3GPP TSG-RAN WG2 Meeting NR Adhoc-1801 *R2-18xxxxx*

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**Agenda item:** x.x

**Source:** Qualcomm Incorporated

**Title:** Summary for email discussion [100#32][NR] UE capabilities

**Document for:**  Discussion and decision

# Introduction

In this document we provide summary for the email discussion [100#32][NR] on UE capabilities.

# Phase 1 discussion

* 1. Discussion point 1: Whether the linking to BPC should be included in the MRDC BCs

It was discussed RAN2#100 if the linking information to BPC should be signalled per MR-DC band combination. A limitation if the linking information is not provided was clarified in the online discussion.

* + MN will not be able to determine when it selects a BPC how many carriers will be available in the other RAT.

The following figure describe the above limitation. In this example, the UE supports different LTE BPCs between EN-DC band combination 1 and 2. This is because the UE would have to use more resources (e.g. processing) in NR side in case of the EN-DC band combination 2 with respect to the EN-DC band combination 1. Now without any linking information (the red arrows), both LTE BPC#1 and #2 are available from eNB’s perspective. The eNB does not know at the time of selecting LTE BPC, how many NR carriers (or total aggregated bandwidth) the LTE BPC#1 or BPC#2 would allow. For example, the eNB may select LTE BPC#1 because it provides better performance for the same 1CC in LTE, but without knowing it only allows 1CC in NR.



**Figure-1:** BPCs dependent on EN-DC band combination

Companies are asked if the limitation explained above should be address by the standard.

**Question 1:** Should this limitation be addressed?

1. **Yes**
2. **No**

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| Company | Input | Comment |
| Ericsson | No | We agree with the observation that from the ”*EN-DC band combinations*” and the ”*LTE UE capability*” the LTE eNB does not know, which of the two entries allows configuring two NR carriers.  We had raised this issue a long time ago when companies in RAN2 suggested to maximize separation and abstraction among the RATs.  It should be noted that the number of NR carriers is not the only thing that the eNB does not know: The number of NR MIMO layers, the NR modulation orders, the NR Beamforming schemes, the number or width of NR BWPs, ... are all *hidden* in the NR BPC.  Nevertheless, the LTE BPC and the EN-DC BCs allow the eNB to choose an *allowed* configuration. If a network node wants to be smart, it may try to comprehend the BPC table of the other RAT to make an even better decision. |
| Intel | Yes | We believe since a MR-DC band combination is a combination of both LTE and NR, both nodes need to know the other RATs combination information. We are laying the framework for MR-DC (also for NE-DC/NR-NR-DC) where we may run into problems if we isolate the MN and SN domains in terms of capability and configuration. At the least the master node should have the information at hand to control/decide the configuration. We agree that the capability size should be reduced, but there could be more technical co-ordination needed going forward (esp due to the flexibility/complexity NR allows) and isolating MN and SN in the interest of size reduction may lead to design issues later. |
| ZTE | Yes | We think the number of available carriers in the other RAT is needed. It can provide more information for the Band combination and BPC combination selection. Besides, it could also be useful as assistance information for the MN in configuring measurements. |
| MediaTek | Yes | The limitation should be clearly indicated in UE capability, otherwise, network cannot properly configure EN-DC. If anything wrong, RRC reestablishment is the consequence. |
| Qualcomm Incorporated | No | It is desirable to address this issue, but the drawback of the identified solutions seems too significant. This limitation may be something we have to accept as part of selecting the UE capability signalling where RAT specific capabilities are separated.  Network implementation can choose to look into the UE capability of the other RAT, if it desires to optimize. |
| Huawei | No | We have similar understanding that if we need precise BPC handling, not only the number of NR carriers, but also other information would also be visible to LTE base station. For both options listed in Question 2, it would result in the different fallback of BC or BPC and thus would increase the signaling required for BC or BPC report. |
| NTT DOCOMO | FFS | Before discussing if it is a considerable limitation or not, we need to discuss whether the UE is allowed to support different BPC as shown in Figure 1.  In the last meeting, RAN2 agreed as follows:  1 The UE only reports the BPC combinations associated to the reported band combinations rather than BPC combinations associated to all the band combinations supported by the UE, where the reported BPC combinations include the super set BPC combinations and **fallback BPC combinations where the capabilities are different from the superset BPC**.  It is still not clear how different BPC can be reported, especially for MR-DC… For example, in Figure 1, although EN-DC band combination is different between #1 and #2, LTE band combination is the same for #1 and #2. The current agreement is such that only one LTE (/NR) BPC is reported for one LTE (/NR) BC.  If this limitation is not addressed, it implies that in case of Figure 1, the UE has to support LTE BPC #2 + NR BPC #1 for EN-BC 1. Is it common consensus to everyone? |
| Nokia | No | We agree with the discussion of the issue and agree that this is a limitation. One way for LTE to know beforehand what performance to expect from the NR side is the number of NR carriers. However, we have been proposing an “expected throughput” type of performance indicator could be a better choice here (the number of NR carriers addresses the issue but as Ericsson pointed out the BPC information could also be convolved into the decision for LTE to know more precisely the impact of its choice.  For Rel-15, in the interest of progress, we can live without addressing the limitation. |
| Samsung | Yes (FFS) | In general, we like to avoid cross RAT comprehension and think some simple assistance may be good since having a mechanism in which the MN blindly selects/ decides does not seem attractive.  We also agree some indication within BPC of throughput achievable in other RAT may be best (taking into account all aspects like CCs, MIMO, BW,…). |
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**Question 2:** If “yes” for Q1, which solution?

