3GPP TSG-RAN WG2 Meeting #116bis Electronic R2-2201917

Online, 17 – 25 January 2022

**Agenda item: 8.24.1**

**Source: Nokia (Rapporteur)**

**Title: Offline 037 on FR2 CA BW class**

**WID/SID: NR\_RF\_FR2\_req\_enh2-Core – Release 17**

**Document for: Discussion and Decision**

# 1 Introduction

This document is the report of the following email discussion:

* [AT116bis-e][037][NR17] FR2 CA BW class (Nokia)

 Scope: Treat R2-2200118, R2-2200839, R2-2200840, R2-2200841, R2-2200843, R2-2201385. Progress the topic, Determine agreeable parts, for agreeable parts, agree CRs, approve reply LS out if agreeable.

 Intended outcome: Report, agreed in principle CRs, Approved LS out if applicable.

 Deadline: EOM (or earlier if online CB is needed, can CB W2).

# 2 Contact Points

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

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Nokia (Rapporteur) | Amaanat | amaanat.ali@nokia.com |
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# 3 Discussion

There are the following input documents:

[1] R2-2200118 LS on release independence aspects of newly introduced FR2 CA BW Classes and CBM/IBM UE capability “both” (R4-2119966; contact: Nokia) RAN4 LS in Rel-17 NR\_RF\_FR2\_req\_enh2-Core To:RAN2

[2] R2-2200839 Introduction of FR2 FBG2 CA BW classes Nokia Italy CR Rel-17 38.331 16.7.0 2867 - B NR\_RF\_FR2\_req\_enh2-Core

[3] R2-2200840 Introduction of CBM/IBM UE capability “both” Nokia Italy CR Rel-17 38.331 16.7.0 2868 - B NR\_RF\_FR2\_req\_enh2-Core

[4] R2-2200841 Introduction of CBM/IBM UE capability “both” Nokia Italy CR Rel-17 38.306 16.7.0 0668 - B NR\_RF\_FR2\_req\_enh2-Core

[5] R2-2200843 Reply LS on release independence aspects of newly introduced FR2 CA BW Classes and CBM/IBM UE capability Nokia Italy LS out Rel-17 NR\_RF\_FR2\_req\_enh2-Core To:RAN4

[6] R2-2201385 Introduction of new FR2 CA bandwidth classes Xiaomi Communications discussion Rel-17 NR\_RF\_FR2\_req\_enh2-Core

The short background is that the LS in R2-2200118 contains two separate topics.

**Topic 1: Introduction of FR2 FBG2 CA BW classes**

With regards to the input documents in [2] and [6] respectively, before discussion on the CRs it is better to discuss the proposals in [6] first as they are quite good to have the alignment between companies.



**Proposal 1: When the UE indicates a new bandwidth class (i.e., R, S, T, U), the UE shall also indicate bandwidth class F.**

**Proposal 2: The indication of the new bandwidth classes (i.e., R, S, T, U) is via new capability signalling of *ca-BandwidthClassDL-NR-v17xy/ ca-BandwidthClassUL-NR-v17xy*.**

**Proposal 3: The indication of the new bandwidth classes (i.e., R, S, T, U) is allowed for early implementation from Rel-15.**

**Question 1: Do companies agree with P1 and P2 i.e., when the UE indicates a new bandwidth class among one of the new ones (i.e., R, S, T, U), the UE shall also indicate bandwidth class F (noting that if yes to P1 then automatically something like P2 is required at BandParameter level)?**

