**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 |
| Nokia | Amaanat | amaanat.ali@nokia.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. |
| Nokia, Nokia Shanghai Bell | No, see comments | 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.    We are not totally convinced about what the additional signalling really achieves. If we redraw the example and formulate above in table, it is clear that RAN2 current assumption is not broken (see also our paper R2-2210244 where we have given some arguments)-  The legacy fallback principle already allows the network to release at least one SCell but maintain the same “overall” capabilities.  As indicated by RAN4, the network is already able to know the “maximum aggregated bandwidth” using existing signalling.  For FBG5 the legacy fallback principle still can be reused because the interpretation allows the understanding that “overall a CC is dropped” but maintains the same capability (i.e., maximum aggregated bandwidth).  Overall, one CC is dropped (dropping 2 from 100 MHz but increasing by 1 in 200 MHz) 🡪 same capabilities are kept. So, why we need new signalling if UE can report just highest BW class R6 and network can then synthesize based on the above table? As in R6 🡪 R3 effectively only 1 CC is dropped and this is consistent in other examples also. |

* + 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 BC 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

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

* + 1. Evaluating RAN4 solution

In phase 1 discussion, majority of companies agreed to rapporteur’s description in section 2.1.1 for the new signalling solution intended by RAN4.

Just to recap what RAN4 indicated in their LS [1].

* “*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.*”

“Dropping CCs” case corresponds to what RAN2 calls the fallback band combination, where the aggregated CA bandwidth is naturally reduced by “dropping CCs”. It is already clear in the current specifications that the UE support of fallback band combinations can be implicitly indicated. In this implicit case, the UE capability on each CC in fallback band combinations is considered the same as that of explicitly signalled superset band combination. In addition, the UE is allowed to explicitly signal feature sets corresponding to fallback band combinations only if the UE capability indicated in those feature sets are different from the superset, e.g. improved MIMO capability in exchange to reducing the aggregated BW.

The new “enhanced” case that RAN4 is referring to is the case where the total aggregated CA bandwidth is kept for CA band combinations corresponding to fallback bandwidth classes. This is different from today’s fallback band combination as explained above. The new UE capability signalling by RAN4 is meant to address this enhanced case. **Rapporteur proposes to focus on this enhanced case in phase 2 discussion.**

RAN4 request in their LS [1] regarding their UE capability signalling solution is as follows. Companies are requested to provide their view.

* “*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…*”

