**3GPP TSG-RAN2 Meeting #117-e R2-211xxxx**

**e-Meeting, 17 – 26 Jan, 2022**

**Source: email discussion Rapporteur (ZTE Corporation)**

**Title: [Post116-e][515][RACH partitioning] MAC Procedure aspects (ZTE)**

**Agenda item:** **8.18.2**

**Document for:** **Discussion and Decision**

# Introduction

This document contains summary of email discussion to related to MAC procedure aspects for common RACH partitioning:

* [Post116-e][515][RACH partitioning] MAC Procedure aspects (ZTE)

- General procedure for feature set selection

- General procedure for initialisation of RACH variables

- Overall RACH procedure in MAC

- Running CR

- Deadline: Long

**Discussion summary**

* TBD

# Discussion

## Selection of RA resource partition

The following agreements were made for the configuration of the RACH resource partitions:

**Agreements:**

1. No new feature and/ feature combination specific preambles are defined within the “not available” preambles defined at the end of a RO through the legacy totalNumberOfRA-Preambles
2. Specification allows for use of Separate time-frequency resources, not defined through legacy RRC signalling, within Contention free preamble defined through legacy RRC signaling and the combination of these (i.e. using the reserved preamble at the end of SSBs like 2-step RACH)
3. RAN2 baseline is that preambles for a particular feature combination shall be present in all SSBs (e.g., a feature combination cannot only have preambles in SSB0 but not SSB1)

4 As a baseline, a feature combination shall have the same number of preambles in all SSBs

5 Signalling should allow that a particular feature/feature combination can be mapped only to a subset of the RACH occasions of a RACH configuration.

6 The legacy masking index approach is reused in Rel-17 RA partitioning

7 RAN2 adopts Approach A as baseline (an IE contains one field for each of the features) for indicating which feature/feature combination a partition applies to. Details are FFS, e.g. details around slicing. FFS how to encode and design the signaling in a future compatible way (i.e. naming)

8 As a baseline, multiple "RA partitions" for one RA type which map to the same feature/feature combination is not supported on a given BWP. FFS if there is any special use case that requires multiple RA partition configuration.

Based on the above, the general RACH resource configuration will look something like below:



Figure : Assumed RACH resource structure

Thus, based on the above structure, for the initiated RACH procedure, the MAC entity should determine which feature(s) are applicable to the RACH procedure. It seems that prior to the RACH being triggered, the applicability of REDCAP, Slice and SDT will be already known to the MAC entity. For CE, this is not clear. There are two options:

Option 1: CE will also be considered as part of the feature combination for each RACH partition and the use of CE will be determined in MAC and the RACH partition selection is performed considering CE to be similar to other features

Option 2: CE will be considered as a type of RA resource within each RACH partition and the use of CE will be determined after the selection of RACH partition (i.e. CE will not be considered during RACH partition selection and is only used in case the CE resource is configured within the RACH partition selected)

Option 3: Other option (pelase explain).

So, the first question is how to handle CE in the overall framework above.

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| **Q1: For handling the CE, which option is preferred?**  Option 1: CE will also be considered as part of the feature combination for each RACH partition and the use of CE will be determined before the RACH partition selection is performed  Option 2: CE will be considered as a type of RA resource within each RACH partition and the use of CE will be determined after the selection of RACH partition (i.e. CE will not be considered during RACH partition selection and is only used in case the CE resource is configured within the RACH partition selected)  Option 3: Other option (pelase explain). | | |
| Company | Preferred option  Option 1/2/3 | Comments (why?) |
| Qualcomm | Option 1 | If selection of RACH partition is up to UE implementation, then the question seems irrelevant because that decision will be up to UE implementation. If selection of RACH partition is based on some redefined rules, then we prefer Option 1 for the following two reasons:   * We think UE can evaluate whether it meets the RSRP threshold for CE before it selects a RACH partition. This evaluation is not difficult to perform regardless of whether the RSRP threshold is configured per RACH paritition or the same for all partitions. It would simplify UE behavior if CE is considered one of the RACH features. * Option 2 may require extra tie breaking rule in selecting RACH partition. For example, suppose there are two RACH partitions. Partition A and Partition B have the same set of features, except that Partition B also supports CE. Then if Option 2 is applied, UE can’t determine whether it should select Partition A or Partition B. But there would be no ambiguity if Option 1 is applied. |
| Apple | Option 1 | When RAN2 agreed the feature/feature combination specific RACH partitioning, the features refer to the SDT, Slicing, RedCap and CE. Therefore, the CE feature should be treated in the same way as other features. |
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Then, we need some general understanding on how the RACH resource partitions are used. As already agreed, each RACH partition will contain an IE indicating which feature/feature combination a partition applies to.