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| Answers to Question 1 |
| Company | Yes/No | Technical Arguments |
| Nokia | No | Due to the single enumeration, it seems that the legacy network that does not support the new bandwidth classes {R, S, T, U } will end up dropping a band combination. To interoperate with legacy networks, a UE is required to do this.[Nokia v2] We update our view based on the comments from Qualcomm and Oppo we also agree that the CA bandwidth class reported by the UE will be conditional to the filter setting. Hence we can simply use the extension as allowed in the BW class NR field. We already have a CR in [2] already built on this understanding. |
| Qualcomm Incorporated | No | We would avoid this unless it is absolutely necessary. But we are ready to listen to the network vendors.We suppose UE capability request filter, where the network can request bands and aggregated BW for each NR band, is sufficient. Then the UE declares CA band combinations and associated BW classes appropriately.  |
| OPPO | No  | Same view as QC, the fallback concept would be good to be kept here for BWC as well.[Xiaomi] The fallback concept in RAN4 remains no change. P1 and P2 is actually used to keep the fallback bandwidth class F when the UE indicates the bandwidth class R. |
| Huawei, HiSilicon | Yes | To avoid inter-operability issue, we support to define the new bandwidth classes in separate capability field. If a new bandwidth class is reported for a BC band, then the legacy bandwidth class within the same fallback group (e.g. BWC-F) should be reported at the same time for the band. For example, UE can indicate BWC-R and BWC-F for a BC band with 5 FSPCs, then the legacy gNB supporting most 4 CCs can interpret the BC band as BWC-F and use any 4 of the 5 FSPCs within the band. For the UE capability request filter method, we think there is a problem when there is handover from a new gNB to a legacy gNB. If the filters used by the new gNB corresponding to the new BWC can be understood by the legacy gNB, the legacy gNB may not inquire UE capability again. Thus the BCs with new BWC and the fallback BCs will be discarded by the legacy gNB. In this case, the inter-operability issue is not solved. |
| Apple | No, and | We also think we should avoid this unless absolutely necessary. RAN4 is very likely to start adding more BW classes with a fallback and the UE cannot simply go on providing older BW classes (which is a bit similar to LTE UE categories, and this created unclean design). We assume that gNB vendors shall update their SW(?) to be able to handle improvements especially when these gNBs inter-operate with latest gNBs… If there was no UE capability filter, then the argument for the UE to provide backup classes would have been valid, but with ‘interactive’ signaling, I think we should try to be better in NR. |
| ZTE | FFS | Based on the above companies’ comments, we just want to confirm whether we need to extend the UE capability filter.In the current spec the maximum AggregatedBandwidth (maxBandwidthRequestedDL /UL) is 800M, and the absence of AggregatedBandwidth (maxBandwidthRequestedDL/UL) in the R15/16 means 1200M. FreqBandInformationNR ::= SEQUENCE { bandNR FreqBandIndicatorNR, maxBandwidthRequestedDL AggregatedBandwidth OPTIONAL, -- Need N maxBandwidthRequestedUL AggregatedBandwidth OPTIONAL, -- Need N maxCarriersRequestedDL INTEGER (1..maxNrofServingCells) OPTIONAL, -- Need N maxCarriersRequestedUL INTEGER (1..maxNrofServingCells) OPTIONAL -- Need N}AggregatedBandwidth ::= ENUMERATED {mhz50, mhz100, mhz150, mhz200, mhz250, mhz300, mhz350, mhz400, mhz450, mhz500, mhz550, mhz600, mhz650, mhz700, mhz750, mhz800}However with the new Bandwidth classes, the AggregatedBandwidth can be 1000/1200/1400/1600mhz.* If UE capability filter (e.g. add a new filter) would be extended, then the P1/P2 seems not necessary, for that the UE can decide to report the new bandwidth class based on the new filter information, e.g.
* When the UE received the new filter (and can understand this new filter), the UE report the new bandwidth class
* Otherwise the UE (include the legacy UE or the new UE but no new filter in the request message) report the old bandwidth class;
* For handover , when a UE which has reported the new bandwidth class handover to an old gNB, the old gNB can set it preferred filter and require UE capability again if the old gNB can’t read the new filter info.
* If we don’t want to extend the UE capability filter (e.g. add a new filter), to require the BC the new bandwidth class, it seems that the UE can only set the maxBandwidthRequestedDL/UL to be absent, then without the P1/P2:

 * The New UE will report BCs with new bandwidth class, but the old gNB may discard these BCs for that it can’t understanding the new reported bandwidth class
* For the handover case, there would also be some problems as Huawei commented.
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| Xiaomi | Yes | We are the proponent. When the UE indicates the bandwidth class R, the legacy gNB without updating the ASN.1 is not able to understand the indication of the bandwidth class R and the fallback bandwidth F of the bandwidth class R in FBG2. Then indicating the fallback bandwidth F seems anyway needed for the legacy gNB. Maybe we can hear more views from the network vendor and the operators regarding the updating schedule/strategy on the gNB.We are also open to discuss “the UE capability request filter method”, but would like to see a more detailed design to deal with some potential issues as indicated above by Huawei and ZTE. Furthermore, it seems that “the UE capability request filter method” is even more complex than the above proposal 1 and 2, for both the UE and the gNB. Would the gNB also indicate the request of a new bandwidth class R to a legacy UE?Would the gNB be forced to support the UE capability filter in order to support bandwidth class R? |
| Samsung | FFS | We have same understanding with ZTE.RAN2 first need to determine how to solve this issue using:1) UE capability request filter method; or2) Method of including Falback BW when the new BW is indicated  |
| vivo | FFS | Same view as Samsung. If companies cannot converge on the choice between UE capa filter based method and always including FB BW method, perhaps it is better to postpone the discussion.  |
| Ericsson | No | We acknowledge there is inter-op issues, at least in theoryHowever, Since RAN4 defines new BCs and BCSs regularly since Rel-15, RAN4 has thereby (hopefully) deliberately decided that all gNBs in a PLMN must be upgraded regularly, i.e., whenever new UEs are likely to report such new BC/BCSs in that PLMN. Otherwise, the gNBs would not know which carrier bandwidths they may configure on which carrier of a band combination that the UE reports. Therefore, gNBs must disregard uncomprehended BCs/BCSs. And this may imply that a UE supporting a new and better BC/BCS can only be used in single-carrier mode. Hence, those upgrades must happen very regularly and coordinated in all gNBs.And it should hence be feasible to upgrade then also the value range of the BWC field (and possibly other fields) at the same time. |
| CATT | FFS | We share the same understanding with ZTE and Samsung.  |
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**Question 2: Do companies agree with P3 i.e., the indication of the new bandwidth classes (i.e., R, S, T, U) is allowed for early implementation from Rel-15.**