1. Linking information to BPC is signalled per EN-DC band combination.
2. For each LTE BPC, an indication of how many NR carriers (or total aggregated BW) are available is signalled
3. Other solution (please explain)

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| Company | Input | Comment |
| Ericsson | none | **Solution A** **would require including the fallback BCs** which RAN2 agreed to avoid:  In the example in Figure 1 the UE would have to include not only the top-level “Combination #2: LTE 1CC + NR 2CC” but also its fallback “Combination #1: LTE 1CC + NR 1CC”. And these two BCs would each **contain explicit indexes** to the same LTE BPC(s) but to different NR BPCs.  While this solution **adds significant overhead**, it makes **only a small sub-set of the NR capabilities visible** to the LTE eNB. To consider other capabilities, the LTE eNB would anyway have to parse and comprehend the indexed NR BPC entries. And if the eNB wants to do this extra effort, it can do that also without the additional indexes, i.e., without increasing the amount of over-the-air signalling.  **Solution B** would allow the eNB to determine the number of NR carriers using only the EN-DC BCs and the ”LTE” BPCs. But of course, **all other baseband processing capabilities are still ”hidden”** from the eNB so that it cannot make a good estimate of the achievable performance anyway.  Furthermore, this scheme will **result in increasing the total number of LTE BPC entries**: In the example of Figure 1, the LTE BPC#2 offers ”1 LTE CC, 2 Layer, 64 QAM”. As shown, it could be combined with an NR BPC#2 offering ”2CC, 2 Layer, 64 QAM”. But it may also be compatible with an NR BPC#3 offering e.g. ”1 CC, 4 layer, 256 QAM”. In the currently agreed structure the LTE BPC#2 is compatible and linkable with both. But by including the *number-of-NR-carriers* into the LTE BPC, such a UE would have to split its LTE BPC#2 into two (one with 1-NR-CC, one with 2-NR-CCs).  And finally, Solution B would be against the intention of separating the RAT-specific capabilities from each other, i.e., it would replicate the NR parameter *number-of-NR-carriers* in the LTE BPC. |
| Intel | **A** | We think that linking of BPC to RF BCs is a better approach. Providing the number of carriers can solve the current problem, but if more information is needed (like the aggregated BW example), then adding that information to BPC can:   * Make the BPC entry definition more complex with the non-critical extensions * Increases the size, which essentially nullifies the ‘size-increase’ reason which is used against linking RF BCs with BPC in the first place. |
| ZTE | Solution A | Besides the problem in the figure 1, our another concern is that without the linking information per BC, the MN node can’t get enough dependency information to make decision.  We assume that UE support the following two band combinations:  #1 Band 1A+ NR Band 2A--> Only support LTE BPC #1 + NR BPC #2  #2 Band 1A+ NR Band 3A--> Only support LTE BPC #2 + NR BPC #3  And according to the UE measurement report, there are no neighbor NR band 3 cells(there are only neighbor cells on the band 2 ).  Then if the eNB select Band 1 and BPC#1, and inform it to the NR, NR may accept the selection. But once the eNB select Band 1 and BPC#2, NR has to re-negotiate with eNB for that NR only can select NR BPC #3, but the NR-BPC #3 can’t be supported by the Band 2(for example the MIMO layer in NR-BPC #3 is higher than the maximal supported MIMO layer of Band 2). |
| MediaTek | Solution A | We consider only solution A can provide sufficient information to do proper configuration. |
| Qualcomm Incorporated | None | We agree with Ericsson on the drawback of the identified solutions. |
| Huawei | none | See above. |
| NTT DOCOMO | FFS | See our comment to Q1 |
| Nokia | None | For Rel-15, we don’t see a need to address the limitation. |
| Samsung | Solution B | See our comment for Q1. |
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* 1. Discussion point 2: How to address the information from RAN4 about MIMO capability and intra-band non-contiguous CA in relation to carrier separation