Hence, for each RACH partition configured, the understanding could be that the RACH partition will be considered as available for a triggered RACH procedure in case all the following conditions are satisfied:

1. if REDCAP indication is configured for the partition, then the RACH partition is only applicable to the RACH procedure triggered for REDCAP UE where Msg1 identification is required. Otherwise, if REDCAP indication is not configured, then the RACH partition is applicable to non-REDCAP UE and REDCAP UE where Msg1 identification is not required. (FFS how to determine whether Msg1 identification is required or not)
2. if slice info is configured for the partition,then the RACH partition is only applicable to the RACH procedure triggered for the slice. Otherwise, if the slice info is not configured, then the RACH partition is applicable to all slices.
3. if SDT indication is configured, then the RACH partition is only applicable to the RACH procedure triggered for SDT. Otherwise, if SDT indication is not configured, then the RACH partition is applicable to the RACH procedure not triggered for SDT.
4. if CE indication is configured, then the RACH partition is only applicable to the RACH procedure where CE is required. Otherwise, if CE indication is not configured, then the RACH partition is applicable to the RACH procedure where CE is not required. (if CE is considered as part of feature combination)

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| **Q2: Do companies agree with the general understanding below:**  for each RACH partition configured, the RACH partition will be considered as available for a triggered RACH procedure in case all the following conditions are satisfied:   1. if REDCAP indication is configured for the partition, then the RACH partition is only applicable to the RACH procedure triggered for REDCAP UE where Msg1 identification is required. Otherwise, if REDCAP indication is not configured, then the RACH partition is applicable to non-REDCAP UE and REDCAP UE where Msg1 identification is not required. (FFS how to determine whether Msg1 identification is required or not) 2. if slice info is configured for the partition,then the RACH partition is only applicable to the RACH procedure triggered for the slice. Otherwise, if the slice info is not configured, then the RACH partition is applicable to all slices. 3. if SDT indication is configured, then the RACH partition is only applicable to the RACH procedure triggered for SDT. Otherwise, if SDT indication is not configured, then the RACH partition is applicable to the RACH procedure not triggered for SDT. 4. if CE indication is configured, then the RACH partition is only applicable to the RACH procedure where CE is required. Otherwise, if CE indication is not configured, then the RACH partition is applicable to the RACH procedure where CE is not required. (if CE is considered as part of feature combination)   If there are any specific comments or other understanding on how each feature is mapped to the partition, please explain in the comments section | | |
| Company | Agree with general understanding?  Y/N/comments | Comments (why?) |
| Qualcomm | Yes |  |
| Apple | See comments | The question is for the feature specific RACH partition, not for the feature combination specific case.  If only we only consider the feature specific RACH partition, we agree with the general understanding.  But for the feature combination specific RACH partition, NW may configure more than one feature indication per RACH partition, and further clarification is needed. |
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Then, we also agreed that not all feature combinations will need to be supported by the network:

**Agreements**

1 RAN2 assumes that the network may not provide all possible permutation. FFS whether the selection in case of missing combination is specified or left to UE implementation

2 For slicing, unified partitioning framework should take priority

This means that we need to discuss what the UE behaviour shall be if only a subset of features are supported.

The main options to consider here are:

If only a subset of features have a matching RACH partition, and the triggered RACH doesn’t fit with any of the configured RACH partitions, then:

**Option 1:** it is up to UE implementation to select the RACH partition that matches UE’s preference based on implementation

* The consequence of this is that if there is no suitable Rel-17 RACH partition satisfying the triggered RACH feature combination, then the UE may choose any other RACH partition (this may even include other Rel-17 RACH partition that suits a subset of the features that triggered the RACH). How the UE chooses this subset is not specified (and left to UE implementation)

**Option 2:** the UE selects legacy RACH resource

* The consequence of this is that if there is no suitable Rel-17 RACH partition satisfying the triggered RACH feature combination, then UE will not select any other Rel-17 partition (even if that partition may indicate a subset of features that triggered the RACH procedure)

**Option 3:** we specify a set of rules based on which the UE shall select another RACH partition

* The consequence of this is that we need to specify clear priority rules that the UE shall follow in determining a fallback subset (if the feature set combination is not available)

Option 3: Would obviously need some further discussion. These can be discussed further down.