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| Answers to Question 2 |
| Company | Yes/No | Technical Arguments |
| Nokia | Yes | This should be technically possible to allow, and we would be fine with this. |
| Qualcomm Incorporated | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Apple | Yes |  |
| ZTE | Yes |  |
| Xiaomi | Yes |  |
| Samsung | Yes |  |
| vivo | Yes |  |
| Ericsson | Yes |  |
| CATT | Yes |  |
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**Solution direction 1 (based on R2-2200839)**

Add the new enumerations in the NR CA bandwidth class IE where an extension marker has already been provided. Based on this, a UE supporting one of the new FR2 CA bandwidth classes {R,S,T,U} will report one of these enumerations and the gNB supporting this will be able to handle this including synthesizing fallbacks. Unfortunately, the old gNB cannot understand this enumeration and will discard this band combination possibly resulting in a non-backward compatible behavior as the UE supporting one of {R,S,T,U} should also be able to support the bandwidth class say F due to the direct fallback within FBG2.

* At least two network vendors are fine with this approach noting that the concern is theoretical as RAN4 defines new BCs and BCSs regularly since Rel-15, RAN4 has thereby (hopefully) deliberately decided that all gNBs in a PLMN must be upgraded regularly, i.e., whenever new UEs are likely to report such new BC/BCSs in that PLMN. Otherwise, the gNBs would not know which carrier bandwidths they may configure on which carrier of a band combination that the UE reports. Therefore, gNBs must disregard uncomprehended BCs/BCSs. And this may imply that a UE supporting a new and better BC/BCS can only be used in single-carrier mode. Hence, those upgrades must happen very regularly and coordinated in all gNBs.
* Some UE vendors seem to be okay with solution direction 1 but would like to leave the discussion further for checking as it is important to have consensus at network side handling as well. One vendor pointed out due to different number of CCs in the band combination, the UE cannot recycle band list, feature set combination and feature set i.e. reporting for both bandwidth class F and bandwidth class R at the same time will impact UE capability size. This also leads to the requirement that the UE can include a band combination with bandwidth class R only if the fallback band combination with bandwidth class F can fit together within the maximum allowed UE capability container size.
* Two network vendors echo the concern that they are not ready to accept it leaving to gNB

**Compromise for solution direction 1?**

* Instead of offering Rel-15 early implementation, Rel-16 or later could be the starting point as it is expected that there are **NO** devices already in the field which are supporting {R,S,T,U} and there are neither any gNB’s which are deployed for Rel-16 as of now. So absorption of the above might be easier starting Rel-16? No consensus
* One company suggested to put clearly about solution direction 1 on the cover page that both the network and the UE shall have to implement this otherwise there is a risk that a legacy gNB will end up dropping this band combination. Seems operators when dealing with real deployment are difficult to accept this so operator input is also essential here who has the real use case. No consensus

**Solution direction 2 (based on R2-2201385)**

Consider a mechanism compatible with legacy gNB’s for example where a UE reports one of the new bandwidth classes and also reports the older one. Motivation is that in the past RAN2 had an issue with the BCS0 support which caused some network cannot support the BCS reported by the UE and result in ignoring the whole BC CA for intra-band EN-DC case.