**Question 3:** Do companies think the new signalling solution can reduce UE capability signalling overhead?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Qualcomm Incorporated | Yes | Current UE implementations already use the legacy way of UE capability signalling to indicate different feature sets for different bandwidth classes, like rapporteur’s example of bandwidth class R6-R3.   1. 6x100MHz 2. 4x100MHz + 1x200MHz 3. 2x100MHz + 2x200MHz 4. 3x200MHz   When the aggregated CA bandwidth is the same among those different feature sets, it is a typical case that each feature set per CC therein indicates the same UE capabilities except for the maximum CC bandwidth. This even includes MIMO capability because the overall baseband processing requirement (e.g. achieved data rates) is determined mainly as a function of aggregated bandwidth and the number of MIMO layers.  The new RAN4 signalling solution allows such UEs to use a single feature set and single feature set per CC, with the addition of new IE for maximum aggregated bandwidth.  The signalling reduction gain is going to be higher for those higher bandwidth classes of FBG5. |
| Xiaomi | No | Although “*some UEs have enhanced aggregated bandwidth capability for fallback BW classes compared to the ‘dropping CCs’ interpretation of the BW class fallback rule*”, this does not mean that those UEs have to support enhanced baseband capability (e.g. increased processing capability for larger TBS in a CC of the fallback BW class) when the bandwidth of a CC is increased due to the fallback from e.g. R6 to R5. If the UE’s baseband processing capability is not enhanced, then the UE has to indicate both the superset BW class and the fallback BW class, so that the baseband capabilities (e.g. MIMO layers) can be indicated explicitly. Given that the change in one parameter (e.g. increased bandwidth) for a feature set per CC will cause the change of another parameter (e.g. MIMO layers) of the feature set per CC.  Furthermore, some legacy BW classes (e.g. FBG2 and FBG3) which have overlapping bandwidth with FBG5 still need to be reported together with FBG5, as the legacy gNB does not understand FBG5. This causes extra signalling overheads.  [Rap1] I agree that the baseband capability assigned for a CC is increased when the CC bandwidth is increased. But the overall baseband processing is kept unchanged when the aggregated bandwidth is maintained. So it seems Xiaomi is assuming a UE implementation where baseband processing is not shared among all CCs of intra-band CA. Is this correct understanding?  [Xiaomi] Yes, due to the supportedBandwidthDL indicated in “FeatureSetDownlinkPerCC”. Let’s consider the example below:  R6 6x100MHz  R5: 4x100MHz + 1x200MHz  For R6, a bandCombination-x (e.g. Band-a) includes 6 “FeatureSetDownlinkPerCC”, and each “FeatureSetDownlinkPerCC” includes separate indications of supportedBandwidthDL (100MHz) and maxNumberMIMO-LayersPDSCH (fourLayers).  For R5, a bandCombination-y (e.g. Band-a) includes 5 “FeatureSetDownlinkPerCC”. However as the fallback from R6 to R5 does not follow the rule of the ‘dropping CCs’ for “**Fallback band combination**” (since dropping a CC would anyway result in the reduction of the BW), and does not follow the rule of “same or lower capabilities” for “**Fallback per band feature set**” and “**Fallback per CC feature set**” (since the bandwidth per CC is increased to 200MHz for a “FeatureSetDownlinkPerCC”), the UE would have to indicate R5 for bandCombination-y. |
| ZTE | No | Similar view as Xiaomi.  [Rap2] See Rap1 comment above.  New signaling would introduce a “super Feature set”, it can work only when all of the other feature set parameters/Feature set per cc parameters are the same for all of the sub-cases (e.g. case 1/2/3/4 as in the phase 1 discussion), if there are parameters that are different from that in the “super Feature set”, the UE has to this additional capability with a separate BC, so it seems that it’s hard to say whether it will increase or decrease the signaling overhead.  [Rap3] The cases 1/2/3/4 are already allowed with the existing UE capability signalling. So it should be considered as baseline and not as “increase” in overhead. The new siganlling is trying to put all of them in a single feature set when it is possible.  Furthermore, in the legacy the UE can report a super BC as in below Note2, but as we commented above, the concept of “super feature set” is quite a new thing, we are not sure whether there is any other risk.  PS: “NOTE 2: The UE may advertise a FeatureSetCombination containing only fallback band combinations. That means, in a FeatureSetCombination, each group of  FeatureSets across the bands may contain at least one pair of FeatureSetUplinkId and FeatureSetDownlinkId which is set to 0/0.  ”  [Rap4] Again, the cases 1/2/3/4 are already allowed with the existing UE capability signalling. Please describe exactly what the issue is.  Then if also take interoperability with legacy FBG(e.g. FBG2, FBG3) into consideration, some extra signaling overheads would also be introduced. |
| Huawei, HiSilicon | No | We do not think there is signalling benefit since it is hard to share the same capability in one FeatureSet for different CC bandwidth combinations which cannot be seen as “fallback band combination” from one another.  In our view, with the current signalling of maximum CC bandwidth capability reported in FSPC level(i.e. supportedBandwidthDL/UL), UE is able to indicate any CC bandwidth combinations flexibly in different FeatureSets. The new signalling brings extra limitation/requirement on UE implementation, and as long as there is one capability different between different CC combinations, the solution cannot be used and brings no benefit. |
|  |  |  |
|  |  |  |
|  |  |  |