So, the first question is which of the broader options do companies prefer and why?

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| **Q3:** If only a subset of features have a matching RACH partition, and the triggered RACH doesn’t fit with any of the configured RACH partitions, then which option do companies prefer and why?:  **Option 1:** it is up to UE implementation to select the RACH partition that matches UE’s preference based on implementation   * The consequence of this is that if there is no suitable Rel-17 RACH partition satisfying the triggered RACH feature combination, then the UE may choose any other RACH partition (this may include other Rel-17 RACH partition that suits a subset of the features that triggered the RACH). How the UE chooses this subset is not specified (and left to UE implementation)   **Option 2:** the UE selects legacy RACH resource   * The consequence of this is that if there is no suitable Rel-17 RACH partition satisfying the triggered RACH feature combination, then UE will not select any other Rel-17 partition (even if that partition may indicate a subset of features that triggered the RACH procedure)   **Option 3:** we specify a set of rules based on which the UE shall select another RACH partition   * The consequence of this is that we need to specify clear priority rules that the UE shall follow in determining a fallback subset (if the feature set combination is not available) | | |
| Company | Preferred option  Option 1/2/3/(Anything else?) | Comments (why?) |
| Qualcomm | Option 3 | We prefer Option 3 because the other two options have the following drawbacks:   * Option 1 can lead to different (unpredictable) RACH performance by different UE implementations. In addition, Option 1 can make it difficult for network to estimate RACH load of different feature sets. That may lead to inefficient allocation of RACH resources; * Option 2 is unnecessarily restrictive and may result in inefficient use of RACH resources. For example, suppose network configures one RACH partition for RedCap and another for legacy. If a RedCap UE triggers RACH and it also satisfies the criteria for SDT, then with Option 2 this RedCap UE has to use legacy partition instead of RedCap partition. That’s clearly not efficient. |
| Apple | Option 1/3 | We are fine with Option 1 or Option 3.  For Option 1, we can trust the reasonable UE implementation.  Option 2 will degrade the intial access performance in some cases, e.g. when UE is in coverage enahcnement area, and NW doesnot provide the CE only RACH partition but provides CE+Slicing RACH partition. |
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Then, the next question, is to discuss the details of option 3, should this be preferred by the majority of companies.

Firstly, if we want to specify a set of rules, there may be multiple sub-options:

**Option a:** Priority rules are static and will be defined in the specs (e.g. the available RACH partition with slice info will be prioritized etc)

**Option b:** Priority rules are configurable (e.g. can be configured in SI)

**Option c:** Others (please explain)

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| **Q 4: If we agree to specify the priority rules, which option is preferred and why?**  **Option a/b/c** | | |
| Company | Preferred option  (option a/b/c/d/) | Comments (why?) |
| Qualcomm | Option a | We expect this priority rule to be fairly static. Hence we do not see a need to signal it in SI, which introduces unnecessary overhead in SIB1. |
| Apple | Option a/b |  |
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If we choose to specify the detailed priority rules (i.e. fallback options), then we need to further discuss how to specify this.

For instance this may be based on some static priority rules (e.g. the available RACH partition with slice info will be prioritized etc etc). i.e. this means if both RACH partition with and without slice info are configured and be considered as available, then the UE should prioritize the RACH partition with slice info configured etc.

Since it is not straightforward to describe all such possible priories, we can start with some open discussion and companies can explain their views on how the priority and order can be specified