* One network vendor fully supports this solution direction. One network vendor thinks asking the UE to report one of the new R,S,T,U BW class + asking UE to report the older one might break RAN2 principle that a UE is not supposed to report a band or band combination which is a fallback. In that sense a new UE can only report from FBG2 the newer BW class if it supports it.
* Extending this discussion a bit, it seems that RAN4 is discussing new mechanism on introducing more BW classes across FBGs, if the intention is to use a single BC entry to report both BW classes for each band from RAN4, for BW class R/S/T/U, we probably can use the same way: i.e. to simply add a new BW class under the band parameters, thus we don’t need to report fallback BCs and we can also accommodate with legacy gNBs.
* UE vendor mentioned the need to consider how such band combination with double bandwidth class should be linked to feature set combinations. Today, the number of feature set per CCs within a feature set (per band) shall be in line with the signalled bandwidth class of the band. An immediate question is if legacy network can handle UE capability violating this rule.

**Other facts**

* For the new Bandwidth classes, the AggregatedBandwidth can be 1000/1200/1400/1600mhz but the current capability filter only allows setting up to 800 MHz. This aspect might be looked into for future meetings to develop a way so that the legacy gNB impact issue can be addressed.
* Double bandwidth class discussion in RAN4 is pertaining across FBG’s but the current RAN4 LS pertains to only the extending of FR2 CA bandwidth class in FBG2.

**Topic 2: Introduction of capability for UE capable of both IBM and CBM**

The CRs in [3] and [4] introduce the capability required by the RAN4 incoming LS in [1].

**Question 3: Do companies agree to the intention of the CRs in [3] and [4] introducing a capability that indicates UE supports both IBM and CBM as required by the RAN4 incoming LS in [1]?**

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| Answers to Question 3 |
| Company | Yes/No | Technical Arguments |
| Nokia | Yes | This aligns to the intent of the RAN4 LS. |
| Qualcomm Incorporated | Yes |  |
| OPPO | Yes | For the issue on applicability of UL and DL raised by ZTE:Our preference is to wait for R4 conclusion on this: based on the feedback from our R4 colleague, they are discussing it and no formal conclusion yet. Technically, one point to check here is whether the design has to be future proof for a case like * For UL, band1 + band2 using a chain so CBM is valid
* For DL, band1 + band2 + band3 where correspondence of band1+2 is OK, but not for band3, so some asymmetric may happen

So prefer to wait for R4 conclusion first or ask R4 actively. |
| Huawei, HiSilicon | No | From RAN4 LS, we think currently there are three cases, IBM only, CBM only, and both IBM and CBM. In current 38.306, it is required that UE shall only indicate IBM for Rel-16. To avoid inter-operability issue with the legacy gNB, we think this should not be changed. If the new capability is defined as support of both IBM and CBM, the CBM only case cannot be reported by UE in Rel-16. Thus, we support to introduce a separate capability to indicate support of CBM. If both IBM and CBM are supported, UE can include IBM in the legacy field and indicate support of the new field at the same time. [Rapporteur] Legacy gNB will only care about the IBM part of enumeration and should neglect CBM. So, there should not be any worry for such gNB if a UE supporting CBM sets it? If legacy gNB should be upgraded then it should be able to either process IBM or CBM and use the new capability for the “both”. With the above CRs UE should be able to signal all the cases { IBM only, CBM only, and both IBM and CBM }.[HW] Thanks rapporteur for clarification. In our view, it is better not to change the Rel-16 capability reporting (e.g. only IBM shall be supported), then an updated UE which supports {CBM only} can report it in the Rel-17 field. This works as well for Rel-16 early implementation. So we still prefers to introduce a new capability to indicate support of CBM. In this way, we do not change the UE behavior for setting Rel-16 field. For the CBM value in Rel-16 field, we think it is clear to dummy it as Ericsson proposed.  |
| Apple | Yes, but we would like to see from Huawei, if we are missing something. | For Huawei’s comments: The Rel-16 UE can technically be able to say it supports CBM-only using Rel-16 signalling, right?  |
| ZTE | Yes(but) | Generally we agree with the intention, but we still have some questions as below:(1)Whether we need to delete the limitation “In this release of the specification, the UE shall only report value of '*ibm*'.” in the Rel 17 CR for that in R17, the UE can support both IBM and CBM, and we also want to confirm whether the R17 UE can only support CBM (without supporting IBM)[Samsung] Same view to confirm that the R17 UE can only support CBM (without supporting IBM). [Rapporteur] Good point, yes we have the same understanding confirmed from our RAN4 that UE is able to perform CBM alone (without supporting IBM).(2) ***beamManagementType-IBM-and-CBM-r17*** “...The UE that indicates support for this feature shall support both independent beam management (IBM) or common beam management (CBM).” It seems that “or” should be changed to “and”[Samsung] Same view.[Rapporteur] Correct, we can update this.1. Until now, only DL was mentioned in the definition of IBM as below
* IBM(Independent Beam Management): A UE that supports inter-band CA with IBM selects its DL Rx beam(s) for all CCs in each configured band based on DL reference signals measurements made in that band.

