**3GPP TSG-RAN WG2 Meeting #119bis R2-22xxxx**

**e-Meeting, 10-19 October 2022**

**Source: Qualcomm Incorporated**

**Title: [DRAFT] Summary of email discussion [AT119bis-e][010][NR17] FBG5 BW Classes (Qualcomm)**

**Document for: Decision**

**Agenda Item: 6.24.1**

# Introduction

This document provides a summary for the following email discussion.

* [AT119bis-e][010][NR17] FBG5 BW Classes (Qualcomm)

Scope: Treat R2-2209347, R2-2209621, R2-2209622, R2-2210540, R2-2210244, R2-2210662, R2-2210701, R2-2210539, R2-2209384. Determine agreeable parts, Based on agreeable parts, progress CRs, LS out if applicable

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

Deadline: In time for CB W2 Mon (if CB is needed)

# Discussion

Companies providing input to this email discussion are requested to leave contact information below.

|  |  |  |
| --- | --- | --- |
| **Company** | **PoC** | **Email** |
| Qualcomm Incorporated | Masato Kitazoe | mkitazoe@qti.qualcomm.com |
| Huawei, HiSilicon | Tong Sha | shatong3@hisilicon.com |
| Xiaomi | Yumin Wu | wuyumin@xiaomi.com |
| Intel Corporation | Seau Sian Lim | seau.s.lim@intel.com |
| Apple | Naveen Palle | naveen.palle@apple.com |
| ZTE | Wenting Li | Li.wenting@zte.com.cn |
| CATT | Jie Shi | shijie@catt.cn |
| Samsung | Seungri Jin | seungri.jin@samsung.com |
| Ericsson | Håkan Palm | hakan.l.palm@ericsson.com |
| MediaTek | Mutai Lin | morton.lin@mediatek.com |

* 1. Phase 1

[Intended deadline for phase 1 discussion is Wednesday October 12, 1000 UTC.]

* + 1. Understanding RAN4 solution

Based on the submitted company documents, email discussion rapporteur observe that companies have different understanding on the solution RAN4 is referring to in their LS R2-2209347 (main body reproduced in Annex). It is therefore proposed that phase 1 of this email discussion focus on building common understanding on the solution. As a starting point for discussion, rapporteur would like to provide his understanding on RAN4 solution below.

--------

Let’s take an example for the case the UE supports bandwidth class R6 (600MHz ≤ BWChannel\_CA ≤ 1200MHz, 6CCs).

In the existing UE capability framework, the UE can signal the following CC/bandwidth combinations, by means of feature sets (and feature sets per CC therein).

1. 6x100MHz
2. 4x100MHz + 1x200MHz
3. 2x100MHz + 2x200MHz
4. 3x200MHz

The cases 1, 2, 3 and 4 correspond to bandwidth classes R6, R5, R4 and R3 respectively. Note that they are all 600MHz in terms of the aggregated CA bandwidth. So the UE is indicating the capabilities for R6 and its fallback bandwidth classes while keeping the aggregated CA bandwidth to its supported maximum. It should be noted that the UE also supports R2 as a fallback CA of case 4.

The key idea of RAN4 solution is reduce the number of CC/bandwidth combinations (feature sets) for the case other UE capabilities except for CC bandwidth within the feature set are the same for all CCs. In that case, it is possible to declare the UE capability with a single feature set by additionally indicating maximum aggregated bandwidth, as follows.

a. 6x200MHz / Maximum aggregated bandwidth =600MHz

The network can configure any CC bandwidth as long as it satisfies both the maximum CC bandwidth and the maximum aggregated bandwidth limitations as signalled by the UE. It can be seen that the new signalling covers all cases 1 to 4 above (bandwidth classes R6, R5, R4 and R3) and 2x200MHz (R2).