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| Q 5: If there is no RACH partition that maps to all triggered features and if we want to define specific rules for fallback to a subset, how should UE determine the alternative Rel-17 partition to be selected (for a subset of features)? | |
| Company | Comments  (e.g. companies can explain how the priority order would look – etc) |
| Qualcomm | In our paper R2-2109452 ([2]), we have described the following steps for UE to apply to select a RACH partition, assuming there is a priority list among different RACH features predefined in the spec:   1. Start with all configured RACH partitions, and the RACH feature which has the highest priority; 2. Determine if the RACH feature selected for this step is one of the triggers for the RACH procedure or UE is eligible to use. If it is not, select the next RACH feature in the priority list and check again. Otherwise, among the RACH partitions selected at the start of this step, select those that include the selected RACH feature and then perform Step 3; 3. Among the RACH partitions selected for this step, select those partitions that UE meets the criteria of all its included RACH features. In addition, select the next RACH feature on the list. Then repeat Step 2. If UE does not meet criteria of any partitions selected for this step, or all RACH features in the priority list has been evaluated, UE stops this proccedure. |
| Apple | The fallback priority list provides the feature priotiy in the order for the RACH paritition selection, e.g. CE is the 1st priority, RedCap is the 2nd priority…and so on.  If there is no RACH partition mapped to all triggered features, UE will follow the fallback priority list to select the feature specific RACH partition.   * UE selects the RACH partition mapped to the feature with the 1st priority, and if not, UE selects the RACH partition mapped to the feature with 2nd priority… * If no RACH partition is selected finally, UE will perform legacy RACH procedure. |
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## Initialization of RACH variables

Once the RACH partition is selected, the RACH variables can be initialised based on the selected partition. We can check if companies share this view.

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| **Q 6: Do companies agree that once the RACH resource partition for a given feature set combination is determined, RACH procedure related variables in sections 5.1.1 and 5.1.1a can be initialized based on the values signalled within the selected RACH partition?** | | |
| Company | Yes/No | Comments (why?) |
| Qualcomm | Yes |  |
| Apple | Yes |  |
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Then, one further question is whether all the RACH parameters within a RACH partition are common to all features that use the corresponding RACH partition. This aspect is mentioned in [2] for instance (see P1). In general, it is possible for the network to configure the RACH parameters within a given RACH partition to take into account all features that are mapped to the specific RACH partition. For instance, if a given slice requires specific power control or other RACH prioritisation related parameters, the network can configure the corresponding parameters in this RACH partition accordingly. It seems that other features which may also use this partition will also use these parameters, but since this is under control and can be tailored to each partition, it seems there is sufficient flexibility to allow the RACH variables to be specific to the partition (i.e. not specific to the feature within the partition). So, the following question is asked.

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| **Q 7: Do companies agree that all features that are mapped to a given RACH partition use the same set of RACH parameters (signalled within this partition) – in other words the RACH parameters are per RACH partition rather than per feature within the partition?** | | |
| Company | Yes/No | Comments (why?) |
| Qualcomm | See comment | We do not fully understand the rapporteur’s question. The following comments are based on our best guess on what the rapporteur is asking.  It seems that the second part of the question asks whether RACH parameters should be configured per RACH partition (e.g. two-step RACH in different RACH partitions can be configured with different values) or per feature globally (e.g. two-step RACH in all RACH partitions share the same values for two-step RACH parameters). In our view, the configuration should be per RACH partition, because different RACH features, when jointly configured, may require different values for the same parameter. For example, suppose Partition A includes only legacy RACH and Partition B includes slice-specific 4-step RACH. Then Partition B may be configured with, say, different *preambleTransMax* or *powerRampingStep* to meet the special requirement of the slice.  Regarding the first part of the question, we first observe that all RACH parameters are unique in a RACH partition, for the following reasons. Since each feature included in a RACH partition is always unique, then one may conclude that RACH parameters specific to a feature (e.g. *msgA-RSRP-Threshold* is specific to only two-step RACH) is also unique within that partition. If there are RACH parameters used by all RACH features, then those parameters have to be associated with either RACH resources or PHY-layer transmission procedures, not RACH features. Since the mapping between RACH resources and RACH partition is one-to-one, then those parameters are also unique/specific to a RACH partition. |
| Apple | Yes | RACH parameters should be provided per RACH partition. In our understanding, the RACH configuraiton of one RACH partition has 3 cases: a) 4-step RACH only, b) 2-step RACH only, and c) 2-step RACH +4-step RACH. |
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## Carrier/BWP selection

Currently, in sections 5.1.1, UE performs the carrier and BWP selection based on the thresholds configured in the RACH configuration. We can check if the same procedure can be reused for the common RACH procedure.

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| **Q 8: Do companies agree that carrier selection and BWP selection can be performed based on the RACH parameters signalled in the selected RACH partition?** | | |
| Company | Yes/No | Comments (please explain any changes needed?) |
| Qualcomm | No | We think carrier and BWP selection should be performed before the selection of RACH partitions. Therefore, the thresholds for their selections should be configured separately from the configuration of RACH partitions. |
| Apple | No | Carrier selection and BWP selection should be performed before RACH partition selection. |
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## RACH type selection

After carrier and BWP are selected, UE performs the RA-type selection and initialise RA-type specific variables (see section 5.1.1a of the MAC spec). We can check whether this procedure can also be replicated (again based on the RACH parameters signalled in the selected RACH partition).