RAN4 requested RAN2 to work on UE capability signalling to enable the following in their LS ([R2-1712137](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_100/Docs/R2-1712137.zip)/ R4-1711623).

* The UE support of NC CA is conditioned on the frequency separation (gap) between the CCs. This capability may be different for UL NC CA and DL NC CA.
* The MIMO capability for intra-band NC CA may depend on the CC frequency separation supported.

RAN4 also sent another LS indicating their preference to include some form of MIMO layer capability in CA band combination to address possible “*constraints on how the number of RF chains can be assigned to different bands*” ([R4-1714257](ftp://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_85/Docs/R4-1714257.zip)). Two options are mentioned in the LS (with the disclaimer “*other options not precluded*”).

* Option 1: Signal the number of MIMO layers per band per CA band combination for the combinations that have constraints
* Option 2: Signal the maximum number of MIMO layers per CA band combination for the combinations that have constraints

It seems sensible to discuss the above all together to come up with a streamlined UE capability signalling structure.

**Question 3:** Should these UE capabilities be implemented in UE capability signalling, and if yes how?

1. **Yes (please explain solution)**
2. **No**

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| Company | Input | Comment |
| Ericsson | OK (for the intra-B NC with max freq)  No  (for MIMO in BC) | In LTE, NC-Intra-Band CA is indicated by a BandCombination with two BandEntries with the same band number. We prefer using this signalling variant for UEs that “*can support any CC placement*”.  **The UEs that “*support NC CA only when CC frequency separation is smaller than full width of the operating band*” could instead use the intra-band contiguous CA signalling with a (new) bandwidth class.** That class defines both the maximum total bandwidth from edge to edge as well as the total number of supported carriers and served carrier bandwidths.  E.g., a UE supporting aggregation of two directly adjacent carriers indicates 1C as today. A UE supporting aggregation of two intra band NC carriers if the total edge-to-edge bandwidth is below a certain limit, indicates e.g. 1CX. RAN4 would define what "class CX” means, such as ”*2 carriers, up to 20 MHz each, total bandwidth up to* ***80 MHz***”. They could also define a ”class CY” meaning e.g. ”*2 carriers, up to 20 MHz each, total bandwidth up to* ***160 MHz***”.  We assume that UEs supporting CY would also support CX and C. UEs supporting CX would also support C. Hence, UEs should omit these fallback BCs.  A UE may add different BPCs for ”Class CX” and ”Class C” without duplicating the fallback BC. But since the intention is to operate these two carriers in both cases with a single RX chain, we don't expect UEs will typically do that and just list ”class CX” in the BPC. As agreed, the NW knows that this BPC applies both for BCs with class CX but also to those with class C.  If the UE supports also the traditional intra-band non-contiguous CA without limited frequency separation, it will list it as 1A-1A in the BC table since it is not a super- or fallback- BC of 1C or 1CX. And, as suggested by RAN4, this would also allow UEs to indicate that “*the MIMO capability for intra-band NC CA may depend on the CC frequency separation supported*”: A UE could indicate BPCs with different number of MIMO layer for the 1A-1A case and the 1CX case.  As discussed in the previous RAN2 meetings and as captured in RAN2's working assumption, we don't think that the BCs should contain the number of MIMO layers. |
| Intel | Yes  Option 1. | We are a bit concerned on the question ‘ should the capabilities be implemented? ‘. There are ways in which the capability size can be reduced (reducing the number of CA BCs to be reported etc..). But not implementing the means by which the UEs can report certain capabilities in the interest reducing the size, effects the UEs negatively, esp when RAN4 (and in some cases RAN1) WGs have agreed that the UE needs to be able to report the support/non-support of these.  We prefer option 1, aggregating the MIMO layers for the entire BC would mean that the UE cannot report the MIMO variations based on the intra-band non-contiguous gap. Also there could be other potential capabilities that need per band in BC reporting (like measurement gap info for NR SA). |