**Question 4:** Do companies see any co-existence issue between the new signalling solution and the legacy fallback rule?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Qualcomm Incorporated | No | The current fallback band combination rule works without any problem for band combinations where the new signalling solution is used. |
| Xiaomi | Yes | Different from the fallback BW class of the legacy FBGs, for a certain band combination with a higher order of BW class (e.g. R6) of FBG5, the fallback BW class (e.g. R5) of FBG5 does not lead to a “**Fallback band combination**” or “**Fallback per band feature set**” or “**Fallback per CC feature set**”, since the increase of the bandwidth in a CC for the fallback BW class of FBG5 will cause the change of the baseband capabilities (e.g. MIMO layers). |
| ZTE | Yes | For a Featureset, in the legacy it includes both Uplink and downlink part.  For the down link, we assume that the below 4 “sub-feature sets”   1. 6x100MHz 2. 4x100MHz + 1x200MHz 3. 2x100MHz + 2x200MHz 4. 3x200MHz   Can be expressed by a “super feature set”:  6x200MHz / Maximum aggregated bandwidth =600MHz  Then what about the uplink?  [Rap6] For further consideration/discussion, it would be great if you see any reason why it has to be different from DL.  [ZTE-Wenting]We didn’t mean there is difference from DL. We just want to clarify how to understand the DL/UL combination with the newly IE.  Take UL R4 with maximum 400M as an example, there would be 3 sub-feature sets as below:  UL 1: 4x100MHz  UL 2: 2x100MHz + 200MHz  UL 3: 2x200MHz  Then there would be 4 different combinations as below   |  |  |  | | --- | --- | --- | | Index | DL case | Available UL case | | 1 | DL case 1:  6x100MHz | UL 1: 4x100MHz | | 2 | DL case 2:  4x100MHz + 1x200MHz | 2a UL 2: 2x100MHz + 200MHz  2b UL 3: 2x200MHz | | 3 | DL case 3:  2x100MHz + 2x200MHz | 3a UL 2: 2x100MHz + 200MHz  3b UL 3: 2x200MHz | | 4 | DL case 4:  3x200MHz | 4a UL 2: 2x100MHz + 200MHz  4b UL 3: 2x200MHz |   So only when the UE support all of the above combinations, this new “super feature set” can work.  For example, if the UE only support 4b without supporting 4a, the UE can’t report a super feature set as above.  Besides, we think some spec work would be needed to describe the available combinations of UL/DL feature set.  If also adopt “super feature set” for uplink, then how to indicate the available UL sub-feature for each downlink “sub-feature sets”(i.e. above case 1/2/3/4)?  If each sub-feature set, UE indicate its available UL featureset, then the UE still need to report these 4 cases with 4 different BCs.  We are not sure whether it belongs to the “co-existence issue between the new signalling solution and the legacy fallback rule”, but we think this issue shall also be considered. |
| Huawei, HiSilicon | Yes | We think the fallback rule of the new signalling is confused. According to Rapp, the maximum aggregated bandwidth reported in FS level is applicable for the lower order of BW classes with reduced CC numbers, but it is not clear whether it is applicable for all of the cases (e.g. 2\*200M in R2). If the answer is no, then the fallback band combination with different capability should be reported explicitly which increases the signalling overhead.  Besides, we agree with ZTE that there will be confusion on determining the corresponding UL feature set for each DL CC bandwidth combination reported in one super FeatureSet.  [Rap7] For further consideration/discussion, it would be great if you see any reason why it has to be different from DL. |
| OPPO | No with clarification | Firstly, it is good to align what is ‘the legacy fallback rule’.  We understand e fallback BC in R2 language (seems some companies are talking about it) is independent from the FBG in R4 language.  For the FBG in R4 language, we understand it is to say   * If UE support a BC-1 with a higher FBG5 BW-Class, Rx * It supports the lower FBG BW-Class, Ry, which has less CC number and smaller max agg BW, than Rx (but not all CC-number/BW combo allowed by Rx), I.e., the supported BW-combo is still the ones within the set allowed by BC-1, rather than other BC:s defined by the Ry. (somehow the same point by MTK comment in Q1)   That rule applies to old/new FBGs. Please correct us if any different view. |
|  |  |  |
|  |  |  |

**Question 5:** Do companies see any inter-operability issue with the new signalling solution?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Qualcomm Incorporated | Yes (backward compatibility) | Taking the rapporteur’s example in section 2.1.1, the new signalling can be misunderstood to mean the UE supports 6x200MHz (total 1200MHz aggregated CA bandwidth) by legacy UE not understanding the new IE indicating the maximum aggregated bandwidth.  We think the applicability of the new signalling solution should be limited to FBG5 and new bandwidth classes to be introduced going forward, with the following requirements.   * The network supporting FBG5 shall support the new signalling. * The UE can use the new signalling only for intra-band CA component with a FBG5 bandwidth class. |
| Xiaomi | Yes | As discussed for the backward compatibility of 2.1.2 in Phase 1, the UE reporting FBG5 also needs to report FBG2 and FBG3 for the overlapping bandwidth, as the UE does not know whether the gNB is a Rel-18 gNB or a legacy gNB which does not understand FBG5.  [Rap8] This is an issue with the introduction of FBG5 itself, but not specific about the new siganlling. |
| ZTE | Yes | Similar view as Xiaomi  [Rap9] See Rap8 comment above. |
| Huawei, HiSilicon | Yes | There is no inter-operability issue if the new signalling is limited to FBG5.  For FBG2/3, the UE can include it in another BC entry if the UE intends to do so. |
| OPPO | Yes | Same view as QC and HW:  There is no inter-operability issue if the new signalling is limited to FBG5.  For FBG2/3, the UE can include it in another BC entry if the UE intends to do so. |
|  |  |  |
|  |  |  |