**Question 1:** Do companies have the same understanding on the RAN4 solution as outlined above?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Huawei, HiSilicon | See comments | The clarification from the Rapp reflects the basic solution in the RAN4 LS, but we understand the overall mechanism is still not so clear from RAN2 perspective.  Talking about the solution, we understand this solution requires all of the capability fields in the FeatureSet are the same among all of the CC bandwidth combinations, otherwise, it is not workable. While merging multiple CC combinations in one FeatureSet changes the original understanding of a FeatureSet. Besides, it is also not a bit clear how to understand the fallback of the maximum aggregated bandwidth. These questions are discussed in our paper in R2-2210539. |
| Xiaomi | Yes, but | We think that we should focus on providing feedbacks to the following RAN4 task:  “RAN4 would like to respectfully request RAN2 to check if a new IE could reduce signaling overhead without potential co-existence issue with the legacy fallback rule and without inter-operability issue”  **Regarding the “potential co-existence issue with the legacy fallback rule”,** we think that the fallback from the above example (e.g. from R6 to R5) without reducing the bandwidth does not follow the legacy definition of fallback band combination in 38.306 as quoted below, as releasing a SCell from a CA configuration would anyway resulting in the reduction of the bandwidth.  **Fallback band combination:** A Uu band combination that would result from another Uu band combination (parent band combination) by releasing at least one SCell or uplink configuration of SCell, or SCG, or SUL. A PC5 band combination that would result from another PC5 band combination (parent band combination) by releasing at least one sidelink carrier. An intra-band non-contiguous band combination is not considered to be a fallback band combination of an intra-band contiguous band combination. A fallback band combination supports the same channel bandwidth(s) for each carrier as its parent band combination(s).  It is also unclear whether some other parameters (e.g. mimo-layer or supportedModulationOrderDL per cc) can follow the legacy fallback procedure. If the number of CCs are reduced but without reducing the bandwidth, the bandwidth of a CC would have to increase (e.g. from 100 MHz to 200MHz as the above fallback example from R6 to R5). Then this will impact the soft buffer design at the UE in the fallback case, as the TBS for a CC will increase when the UE falls back from R6 to R5. We think that RAN1 needs to be involved to evaluate whether this is common for the fallback from R6 to R5 with reduced number of CCs but without changing the maximum supported bandwidth.  **Regarding the “signalling overhead”**, we consider that this depends on how the UE supports the fallback cases. If in many cases the UE still needs to indicate a lower-order of a bandwidth class within FBG5, the signalling overhead will not be reduced. Furthermore, as indicated by the ZTE’s paper, we think that the UE needs to indicate FBG2 as well when indicating FBG5. This seems causing extra signalling overheads.  **Regarding the “inter-operability issue”,** we would agree with the backward compatibility issue raised below by ZTE. |
| Intel | Yes, but | The RAN4 LS seems to be just focusing on reducing the overhead by reducing the number of FSs needed as outline by the LS and as explained by the rapporteur by introducing the maximum aggregated bandwidth to a FS and the FS can implicitly indicate the fallback support of the lower order CCs (i.e. BW class R6 can implicitly indicate support of R5, R4 and all the way to R2 since the BW range is overlapped). For this, we agree with the rapporteur’s understanding of the LS.  With this new signalling, it is unclear to us whether the existing bandwidth class definition (CA-BandwidthClassNR) needs to be extended to include the new BW classes {R2,R3,…,R12}. If not, what should the existing CA-BandwidthClassNR be populated for UL and DL if FBG 5 is used. Our understanding is that this needs to be populated regardless of whether the overhead reduction proposed by RAN4 LS is to be adopted. |
| Apple | Yes, but | We share the same views as Xiaomi. |