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| **Q 9: Do companies agree that the RA-type selection can happen like today (i.e. after the carrier and BWP selection) based on the RACH parameters signalled in the selected RACH partition?** | | |
| Company | Yes/No | Comments (please explain any changes needed to the current procedure?) |
| Qualcomm | No | In our view, RA-type selection should be a part of selection of RACH partitions, because the priority between 4-step or 2-step RACH may be depend on which other R17 feature(s) it is configured with. For example, slice-specific 4-step RACH may be prioritized over common 2-step RACH. |
| Apple | Yes | After RACH partition is selected, UE will perform the RACH type selection if both 4-step RACH and 2-step RACH are provided in the RACH configuration of the selected RACH partition. |
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## RNTI collision problem

In [1], [3] the RNTI collision issue for RACH partitioning is discussed. In [1] it is proposed to solve this issue by using a custom offset signalled through RRC and associated with each PRACH configuration to solve this problem. On the otherhand in [3], it is proposed to use a separate search space for RAR/MSGB monitoring. It should be noted that for some work items (e.g. SDT), separate search space has already been agreed to be configured. So, it seems we need to support this option anyway and it seems it may be possible then to extend this to all RACH partitions too. So, companies are asked to answer the following question.

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| **Q 10: To solve the RNTI collision issue, which option do companies prefer?**  **Option 1: Do nothing (i.e. leave to network implementation)**  **Option 2: A custom offset, signalled through RRC and associated to each PRACH configuration, is added in the formula for RA-RNTI and/or MSGB-RNTI. The legacy PRACH configuration it is assumed to have offset = 0 (see [1])**  **Option 3: the network should be able to (optionally) configure a specific search space for RAR/MSGB monitoring per RACH resource partition (see [3] – as was already agreed anyway for some features – e.g. SDT)** | | |
| Company | Option 1/2/3 | Comments (why?) |
| Qualcomm | Option 1 | Although there can be more RACH configurations in R17, network still has several options to handle possible RNTI collision, as discussed in the past.  If a super-majority of companies (e.g. more than 2/3) want to introduce enhancements to handle RNTI collision, we are fine with option 2, or option 2 together with Option 3. |
| Apple | Option 2 | The RA-RNTI/MsgB-RNTI used for R15/R16 and R17 can be overlapped due to the multiple PRACH configurations for the same RACH type in one cell.  The RNTI offset should be introduced to avoid the overlapping between between legacy and R17 usage and to avoid the impact to legacy UE. |
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# Conclusion and proposals

TBD

# References

1. R2-2110560 RNTI collision problem for Rel-17 features Ericsson discussion
2. R2-2109452 Selection and fallback between RACH partitions Qualcomm Incorporated discussion
3. R2-2110598 MAC aspects for RACH partitioning Huawei, HiSilicon discussion
4. R2-2110578 User plane aspects of RACH partitioning ZTE Corporation, Sanechips discussion Rel-17
5. R2-2109532 RA Procedure Aspects Samsung Electronics Co., Ltd discussion Rel-17 NR\_cov\_enh-Core
6. R2-2109542 Considerations on the common aspects of RACH procedure Beijing Xiaomi Software Tech discussion Rel-17
7. R2-2109882 RACH resource/configuration selection and fallback mechanism Intel Corporation discussion Rel-17
8. R2-2110260 Discussion on RACH indication and partitioning CMCC discussion Rel-17
9. R2-2110665 Overview of RACH resource selection NEC discussion Rel-17
10. R2-2110813 Selection of RACH partition Nokia, Nokia Shanghai Bell discussion Rel-17
11. R2-2110917 RACH indication and partitioning InterDigital discussion Rel-17
12. R2-2110927 Discussion on RACH Partitioning in RA Procedure Aspect vivo discussion Rel-17
13. R2-2111164 Discussion on common RA procedure for RACH partitioning features LG Electronics Inc. discussion

# Annex (contact details for email discussions)

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| Company | Contact name | Contact email |
| Apple | Fangli XU | fangli\_xu@apple.com |
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