**3GPP TSG-RAN WG2 Meeting #126 R2-240xxxx**

**Fukuoka, Japan, May 20-24, 2024**

**Source: Qualcomm Incorporated**

**Title: Offline discussion summary: [AT126][502][R18MobE] UE cap Early TA acquisition (Qualcomm)**

**Document for: Decision**

**Agenda Item: 7.4.5**

# Introduction

This document summarises the following offline discussion.

* [AT126][502][R18MobE] UE cap Early TA acquisition (Qualcomm)

Scope: Continue offline, i.e. based on R2-2405245 and R2-2404705 and the related discussion, determine if change is needed / desired and converge as far as reasonable, determine way forward, or alternatives / discussion points, If applicable, check impact on this discussion of R4 involvement, if any.

Intended outcome: Report

Deadline: CB, see schedule

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

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| --- | --- | --- |
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# Discussion

* 1. Background

RAN1 and RAN4 Rel-18 feature lists [1][2] define the following features requiring “per band-pair” UE capability signalling.

RAN1 [1]

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| --- | --- | --- | --- | --- |
| **Features** | **Index** | **Feature group** | **Components** | **Type** |
| 45. NR\_Mob\_enh2 | 45-5a | RACH-based early TA acquisition with simultaneous transmission | Support of simultaneous transmission to handle the overlap between UL transmission on serving cell(s) and PRACH on candidate cell(s) | Per band pair per band combination (between the target band for RACH transmission and band under UE’s current band combo) |

RAN4 [2]

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| --- | --- | --- | --- | --- |
| **Features** | **Index** | **Feature group** | **Components** | **Type** |
| 39.  NR\_Mob\_enh2 | 39-4 | Interruption on DL slot(s) due to PDCCH- ordered RACH transmission | Capability on whether UE may cause interruption on DL slot(s) on serving cells due to PDCCH-ordered RACH transmission | Per band pair (between the target band for RACH transmission and band under UE’s current band combo) per band combination |
| 39.  NR\_Mob\_enh2 | 39-4a | Interruption due to RF retuning for PDCCH- ordered RACH | Indicates the interruption length (Y ms) due to RF re-tuning for PDCCH ordered RACH of which the resources are not fully contained in any of UE’s configured UL BWP(s) of active serving cells | Per band pair (between the target band for RACH transmission and band under UE’s current band combo) per band combination |
| 39.  NR\_Mob\_enh2 | 39-5 | RF/BB preparation time for PDCCH-order RACH | Indicates the RF/BB preparation time for PDCCH ordered RACH of which the resources are not fully contained in any of UE’s configured UL BWP(s) of active serving cells | Per band pair (between the target band for RACH transmission and band under UE’s current band combo) per band combination |

* 1. General principle

Offline discussion rapporteur understands companies are in agreement that the standard needs to support the UE capability signalling where the “target band” for RACH transmission is any supported band within or outside the bands of the band combination.

**Proposal 1:** The target band for RACH transmission is any supported band within or outside the bands of the band combination.

**Q1:** Agree to proposal 1?

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes |  |
| Huawei | Yes | However, we understand that RAN1 is still discussing this. |
| MediaTek | Yes |  |
| Nokia | Yes, but | We understand RAN4 is still discussing this and may share with us their conclusion (which apparently might be limiting this to BC of the serving cells). |
| Qualcomm Incorporated | Yes |  |
| Intel | Yes |  |

* 1. Solution

Two solutions, with some variants within a solution, have been discussed so far. Rapporteur’s attempt to describe the solutions and discussion points can be seen below.

* + 1. Solution1: Static UE capability reporting in *UECapabilityInformation*

This solution replies on the normal UE capability reporting signalling we have today. For each band of a band combination, the UE signals an index to the target band. Two variants for signalling granularity were discussed.