| Qualcomm Incorporated | Yes | To Xiaomi  Fallback band combinations and fallback bandwidth class within fallback group are different concept.  The support for fallback band combination can be implicitly signalled. For example, the case 1 indicates the support for 5x100Mz implicitly, but it is different from Case 2 as can be seen. Case 2 is simply a set of capabilities corresponds to bandwidth class R5 but is not fallback band combination of case 1.  Please clarify how those two things are not compatible each other. |
| ZTE | Yes, but | We agree with Rapporteur’s understanding on the newly introduced elements. But we have the similar concern as Huawei on the efficiency of this newly introduced elements (e.g. different MIMO layers for different cases)  Furthermore, based on the comments from Xiaomi and rapporteur, it seems that with this scheme, one feature set can include multiple cases, even they are not satisfy fallback rule, which is quite different from the legacy and we are not sure whether there is any risk with this new method.  Besides, in our paper we also analyze the signaling Overhead from FBG5/FBG2 aspect as Xiaomi pointed out, we think this shall also be considered. |
| CATT | Yes, but | Agree with Rapp’s explaining to RAN4 LS, but we needs to discuss above proposed issues before going to new signalling design. |
| Samsung | Yes, but | Agree with Rapp’s explaining to RAN4 LS but we are also not clear how this is work with the legacy signaling.  For example, a UE reporting the new IE for a legacy CA BW class, e.g. reporting maximum aggregated BW as 250MHz (100+50+50+50) for CA BW class Q in FBG4, then the legacy network would not understand the new IE and will ignore it. Consequently the network would not know the UE actually could also support CA BW class P with 100+100+50.  As indicated by the ZTE’s paper, we also think that the UE needs to indicate the legacy FBGs as well when indicating FBG5. This seems causing extra signalling overheads. |
| Xiaomi2 |  | To QC  The legacy fallback bandwidth class within fallback group also follows the rule of “releasing at least one SCell” provided by the “**Fallback band combination**”. For example, when the UE indicates bandwidth class E (400 MHz < BWChannel\_CA ≤ 600 MHz, 3CC) in FBG2, the UE supports the following feature sets:  (1) 3\*200MHz  (2) 2\*200MHz (i.e. bandwidth class D (200 MHz < BWChannel\_CA ≤ 400 MHz, 2CC) in FBG2) by release one SCell of 200MHz  Then the signalling overhead to report bandwidth class D can be saved.  However, when the UE falls back from R6 to R5, as the bandwidth is increased for a certain CC for R5, in order to keep the soft buffer design of the CC, the UE would need to reduce the supported MIMO layer and/or modulation order. Then the UE still needs to indicate R5 together with its specific MIMO layer and/or modulation order. |
| Ericsson | Yes | We agree with Rapporteur’s understanding as expressed in the example.  And we also agree (or note) that this proposal (“new IE”) itself (as commented by others) might or might not lead to a signaling reduction. |
| MediaTek | Yes, but | We understand that the R4-suggested solution takes only CC/BW dimension into consideration so that common UE capability diversity can easily defeat its applicability. (We don’t even have to touch the fact it requires UE to support all the same capabilities in the FeatureSet among all the fallback band combinations, which is quite rare for 5G phone product nowadays.)  For example, if the UE can only support up to three 200MHz CCs somehow, it could not just report “5x200MHz / Max. aggre. BW=800MHz” in order to avoid that NW mistakes that 4x200MHz / Max. aggre. BW=800MHz is supported by the UE. Furthermore, the capability “3x200MHz+2x100MHz / (implicitly aggre. BW=800MHz)” can already be covered by current signaling and we do not have to worry about applying the fallback rule.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **BWClass R5** | | **Aggre. BW** | **BWClass R4** | | | **CC# w/ 200MHz BW** | **CC# w/ 100MHz BW** | **CC# w/ 200MHz BW** | **CC# w/ 100MHz BW** | | 5 | 0 | 1000 |  |  | | 4 | 1 | 900 |  |  | | 3 | 2 | 800 | 4 | 0 | | 2 | 3 | 700 | 3 | 1 | | 1 | 4 | 600 | 2 | 2 | | 0 | 5 | 500 | 1 | 3 | |  |  | 400 | 0 | 4 |   Other signaling and interpretation details can be further discussed in phase 2. |