**Question 6:** Any other comment?

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

* + 1. Fallback Group definition

In phase 1 discussion, majority of companies agreed that the following current RAN4 requirement in 38.101-2 applies to FBG5 as well.

* “***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*”

The remaining question seems whether the UE indicating the support of FBG5 bandwidth class shall also indicate FBG2 bandwidth class for the same band combination. The motivation is to maintain inter-operability with legacy network not supporting the new FBG5 bandwidth classes. Some companies, on the other hand, are concerned that it results in large signalling overhead due to repeated band combination signalling.

**Question 7:** Do companies think the UE indicating the support of FBG5 bandwidth class shall also indicate FBG2 bandwidth class for the same band combination?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Qualcomm Incorporated | No | If the inter-operability with legacy network needs to be addressed, RAN2 should introduce a new UE capability filter mechanism where the network requests UE capability for CA band combinations with FBG5 bandwidth class. |
| Xiaomi | Yes | This is the normal way that RAN2 used to resolve the inter-operability issue with the legacy gNB. Using a new gNB requesting signalling for filtering the FBG5 does not resolve the problem, as the capability signalling will be forwarded to a target gNB which could be the legacy gNB not understanding the FBG5. |
| ZTE | Yes | Agree with Xiaomi |
| Huawei, HiSilicon | No | It is up to UE implementation whether to include FBG2 BW class in an additional BC entry. We should avoid restricting UE capability reporting in the spec. |
| OPPO | No | Same view as HW. |
|  |  |  |
|  |  |  |

Another question asked over email and in R2-2209384 was whether, under the fallback group requirement (e.g. FBG3), the UE supporting a given band combination with a bandwidth class (e.g. CA\_n46O) shall support the same band combination with a fallback bandwidth class of the same fallback group (e.g. CA\_n46N). It was noted that this question is not specific to FBG5, but applies to legacy FBGs as well.

**Question 8:** Do companies think the UE supporting a given band combination with a bandwidth class shall support the same band combination with a fallback bandwidth class of the same fallback group?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Qualcomm Incorporated | No | Our understanding is that the bandwidth class only regulates the aggregated bandwidth and number of carriers, and the fallback group requirement regulates fallback of only those two parameters.  CA band combination definition in RAN4 specifications additionally defines the carrier bandwidth of each CC. So the fallback group requirement does not apply across different CA band combinations. |
| Xiaomi | No |  |
| ZTE |  | We think it’s hard to say yes or no. From the network side it can derive the fallback capability (e.g. CA with 4 carriers) from the CA\_n46O by releasing one cell. From this aspect: the UE supporting a given band combination with a bandwidth class can support the same band combination with a fallback bandwidth class of the same fallback group.  However there are also some special cases as discussed in the previous meeting, the supported bandwidth combination of the same BCS maybe different, then the network can’t not derive all of the supported capabilitys for “the same band combination with a fallback bandwidth class of the same fallback group.”(e.g.CA\_n46N) from the BC with the higher order bandwidth class (e.g.)CA\_n46O. Which is also highlighted in the Oppo’s paper as below |
| Huawei, HiSilicon | No | The supported fallback band combination with fallback bandwidth class shall obey RAN2’s fallback rule as follows. UE is only mandatory to support fallback band combinations with same CC bandwidth capability.  **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). |
| OPPO | No | It is obvious by comparing n46O and n46N, i.e., for a same FBG, the R4 requirement on mandatory fallback support is not for the BW-combo.  And they (R2 fallback BC, and R4 fallback group) target at different thing, although both talks about ‘fallback’. |
|  |  |  |
|  |  |  |

**Question 9:** Any other comment?

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# 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.