* Option 1: Per band per BC (in *BandCombination*) [3]
* Option 2: Per Feature Set [4]

For further discussion:

1. What should the band index above be pointing to, e.g. a band in *supportedBandListNR* (Max. size 1024)?
2. Should we aim for some signalling overhead reduction? For example, we could consider additional UE capability filter/request by the network indicating potential target bands for RACH transmission, in *UECapabilityEnquiry* message.
   * Note that the existing UE capability filter *FreqBandList* would not really help because its maximum size is 1280.
   * It was pointed out during additional offline discussion that the network-requested target bands may have to be per CA band combination. Or can it be a common target band list?
     1. Solution2: Dynamic UE capability reporting [5]

This solution can be summarized as follows.

* In *RRCReconfiguration*/*RRCResume*, the network configures, a list of NR bands that the UE is requested to report as the target bands for RACH transmission.
* In *RRCReconfigurationComplete*/*RRCResumeComplete*, the UE reports, for each requested target band, the interruption time / preparation time required for the serving cells.

For further discussion:

1. It was pointed out during additional offline discussion that the network-requested target bands may have to be per candidate LTM configuration because each candidate LTM configuration may include different CA band combination. Or can it be a common target band list?
2. Rapporteur identified one potential drawback of this solution. The network may want to configure LTM candidate cells based on the UE capability of early TA acquisition, together with other relevant UE capabilities. This solution does not allow this because the network will know about the early TA acquisition capabilities only after LTM candidate configuration.