* + 1. Backward compatibility

The following documents additionally discusses the backward compatibility of FBG5.

|  |  |  |
| --- | --- | --- |
| [R2-2210662](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210662.zip) | Consideration on the FR2 Fallback Group 5 | ZTE Corporation, Sanechips |
| [R2-2210701](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210701.zip) | (Draft)Reply LS on new contiguous BW classes for legacy networks | ZTE Corporation, Sanechips |

Some observations are made in the first document.

**Observation 1: The <Aggregated channel bandwidth, Number of contiguous CC> of FBG 2 bandwidth classes are covered by that of FBG 5 bandwidth classes.**

**Observation 2: The <Aggregated channel bandwidth, Number of contiguous CC> of FBG 3 bandwidth classes are partly overlapped with that of FBG 5 bandwidth classes.**

**Observation 3: The old gNB can’t understand FBG 5 bandwidth class (e.g. when the UE get the UE capabiliy from a R17 gNB then handover to an old gNB, or when the UE move to an old gNB at idle state and then establish connection with old gNB), then the network may ignore the BC with FBG 5 bandwidth class.**

**Question 2:** Do companies agree to the observations above?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Huawei, HiSilicon | Yes but | We agree that FBG5 BW classes themselves can only be understood by an upgraded gNB but not a legacy gNB. From the agreement in RAN2#119e, there is no inter-operability issue with legacy gNB for FBG5 BW classes although it cannot be identified by the legacy gNB.   * [023] RAN2 agrees there is no backward compatibility issue for network in introducing new FR2 FBG5 BW classes in the CA-BandwidthClassNR field (proposed in CR R2-2208511). |
| OPPO | Yes | O1 and O2, agree  O3 although we understand the backwards compatibility issue is somewhat independent of whether we use an existing FBG (but with new BW-Class) or a new FBG, we rely on infra-vendor to decide. |
| Xiaomi | Yes |  |
| Intel | Yes | Agree that BC with FBG5 BW classes cannot be understood by legacy gNB and hence will be ignored by the legacy gNB. |
| Apple | Yes |  |
| Qualcomm Incorporated | Yes |  |
| ZTE | Yes (proponent) |  |
| CATT | Yes |  |
| Samsung | Yes |  |
| Ericsson | Yes |  |
| MediaTek | Yes, but | O1 and O2 are true while considering only CBW per CC and its combination set but could be not true if considering other capability parameters per CC for example the MIMO layer or RF related ones.  Agree with O3 regarding to the interoperability concerns.  Regarding to backward compatibility, we understand that most CA requirements in 38.101-x are release independent, but it is inevitable to consider and ensure the interoperability related to legacy gNB and MR-DC scenarios as well. Since the special characteristic of FBG5 is not fully compatible with BW classes in legacy FBGs, we think the simplest way that it shall be disregarded by legacy gNB. |

Based on the observation 1, the document asks the following question.

* **whether the BC with FGB2 bandwidth class can be seen as a fallback of a BC with FBG5 bandwidth class.**

**Question 2:** Companies are requested to provide their view on the question above.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Huawei, HiSilicon | We understand a BC with FBG5 BW class cannot fallback to a BC with FBG2 BW class, but can fallback to a BC with lower order of BW classes in FBG5. |
| OPPO | Firstly, we do not know what is the definition of ‘fallback’ here  We raised the Q in our paper 09384,  Proposal 1       R2 clarifies how to interpret “It is mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration within a fallback group.”, i.e., whether it is applicable to the BW-combo and/or maximum aggregated BW. And if needed, confirm with R4 using LS.  We suggested to discuss the issue here, as included in the scope of this offline discussion.  [Additional comment] based on the discussion on reflector, if the thinking is the ‘fallback’ of intra-FBG is more of R4 scope, then we believe there is no need to progress on inter-FBG either in R2, i.e., it should be handled by R4 as well. |
| Xiaomi | Our understanding is that when a bandwidth class – X is a fallback of a bandwidth class – Y. When indicating the support of the bandwidth class – Y, the UE does not need to report the support of the bandwidth class – X, as the bandwidth class – X is supported by default.  Thus, the BC with FGB2 bandwidth class shall not be seen as a fallback of a BC with FBG5 bandwidth class. Since the UE does not know whether the gNB is a legacy gNB or a new gNB, the UE has to report both FBG5 and FBG2 as the legacy gNB does not understand FBG5. |
| Intel | We have the same understanding as Huawei that the fallback is within the FGB5 |
| Apple | FBG2 cannot be seen as a fallback of FBG5. |
| Qualcomm Incorporated | Agree with Xiaomi, except that we do not agree the UE is mandated to signal both FBG5 and FGB2, while the UE is allowed to. |
| ZTE | In the legacy FBGs, there is no overlap, so when we consider the fallback BC, only the bandwidth class in the same FBG are considered.  But the FBG 5 is quite different, it covers the bandwidth of FBG2. We think the capability of BC with FBG2 bandwidth class would overlapped with (or can be derived from) the with FBG2 bandwidth class, which would leads to additional BC\_level signaling overhead for that the UE has to report both FBG2 and FBG5 (considering the old gNB can’t read FBG5)  So we think we need to evaluate this extra signaling overhead. |
| CATT | Agree with HW and Xiaomi, FBG2 are not a fallback of FBG5. |
| Samsung | Agree that FBG2 are not a fallback of FBG5. |
| Ericsson | We also agree FBG2 are not a fallback of FBG5.  We understand TS 38.301-2 specifies this:  **Fallback group:** Group of carrier aggregation bandwidth classes for which it is mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration. It is not mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration that belong to a different fallback group |
| MediaTek | It may but cannot treat FBG2 is a fallback of FBG5 by default. We are sure about RF characteristics of BW classes in the same FBG are required to be the same to support mandating the fallback principle, but not sure the same across different FBGs.  However, it would be worthwhile to have RAN4 confirmation for possible fallback cases between different FBGs (without incompatibility risks), to explore signaling reduction potential. |

* 1. Phase 2: Signalling solution

[Intended deadline for phase 2 discussion is Friday October 14, 1000 UTC.]

[Intended to collect companies views on the benefit of solution, discuss signalling details and so on.]

