | Absent | * Contiguous/contiguous * Non-contiguous/Non-contiguous |
| 6 | Both | Contiguous | * N/A   NOTE:  “Contiguous/Contiguous” is covered by case 1.  “Non-contiguous/Contiguous” is not valid. |
| 7 | Both | Non-contiguous | * Contiguous/Non-contiguous * Non-contiguous/Non-contiguous |
| 8 | Absent (Contiguous) | Both | * Contiguous/Contiguous * Contiguous/Non-contiguous |
| 9 | Non-contiguous | Both | * N/A   NOTE:  “Non-contiguous/Non-contiguous” is covered by case 3.  “Non-contiguous/Contiguous” is not valid. |
| 10 | Both | Both | * Contiguous/Contiguous * Non-contiguous/Non-contiguous * Contiguous/Non-contiguous |

**Q5:** Companies are invited to provide comments on the solution above.

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| **Company** | **Comments** |
| OPPO | For bullet-1: ‘1. The new UE capability parameter intraBandENDC-Support-UL is only signalled **when UL capability is different from the one indicated by the existing parameter intraBandENDC-Support**.’: Although we understand that the legacy field only restricts DL, yet if we conclude in a way that it restricts both DL and UL, i.e., a subset of it, it seems still compatible. From this perspective, we are fine for this way-forward.  For bullet-2: ‘2. If the new parameter intraBandENDC-Support-UL is not signalled. the existing UE capability parameter intraBandENDC-Suppor indicates: either - **the UE capability for DL-only (when the UE supports intra-band EN-DC only in DL)**; or - the same capability for DL and UL (when the UE supports intra-band EN-DC in DL and UL)’, just confirm the meaning of ‘**when the UE supports intra-band EN-DC only in DL**’ for crystal clear, does it mean  1/ the UE only have DL in the intra-band part of EN-DC, but no UL, so no need to care about UL at all  2/ the UE have both DL and UL in the intra-band part of EN-DC, but the parameter only restrict UL  We assume it meant interpretation-1, since otherwise (interpretation-2) it collides with bullet-1?  A further Q is for the two combinations below   |  |  |  |  | | --- | --- | --- | --- | | 2 | Absent (Contiguous) | Non-contiguous | * Contiguous/Non-contiguous | | 7 | Both | Non-contiguous | * Contiguous/Non-contiguous * Non-contiguous/Non-contiguous |   Assuming the UE supporting Contiguous/Non-contiguous will typically also support contiguous/contiguous, same Q as MTK, i.e., whether the UE will need to additionally report an entry for the contiguous/contiguous case? So that enhanced network does not miss any UE capability?  [OPPO2] Thanks for the help by HW comment below! Indeed case8/10 helps if ‘the UE supporting Contiguous/Non-contiguous will typically also support contiguous/contiguous’ yet that on the other hand means case-2/7 are not needed? => **Just would like to know the view by others on whether there is a case that UE support Contiguous/Non-contiguous but not contiguous/contiguous**, since that is related to whether we need to have case-2/7 given case-8/10 is already there. |
| Huawei, HiSilicon | We are proponent of the solution above.  For bullet-2, our understanding is the interpretation-1 from OPPO.  For the further Q from OPPO, for case2 and case7, we understand if contiguous/contiguous is also supported by the UE, case8 and case10 will be signalled instead of case2 and case7 when the feature sets for different contiguity types are the same. Otherwise, a separate entry is needed. We assume this is the basic principle for all the cases above with more than one contiguity types, e.g. case 5, 7, 8, 10. |
| CATT | Firstly, we think the invalidity of case4 non-contiguous/Contiguous(DL/UL) in **Q2** needs to be confirmed by RAN4.  If case4 in Q2 is invalidity, the bitmap way will consume 3 bits, the solution in [3] will need UE to report the combination of intraBandENDC-Support and intraBandENDC-Support-UL, or either of the two capability, or both absent of the two capability in a specific case from 1-10, it is less than 3 bits in some case. Hence, if the majority view is to go to solution3 with above table, we are fine to this way. But in order to give a clear description of the solution in [3] for different case, it is suggested to clarify the possible supported case or the invalid case in the field of intraBandENDC-Support-UL, for example, only three types of DL/UL contiguous or Non-contiguous is supported in case 10 if intraBandENDC-Support is set as both, which could help network understand the case clearly. |
| Nokia | Although our preference would have been solution in R2-2300142 (as agreed in last meeting), we are ok with the proposal. |
| Rapporteur | To OPPO’s comment on bullet-2, interpretation-1 is indeed intended in this solution.  To CATT’s comment on case 4, we can confirm with RAN4. We already agreed to send an LS to RAN4 to ask their review of RAN2 solution. I did not understand where the bitmap of 3 bits came from, because in this solution we only have two UE capability bits; *intraBandENDC-Support* and *intraBandENDC-Support-UL.* |
| Qualcomm Incorporated | To OPPO’s question, “**Just would like to know the view by others on whether there is a case that UE support Contiguous/Non-contiguous but not contiguous/contiguous**”:  We already shared our view in the last meeting in the online presentation of [2]. Essentially, the support for non-contiguous band combination does not necessarily mean the UE supports contiguous band combination. For example, realizing contiguous band configuration using two LOs may result in different spurious products, hence may not meet the emission requirement. |
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* 1. LS to RAN4

TBD

# Conclusion

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# References

[1] [R2-2300060](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121/Docs/R2-2300060.zip) LS on intraBandENDC-Support RAN4

[2] [R2-2300142](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121/Docs/R2-2300142.zip) Discussion on UE capability ‘intraBandENDC-Support’ Qualcomm Incorporated

[3] [R2-2301611](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121/Docs/R2-2301611.zip) Discussion on intra-band EN-DC combination Huawei, HiSilicon