| ZTE | OK | Our understanding is that, this kind MIMO capability is only related to the band and the frequency Separation, so it shall be defined per frequency separation per band(not per band combination) as follows:  SupportedMIMOList ::= SEQUENCE (SIZE (1..maxBands)) OF SupportedMIMO  SupportedMIMO = ::= SEQUENCE {  bandNR FreqBandIndicator,  MIMOUL MIMOParametersUL optional  MIMODL MIMOParametersDL optional  }  MIMOParametersUL ::= SEQUENCE (SIZE (1..maxFreqSep)) MIMO-ParametersUL  MIMOParametersDL ::= SEQUENCE (SIZE (1..maxFreqSep)) MIMO-ParametersDL  MIMO-ParametersDL ::= SEQUENCE {  fRequencySeperation FrequencySeperation  SupportedMIMOlayer\_DL SupportedMIMOlayer\_DL  }  MIMO-ParametersUL ::= SEQUENCE {  fRequencySeperation FrequencySeperation  SupportedMIMOlayer\_UL SupportedMIMOlayer\_UL  }  SupportedMIMOlayer\_UL ::= ENUMERATED {...}  SupportedMIMOlayer\_DL ::= ENUMERATED {...}  Then for each band combination, according to the latest Asn1 structure: the MIMO layer is defined per cc, obviously when the network configure NC CA, the maximum number of MIMO layers for NC CA on a certain Band shall under the limit of the MIMO layers listed above. |
| MediaTek | Yes, option 2 | For intra-band non-contiguous CA, if UE uses the same DL/UL RF paths, for BPC, it should be regarded as a single carrier instead of CA. For example, UE cannot be configured total 16 layers (8+8) in certain 2CC DL CA cases since the guard band is less than a threshold. In these cases, UE can only support total 8 layers. However, it is difficult for BPC table to address such concern since BPC does not differentiate inter-band and intra-band non-continuous CA.  We should let RAN4 decide the gap of the two CCs (i.e. the threshold X for band separation) and it is sufficient for UE to signal a maximum number of MIMO layers per band combination (optional 2) for those special CA band combination. |
| Qualcomm Incorporated | Yes  Option 2 | Our proposal is to signal maximum frequency separation for DL and UL explicitly (proposal 6-8 in R2-1712369). We are fine with RAN4’s option 2 for two use cases identified. This means that the frequency separation may or may not be signalled (OPTIONAL in ASN.1) depending on the type of UE implementation constraints. |
| Huawei | OPEN | In our understanding one important principle of capability structure design in NR is to decouple UE capability from CA band combination as much as possible to reduce the different fullback combinations.  Based on this reason, we think it is worth considering to report the maximum CC frequency separation together with MIMO layer per band so that the network could know the allowed CC frequency separation for NC CA carrier combination. We think for this part, it would be good that RAN4 can provide RAN2 more inputs before we making UE capability discussion as currently it is unclear how the MIMO capability would be affected by frequency separation. |
| NTT DOCOMO | No | On the MIMO capability, We share the same view Ericsson and Huawei. Given that RAN2 is trying to get rid of one root cause of signalling explosion (MIMO capability) from the BC signalling, the MIMO capability should be kept in BPC even for intra-band non-contiguous BCs.  On the frequency separation, it could be specified in the RAN4 spec as Ericsson pointed out. We’re of opinion to ask RAN4 if the frequency separation can be specified in the RAN4 specification as a part of the denotation for NR CA band combination. |
| Nokia | Yes | We would propose to have a common approach for all non-contiguous CA for both FR2 and FR1. RAN4 agreed to introduce a max separation as a UE capability for FR2 and capability signalling should consider an additional parameter for the limited max frequency separation (this is an optional parameter if UE does not support arbitrary separation). This is more future-proof compared to the proposal from Ericsson. |
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# Phase 2 discussion

Building on top of the discussion (and hopefully conclusion) of the phase 1 discussion, the email discussion moderator would like to propose to further discuss the following aspects.