# Conclusion

# References

[1] R2-2209347 LS on new contiguous BW classes for legacy networks RAN4 (To: RAN2)

[2]

# Annex: Main body of RAN4 LS [1]

RAN4 have agreed new FR2 CA BW classes for supporting operator block sizes up to 2400 MHz with a mix of 100 MHz and 200 MHz carriers and agreed to introduce new CA BW classes as shown in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| NR CA bandwidth class | Aggregated channel bandwidth | Number of contiguous CC | Fallback group |
| A | BWChannel ≤ 400 MHz | 1 | 1,2,3,4,5 |
| (unchanged legacy FBG2,3,4) | | | |
| R2 | 200 MHz ≤ BWChannel\_CA ≤ 400 MHz | 2 | 5 |
| R3 | 300 MHz ≤ BWChannel\_CA ≤ 600 MHz | 3 |
| R4 | 400 MHz ≤ BWChannel\_CA ≤ 800 MHz | 4 |
| R5 | 500 MHz ≤ BWChannel\_CA ≤ 1000 MHz | 5 |
| R6 | 600 MHz ≤ BWChannel\_CA ≤ 1200 MHz | 6 |
| R7 | 700 MHz ≤ BWChannel\_CA ≤ 1400 MHz | 7 |
| R8 | 800 MHz ≤ BWChannel\_CA ≤ 1600 MHz | 8 |
| R9 | 900 MHz ≤ BWChannel\_CA ≤ 1800 MHz | 9 |
| R10 | 1000 MHz ≤ BWChannel\_CA ≤ 2000 MHz | 10 |
| R11 | 1100 MHz ≤ BWChannel\_CA ≤ 2200 MHz | 11 |
| R12 | 1200 MHz ≤ BWChannel\_CA ≤ 2400 MHz | 12 |
| NOTE 1: Maximum supported component carrier bandwidths for fallback groups 1, 2, 3, 4 and 5 are 400 MHz, 200 MHz, 100 MHz, 100 MHz and 200 MHz respectively except for CA bandwidth class A. For CA bandwidth classes of fallback group 5, requirements apply for non-interlaced 100 MHz and 200 MHz channel bandwidths (each CA bandwidth class consisting of up to two contiguous sub-blocks each with component carriers of a single channel bandwidth).  NOTE 2: It is mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration within a fallback group. It is not mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration that belong to a different fallback group.  NOTE 3: In this release of the specification, the minimum requirements for intra-band contiguous CA configurations apply for aggregated channel bandwidths up to 1600 MHz (this note is not relevant for UE capability parsing by the network). | | | |

The new fall-back group 5 contains classes with up to 2400 MHz aggregated bandwidth with 12 carriers. The new classes in FBG5 are different from legacy FBGs, because the aggregated channel bandwidth ranges overlap between adjacent classes.

RAN4 have also determined that some UEs have enhanced aggregated bandwidth capability for fallback BW classes compared to the ‘dropping CCs’ interpretation of the BW class fallback rule. Specifically, some UEs have independent maximum limits on number of carriers and aggregated bandwidth. For example: a UE can support R8 to R12 with a 1600MHz aggregated channel bandwidth. RAN4 understanding is that the BW capabilities of such UEs can be indicated by different feature sets of a band combination. RAN4 would like to respectfully request RAN2 to check if a new IE could reduce signaling overhead without potential co-existence issue with the legacy fallback rule and without inter-operability issue if it were introduced with the following characteristics :

1. The new IE is optional for a UE to signal. When the IE is not signalled, legacy operation is assumed:
   1. the UE can still communicate to the network the maximum aggregated BW limitation using the existing framework.
   2. The network understands that the UE supports the legacy fallback BW classes.
2. The new IE applies to intra-band carrier contiguous aggregation as well as an intra-band contiguous carrier aggregation component within an inter-band carrier aggregation. The new IE is separately applicable to each, UL, and DL.
3. When signalled for an explicitly supported BW class in FBG5:
   1. It is in addition to the existing signaling for that BW class.
   2. The network understands that the UE has independent maximum limits on number of CCs and max. aggregated bandwidth for that band. For example, when the UE indicates explicit support for R12 and a max. aggregated bandwidth of 1600Mhz using the new IE, it not only means the max. aggregated bandwidth 1600MHz applies to 12 CCs, but also applies to lower order classes, i.e., 11CCs, 10CCs, and so on.
   3. The IE conveys the max. aggregated bandwidth value for each FeatureSetListPerUplink(Downlink)CC. for example, in each FeatureSetUplink(Downlink).
   4. A band may have multiple values of max. aggregated bandwidth associated with different FeatureSetListPerUplink(Downlink)CC.

RAN4 defers to RAN2’s decision on whether to introduce an IE as proposed above depending on feasibility and benefit.