**Q2:** Companies are invited to provide their comment for the solutions and discussion points above.

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| --- | --- |
| **Company** | **Comment** |
| Ericsson | Solution 1:  Discussion point 1: It makes sense that the index points to a band in supportedBandListNR as hinted by the rapporteur.  Discussion point 2: If we go for Per Feature Set, my understanding is that there would be no need to reduce the signaling size since the index size would be “hidden” in the FeatureSetID, while also the expectation should be that the same/few FeatureSetIDs can be used for many BCs.  If we go for Per band per BC (in BandCombination) then we should find indeed some signaling reduction solution. If we would have a NW filter for target bands for RACH transmission, typically this filter would also include target bands for neighbour nodes (to avoid re-enquiring the UE capabilities after handover), and then multiple bands would be added to this filtering, which at the end would be the same as FreqBandList? On whether the network-requested target bands may have to be per CA band combination – by that time the NW does not know which BCs the UE supports, so if it would be per BC the NW would just include all the possible combinations of bands (possibly with BCs that the UE does not even support), so it seems simpler to have a common target band list, though as mentioned before this list would look pretty much like FreqBandList. All in all, we could say that FreqBandList is also applicable for the UE to filter these capabilities.  Solution 2:  Discussion point 1: For a certain candidate LTM configuration, the UE can provide new interruptions in RRCReconfigurationComplete once it applies that candidate LTM configuration. Hence it seems sufficient to have just one common target band list. As the rapporteur pointed out, this solution does not allow for the NW to take the interruption into account when providing the candidate configuration, hence it should not be a problem for this solution that the UE sends possible new interruptions in RRCReconfigurationComplete once it applies that candidate LTM configuration.  Discussion point 2: It would be nicer if these capabilities can be taken into account when configuring candidates, otherwise the NW may have to assume the worst interruption case when configuring the candidates, and maybe it could preclude the benefit of providing smaller interruption values later on. From that perspective, we understand that even if LTM is configured, the NW is not required to configure this list of NR bands since it can also assume the worst case. |
| Huawei | For Solution 1 Option 1, this is without any signalling overhead reduction.  For Solution 1 Option 2, our understanding is that each entry of the list of target bands or bitmap in each (source) band in the band combination (BandParameters) will be corresponding one to one to a band in appliedFreqBandList. If it is clear that the UE and network will support many more target bands for each source band in a band combination, we can think of further signalling overhead reduction. However, with FS, such list/bitmap can be reused and thus there may not be a need for this optimisation. One further point mentioned during the offline is that of fallback BC where UE may want to indicate more target bands than the parent BC for a band in a band combination. For this case, the fallback BC can be reported explicitly with the band pointing to a FS with more target band.  For Solution 2, we also think that the network-requested target bands may have to be per candidate LTM configuration as when the target band becomes the source band, the band combination changes and the capability for the target band may also change. We are just wondering whether network just requesting the target bands are sufficient or the network also needs to indicate all possible CA band combinations that may occur for the CA operation. Maybe it is ok for the UE to also include the new capability in the RRCReconfigurationComplete. |
| MediaTek | Proposal 1 is right. The target band can be inside or outside of serving cell band combination. The change is needed in either way to align with RAN1/4 intention.  For solution 1 (static way, either op1 or op2), the band list should be replaced by FreqBandIndicator to present any target band outside the band list. The signalling overhead reduction mentioned by the rapporteur can be performed in either op1 or op2 as the same way. Meanwhile, op2 (FS) can save some extra overhead by reusing the capabilities of bands for different BC.  For solution 2 (dynamic way), the capabilities are reported as a target band list under the current band combination. These capabilities for target bands need to be updated if network changes the current band combination.  For discussion point 2, we understand this request can be delivered via LTM candidate configuration, or maybe it can be sent earlier so that the network will know about the early TA acquisition capabilities before LTM candidate configuration, and the drawback does not exist. This may need to be further discussed and clarified.  Considering that the current solutions are not very clear, we suggest to postpone this discussion to the next meeting. |
| Nokia | We have some concerns with Solution2 related to the drawback mentioned by the rapporteur (on the lack of such capability information at the network at the time of LTM configuration). On the other hand, we agree this is the most signalling-friendly option.  For Solution1, we think per-FS signalling can be adopted (Option 2), which would mitigate some signalling overhead concerns as discussed in [4].  supportedBandListNR seems appropriate for identifying the target band index, but if companies have further concerns about the capability signalling overhead for source-target band pairs (e.g. if UE supports a large number of bands) then additional filtering can be considered. For filtering, a common target band list may be sufficient, as the UE can anyway signal these capabilities as not supported for the FS of the CA band combination where it does not apply. However, this filtering may need to be discussed considering the other issues raised with solution2. |
| Qualcomm Incorporated | It is our understanding that *supportedBandListNR* is not filtered by the UE capability filter *FreqBandList* (which is echoed back in *appliedFreqBandList*). So in reality, the number of band entries in *FreqBandList* is smaller than that of *supportedBandListNR*.  With this, it may be OK to have variable size bitstring pointing to *appliedFreqBandList*, per FS. |
| Intel | Solution 1:  Option 2 is a signalling optimisation of option 1 and can, in general, be considered as a possible option.  Discussion point 1: As mentioned in the online session, the target band has to (be updated to) within the UE supported bands.  Discussion point 2: We think network filtering using *FreqBandList* will help reduce the number of reported bands in reality even though the max theoretical max is 1280. If we want to further reduce the size using an additional filtering can be considered and in this case, a common target list for filtering seems sufficient.  Solution 2:  We are open to consider such solution. However, we agree with the solution limitations as summarised by the rapporteur above. This means that further enhancements will be needed to the solution to consider the different candidate cell band combinations. This will need further discussion and it is unclear at this time complexity of the updated solution.  Considering the above, option 2 of solution 1 seems a reasonable approach at this time. |

# Conclusion

# Reference

[1] R1-2403703 Updated RAN1 UE features list for Rel-18 NR after RAN1#116bis

[2] R4-2406680 Rel-18 RAN4 UE feature list for NR (version 4)

[3] R2-2404527/4528 Corrections and Updates to UE capabilities for Rel-18 WIs, including TEI18 [RAN1], Intel Corporation

[4] R2-2405245 Mobility UE capabilities with Per band pair per band combination granularity Huawei, HiSilicon

[5] R2-2404705 Band-pair signalling for Early TA acquisition UE capabilities Qualcomm