* 1. Discussion point 3: Inter-node coordination for BPCs in case of EN-DC

For EN-DC band combination coordination, the following was agreed in RAN2#100. It is left open in the meeting how the BPCs are coordinated in case of EN-DC.

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| * SCG-ConfigInfo (MN to SN): MN indicates which NR BCs the SN can select by field allowedBandCombinationNR that indicates a list of indices of all the EN-BCs in the MR DC capability container that includes the LTE BC it selected * SCG-Config (SN to MN for the case that the SN wants to request to use a different EN-BC): SN indicates which NR BC the SN wants to use by field requestedBandCombinationNR that indicates a list of indices of all the EN-BC in the MR DC capability container that includes the NR BC it wants to use. |

Discussion on the same coordination issue for BPC was postponed in RAN2#100.

[Moderator’s note] Hoping that we can make an informed decision after phase 1 discussion.

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| Company | Input | Comment |
| Intel |  | This is dependent on if RF BCs have links to BPC. If yes, then the RF/BPC table is consistent and MN/SN can look-up BPC without significant co-ordination. But since the RF linking to BPC is not decided, this needs revision after phase-1 discussion. |
| Huawei |  | In our understanding, in SCG-ConfigInfo MN indicates which NR BPCs the SN can select based on selected BPC in MN and BPC dependency in MR-DC container, and in SCG-Config SN indicates which NR BC wants to use. This is relevant to Question 1, if NR BPC is not visible to LTE, it seems no sense to allow the SN to request a different BPC to MN as MN has no idea on what it is. |
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* 1. Discussion point 4: Decoupling of DL and UL bands for band combinations

3 options for the decoupling of DL and UL bands were discussed in the email discussion [99bis#28][NR] on UE capability ASN.1 (R2-1712677, also see the appendix of this document). It was suggested to further discuss between the option 1 and option 3.

No conclusion could be reached in RAN2#100, mainly due to lack of clarity on the content of the band combination UE capability signalling (e.g. whether MIMO capability is signalled).