In the rel-16, the inter-band UL CA was not supported, so we understand the legacy signal is only for the DL, then what about the UL? In Rel17, it seems that only IBM was discussed for the UL by RAN4, so does the newly added capability is only for the DL? If it was, what about the UL?[Samsung] It is not clear so it should be asked to RAN4 (?)[Rapporteur] Correct, our RAN4 confirmed an understanding is that the same capability is applicable for both DL and UL. So, when inter-band UL CA becomes possible then there should be no additional impact. I request companies to check this from their RAN4 delegates as well. |
| Xiaomi | Yes, but | We agree with the inter-operability issue indicated by Huawei.[Rapporteur] Our understanding is aligned with other companies that the current signalling allows signalling IBM only or CBM only so this can be reused. On top a separate capability indicates support for both IBM and CBM. If we just follow Huawei’s suggestion what to do with the CBM enumeration in the capability in Rel-16 as this is early implementable starting from Rel-16 so a UE that supports CBM also may use that codepoint? |
| Samsung | Yes | We agree with the comments from ZTE, those issues are valid and should be clarified. |
| vivo | Yes, but | Share the inter-operability issue raised by Huawei. Also agree with above comments to first clarify whether the CBM only case is really supported for a R17 UE.[Rapporteur] CBM only case is for Rel-17 UE. Please see answer to Xiaomi also. |
| Ericsson | Maybe | We note that existing beamManagementType-r16 is marked with Yes in the M-column in 38306. And it is stated “In this release of the specification, the UE shall only report value of '*ibm*'”. We understand this means IBM is mandatory and the field is an IOT-bit. So a Rel-16 UE should not really set the value “cbm”, right. We do not expect this to change for Rel-17 UE, IBM should still be mandatory (Yes in the M column). So with have some sympathy with Huawei, we only need a new field to indicate support of CBM.If companies agree, we could even dummify the value “cbm” in the Rel-16 field (both in Rel-16 and Rel-17 spec). |
| CATT | Yes,but | Share the same view with Ericsson. |
| Huawei, HiSilicon |  | We share the same view with Ericsson.[HW-v3] After checking with our RAN4 colleagues, we agree the issues raised by ZTE and OPPO are still under discussion in RAN4. We support to wait for more conclusions from RAN4. |
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**Question 4: Do companies agree to introducing the capability early implementable for UE capable of both IBM and CBM starting from Rel-16?**

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| Answers to Question 4 |
| Company | Yes/No | Technical Arguments |
| Nokia | Yes | This should be technically possible to allow, and we would be fine with this. |
| Qualcomm Incorporated | Yes |  |
| OPPO | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Apple | Yes |  |
| ZTE | Yes |  |
| Xiaomi | Yes |  |
| Samsung | Yes |  |
| vivo | Yes |  |
| CATT | Yes |  |
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**Summary for CBM/IBM**

There were two solution directions discussed. One approach is based on the R2-2200840/R2-2200841 that proposes to include a “both IBM/CBM capability” starting Rel-17 while the other approach (no contribution but offered as input in this discussion) is to dummify the CBM capability in Rel-16 and introduce the CBM only capability from Rel-17 with early implementation from Rel-16. Rapporteur thinks based on the inputs from two network vendors, the approach to dummify and create CBM only capability from Rel-17 with target early implementation from Rel-16 is good and workable from a legacy gNB perspective as well wherein a Rel-16 UE will indicate IBM only.  One company brought up another IBM/CBM issue for R4 to conclude, i.e., applicability to DL and/or UL. Rapporteur company thinks the capability applies to DL only for now but when UL discussions are over in RAN4 the same capability may be reused. But seems companies may need time to check with their RAN4 colleagues on this aspect.

# 4 Conclusion

Based on the summary above the following proposals are made.

**FR2 CA BW class**

**Proposal 1: Continue discussion for solution options for introducing the extended bandwidth class for FR2 CA bandwidth class in FBG2 (early implementation target as Rel-15)**

**Proposal 2: FFS if RAN2 aims to harmonize solution to also include  “dual bandwidth class” which is under discussion in RAN4**

**IBM/CBM**

**Proposal 3: Introduce CBM-only capability from Rel-17 (allowing early implementation from Rel-16) and dummify CBM enumeration from Rel-16 capability**

**Proposal 4: FFS if IBM/CBM capability apply to DL and/or UL**