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| Company | Input | Comment |
| Ericsson | Option 1 | In our contribution [R2-1713432](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_100/Docs//R2-1713432.zip) to RAN2-100 we provided an ASN.1 example for option 1 that can be summarized as follows:   * each BandCombination comprises of (one or) several Band Entries. * each BandEntry includes an NR or EUTRA band number * each BandEntry contains one downlink bandwidth class * each BandEntry contains a list of uplink bandwidth classes. The lists of UL BWCs in all Band Entries of a BC must have the same length. Entries with the same “position” form a possible UL combination. * in NR and EUTRA Band Entries an uplink bandwidth class may be absent (NULL) indicating that the UE supports (in this band combination and in combination with the set of configured uplink carriers) only a downlink SCell on this band * in an NR Band Entry the downlink bandwidth class may be absent (NULL) indicating that the UE supports (in this band combination) only an Supplementary Uplink carrier on this band   Besides being more signalling efficient (fewer “band numbers”, no explicit indexes) the structure is also easy to comprehend since things that belong together are signalled together (not in separate linked lists). |
| Intel | Option 3 | BITSTRING is more effective in reducing the size. We also think that the UL capabilities are usually specific to the UL (with CA or without) and so BC\_ParameterUL can carry these irrespective of the DL CA on which this capability is linked to. In this case BITSTRING is a compact notation assuming there won’t be many UL variants (due to the skipFallback logic). |
| ZTE | Option 3 | We slightly prefer option 3 as it can reduce the UL band combination repetition. For the additional indexes problem mentioned by E/// , we think that some optimization should be made for the option 3: such as delete the “BandUL” in the “BC\_parameterUL” structure  BC\_ParameterUL ::= SEQUENCE {  ~~bandsUL = [BandX, BandY],~~  bwClassUL = [A,A]  }  We can take the same UL structure as in the option 1. e.g. only bandwidth class information( The gNB can get the corresponding Band information from the “BAND DL”).  BC\_ParameterUL\_List ::= SEQUENCE (SIZE (1..maxUL-BandCombination)) OF BC\_ParameterUL  BandCombination\_List ::= SEQUENCE (SIZE (1..maxDL-BandCombination)) OF BandCombination  BC\_ParameterUL ::= SEQUENCE {  ~~bandsUL = [BandX, BandY],~~  bwClassUL = [A,A]  }  BandCombination ::= SEQUENCE {  bandsDL = [BandX, BandY, BandZ],  bwClassDL = [C,A,A],  ul-BC-List = BIT STRING (SIZE (1.. maxUL-BandCombinations))  }  By this scheme, the “maxUL-BandCombination” equals to the number of the different UL bandwidth class combinations. Then, according to the table in the 36.101(for that the corresponding NR table hasn’t been endorsed, we take LTE as an example), we can find that the ul bandwidth class combinations are the same for most of the DL band combinations, e.g. A-A or A-C. Thus, the BIT STRING size of “ul-BC-List” won’t be too large. |
| MediaTek | Option 3 | Agree with Intel. We believe bit string is the most efficient way to avoid UL BC across DL BC. |
| Qualcomm Incorporated | Option 1 | We agree with Ericsson and ZTE that we should adopt a structure where frequency bands are not repeated for DL and UL. We can think about optimizing “*UL-BC-List*”, e.g. by using BIT STRING (the solution suggested by ZTE). |
| Huawei | Option 3 | We slightly prefer Option 3 with similar reasons mentioned by Intel. We understand the example from Ericsson in the Appendix where the UE supports 10 bands and can do UL CA of any 3 of them resulting in 120 possible combinations, however we are not sure in the same case how Option 1 works better as the list would be similarly long. We want to understand better on this before making a concrete conclusion. |
| NTT DOCOMO | Option 1 | Agree with Ericsson and Qualcomm. In our understanding, Ericsson’s example of Option 1 in R2-1713432 has already covered ZTE’s suggestion, i.e. not duplicating the band number for UL. |
| Nokia | Option 1 | The baseline benefit is clear from Option 1 i.e. the Band Identifier information is not duplicated in the UL BC entry. The gain from Option 3 over Option 2 is very difficult to evaluate without having any common assumptions in RAN2 between companies as to how many maximum BC combinations in DL and UL (which are not fallback) are possible so that a comparison could be made regarding the maximum size of the encoding for each band combination entry. We only guess that these must be rather limited in number (and quite UE architecture and hardware specific constraints which are not easy to factor in). |
| Samsung | Option 1 | We agree with Ericsson and Qualcomm. We think the overhead of index signalling is not clearly solved. Option 1 may cover all which option 3 covers, but it is simple and there are no uncertainty of size. |
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# Summary

In this email discussion, the following points were discussed.

* **Discussion point 1:** Whether the linking to BPC should be included in the MRDC BCs
* **Discussion point 2:** How to address the information from RAN4 about MIMO capability and intra-band non-contiguous CA in relation to carrier separation
* **Discussion point 3:** Inter-node coordination for BPCs in case of EN-DC
* **Discussion point 4:** Decoupling of DL and UL bands for band combinations

Based on this email discussion, the moderator would like to suggest the following.

Tentative conclusion:

**Discussion point 1:** No conclusion

**Discussion point 2:** Agree to address the MIMO capability constraints identified by RAN4. Signalling details FFS

**Discussion point 3:**  No conclusion (conditional to discussion point 1)

**Discussion point 4:**  Adopt a solution where frequency bands are not repeated for DL and UL and “UL-BC-List” is signalled by BIT STRING > Combination of option 1 and option 3.

# Appendix (excerpt from Email Discussion on [99bis#28][NR] UE capability ASN.1)

**2.1 ASN.1 structure of decoupling of DL and UL bands:**

ASN.1 structure for decoupling of DL and UL bands were discussed by the email discussion [[1](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_99bis/Docs/R2-1710609.zip)] before RAN2#99bis and online discussion at RAN2#99bis. However it was not concluded. Please see the following part of RAN2#99bis Chairman Notes for remind:

[R2-1710609](https://ericsson.sharepoint.com/sites/star/Shared Documents/Users/kyeongin/AppData/Data/3GPP/Extracts/R2-1710609_Email report_DL_UL_decoupling_v4.doc" \o "C:Data3GPPExtractsR2-1710609_Email report_DL_UL_decoupling_v4.doc) Email discussion report on [99#24][NR] Decoupling DL band and UL bands Intel Corporation discussion Rel-15 NR\_newRAT-Core

=> Noted

[R2-1710691](https://ericsson.sharepoint.com/sites/star/Shared Documents/Users/kyeongin/AppData/Data/3GPP/Extracts/R2-1710691.docx" \o "C:Data3GPPExtractsR2-1710691.docx) Further analysis on decoupling DL and UL bands Intel Corporation discussion Rel-15 NR\_newRAT-Core

- DOCOMO think in the email most companies preferred approach 1 and think this could be a viable option. Think it also depends whether the some things such as MIMO capability is included in the BC.

- Intel think we need to consider if option 3 has a problem with duplicating capabilities. The MIMO aspects needs to be discussed based on other email but think MIMO should be in the BC.

=> Comeback to discussion after other capability discussion

- Update from offline: Other discussions have not progressed enough to continue this discussion.

=> Can be discussed as part of the UE capability email discussion.

Since key issues were already discussed by the previous email discussion and some dependency issues (e.g. whether MIMO capability is included in the BC) were already discussed at RAN2#99bis, it would be good to directly check companies’ preferred option out of the discussed options. Three options were copied from email discussion [[1](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_99bis/Docs/R2-1710609.zip)] below. Note compared to the one from [1], there is some modification in ASN.1 for clearer comparison.

Option1: The following example structure is a modified version from the proposed structure in [[2](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_99/Docs/R2-1708031.zip)]. In each band combination, there is one DL band combination and a set of UL band combinations (UL-BC-List IE in the example) that can be combined with the DL band combination. maxUL-Bandcombinations of UL BCs can be included. With UL-BC-List, it includes corresponding bwClassUL and UL related capabilities. In LTE case, multiple Timing advance capability can be an example of UL capability.

BandCombination\_List ::= SEQUENCE (SIZE (1..maxDL-BandCombination)) OF BandCombination

BandCombination ::= SEQUENCE {

bandsDL = [BandX, BandY, BandZ],

bwClassDL = [C,A,A],

UL-BC-List = SEQUENCE (SIZE (1.. maxUL-BandCombinations)) OF UL-BandCombination

}

UL-BandCombination ::= SEQUENCE {

bwClassUL = [A,A,-],

}

Option2: Alternative structure is based on a proposal in [[3](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_99/Docs/R2-1708784.zip)]. Three band combinations IE groups (1) DL BC, 2) UL BC and 3) DL/UL BC are defined. DL BC includes UE capabilities which are defined per DL band/DL BC. UL BC includes UE capabilities which are defined per UL Band/UL BC. All remaining UE capabilities which are defined per DL/UL BC, are included in DL/UL BC. In each DL BC and UL BC, an Index is included and this index is used in DL/UL BC to link to the corresponding DL BC and UL BC. UL-BC-List is introduced to indicate multiple UL BCs per DL BC similar to option1.

BC\_ParameterDL\_List ::= SEQUENCE (SIZE (1..maxDL-BandCombination)) OF BC\_ParameterDL

BC\_ParameterUL\_List ::= SEQUENCE (SIZE (1..maxUL-BandCombination)) OF BC\_ParameterUL

BandCombination\_List ::= SEQUENCE (SIZE (1..maxDL-BandCombination)) OF BandCombination

BC\_ParameterDL ::= SEQUENCE {

bandsDL = [BandX, BandY, BandZ],

    bwClassDL = [C,A,A]

}

BC\_ParameterUL ::= SEQUENCE {

    bandsUL = [BandX, BandY],

bwClassUL = [A,A]

}

BandCombination ::= SEQUENCE {

bc\_ParameterDL\_Index, // Index = order

UL-BC-List = SEQUENCE (SIZE (1.. maxUL-BandCombinations)) OF bc\_ParameterUL\_Index

}

Option3: The combination between option1 and option2. It only has UL index (as the format of BIT STRING).

BC\_ParameterUL\_List ::= SEQUENCE (SIZE (1..maxUL-BandCombination)) OF BC\_ParameterUL

BandCombination\_List ::= SEQUENCE (SIZE (1..maxDL-BandCombination)) OF BandCombination

BC\_ParameterUL ::= SEQUENCE {

bandsUL = [BandX, BandY],

bwClassUL = [A,A]

}

BandCombination ::= SEQUENCE {

bandsDL = [BandX, BandY, BandZ],

bwClassDL = [C,A,A],

ul-BC-List = BIT STRING (SIZE (1.. maxUL-BandCombinations))

}

**Q1: Companies are encouraged to provide the input on the preferred option out of three options above.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Option1  (List company name) | Option2  (List company name) | Option3  (List company name) | No strong preference  (List company name) | Additional comments |
| NTT DOCOMO |  |  |  | Given that RAN2 aims to take capability signalling away from the band combination, the advantage of Option 2/3 is diminishing? |
|  |  | Qualcomm Incorporated |  | We think using a list of indexes to UL band combination, as opposed to the BIT STRING, is better in term of overhead, because the UE may support a large number of UL band combinations, while the number of UL band combinations linked to a DL band combination is rather limited. |
|  |  | Huawei, HiSilicon |  | As in discussion [99#24] previously, Option 3 avoids the duplication of UL BC information. The only duplication should be if we have different DL capabilities (other than MIMO) for the same DL BC depending on the UL BC. |
|  |  | MediaTek |  | We believe bit string is the most efficient way to avoid UL BC across DL BC. |
| Ericsson |  |  |  | Options 2 and 3 may result in a lot of overhead: Example: A UE supports in total 10 bands and UL CA of any 3 out of those 10 bands. It might advertise up to 120 UL BCs (without any fallback BCs!). Hence, the ul-BC-List bit string has to be 128 bit. If this UE supports DL CA of any 5 bands, it advertises up to 252 DL band combinations (without any fallback BCs!). Hence, the 128-bit bit-string would be repeated up to 252 times, i.e., 4000 Byte. Furthermore, the band numbers (BandX, BandY) would be listed both in the DL and in the UL BCs |
| Nokia | Nokia | - |  | - Option 1 clearly provides the baseline gain from the reference signalling model in LTE.  - An example (256 combinations of DL and 32 combinations of UL band parameters): Assume for each DL entry there are at least 2 or 3 UL combinations possible:  Option 2: Size of Band Combination entry in bits (8 bits DL index + 5\*3 UL index) 🡪 23 bits  Option 3: Each Band Combination entry requires 8 bits + 5 bits 🡪 13 bits)  It seems difficult how UE can partially fill in bitmap when asked to only report subset of band combinations.  Essentially the bit string fixes a position for the UL-BC and then the order is fixed so partial reporting does not seem to be allowed. If the number of UL-BCs are very high then the bit string approach is attractive and the indexing approach starts becoming prohibitive.  Conversely, for small number of UL-BCs, the difference between Option 2 and 3 is not much.  One issue with Option 3 is that the bit map cannot reflect unambiguously when the network is requesting a subset of BCs, if a UL-BC is supported or not (a 0 is indicated in the bitmap and cannot clearly discriminate if the UE did not support the UL BC or did not simply fill it because the network asked it to be filtered away).  We support Option 2 because it is easier to extend to changes in the future compared to Option 3.  Note: FFS how fallback combinations are indicated |
|  |  | Intel |  | We think there is not much difference between options #2 and option #3, but with option #2, the number of bits needed for each UL BC depends on atleast 9 bits for each UL index. The advantage of option #2 over option #3 is when total number of band combinations with UL (with or without CA) is less than 9. Otherwise BITSTRING is more effective. |

[Observation1]: Based on the companies’ inputs, there is no clear majority companies’ preference. However option2 has only one supporting company out of seven companies, so RAN2 is asked to continue the discussion to select the preferred option between option1 and option3.

[Proposal1]: RAN2 is asked to continue the discussion to select the preferred option between option1 and option3 for decoupling of DL and UL bands.