**3GPP TSG RAN WG1 #101 R1-20xxxxx**

**e-Meeting, May 25th – June 5th, 2020**

**Source: Moderator (NTT DOCOMO, INC.)**

**Title:** **Summary on [101-e-NR-UEFeatures-2step-02]**

**Agenda Item:** **7.2.11.1**

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

1. Introduction

This contribution summarizes the following email discussion/approval regarding UE features for two-step RACH.

[101-e-NR-UEFeatures-2step-02] Email discussion/approval on capability signaling design for existing FGs for two-step RACH (25th – 29th May) – (DCM, Hiroki)

* Discuss and decide capability signaling design (including components, candidate values, reporting type, xDD/FRx differentiations) for existing FGs
* Discuss and decide any other necessary update for the UE features list for two-step RACH based on identified issues/proposals in R1-2004401

1. Discussion on UE features for two-step RACH

## 2.1 FG9-1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |  | Yes | N/A | UE cannot initiate a 2-step RACH process, and thus would not be expected understand the 2-step RACH configurations | per band | N/A | N/A | N/A |  | Optional with capability signalling |

* **Components of FG9-1**
  + **More simplified basic FG, i.e., three compornents: [2], [5], [10]**
  + **Confirm the current baseline: [3], [12]**
  + **Update the current baseline**
    - **Remove compornent 2, 3a, 6a and 6b, and modify compornent 3 to “msgA resource configuration and waveform determination for 2-step CBRA”: [4]**
    - **Remove compornent 8, and modify compornent 2 by removing “separately configured ROs not applicable to 4-step RO configuration and”: [6]**
    - **Remove compornent 4 and 5, and modify compornent 6 to “msgB monitoring without msgB window extension and decoding for 2-step CBRA” (i.e., support RAR extention from 10ms to [40ms] is based on FG10-2f) : [8]**
    - **Update the component 3 and 5 to support CFRA: [9]**
* **Need for the gNB to know if the feature is supported for FG9-1**
  + **The input of need for the gNB to know if the feature is supported requires separation of components for RRC connected UEs for proper signaling design in RAN2: [8]**

Above remaining issues and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

|  |  |
| --- | --- |
| [2] | **Proposal 1: For FG 9-1, support a more simplified basic feature group with following components included.**   1. **MsgA PRACH and PUSCH transmission** 2. **MsgB monitoring, reception, and feedback** 3. **Power control for MsgA PRACH, MsgA PUSCH, and PUCCH for HARQ-ACK feedback to a MsgB** |
| [3] | ***Proposal 2:*** Confirm the following components to be captured in the basic feature group.   |  |  |  | | --- | --- | --- | | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB | |
| [4] | **Proposal 1: We suggest using more simplified and clear description on the basic feature group 9-1 as below TP.**  ----------------------------------------------------Start of TP for RAN1-2003197-------------------------------------  9-1 Basic channel structure and procedure of 2-step RACH， description for components items   1. RACH type selection for CBRA according to SSB-based RSRP threshold 3. msgA resource configuration and waveform determination for 2-step CBRA 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA 7. (PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB   ---------------------------------------------------End of TP for RAN1-2003197-------------------------------- |
| [5] | **Proposal 1**   * *It is preferable to consider a simplified description of FG9-1 for 2-step RACH.*   1. *MsgA PRACH and PUSCH configuration, validation and transmission*   2. *MsgB monitoring, reception, and HARQ-ACK feedback*   3. *Power control for MsgA PRACH, MsgA PUSCH, and PUCCH for HARQ-ACK feedback to a MsgB* |
| [6] | ***Proposal 1: Adopt the revised UE feature group in the appendix by change item 2) by removing “***~~separately configured ROs not applicable to 4-step RO configuration and~~***” and remove 8) in FG9-1 for 2step RACH Rel-16***.   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 9. NR\_2step\_RACH | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |  | Yes | N/A | UE cannot initiate a 2-step RACH process, and thus would not be expected understand the 2-step RACH configurations | per band | N/A | N/A | N/A |  | Optional with capability signalling | |
| [8] | **Components**  Component 4 & 5 is not needed as not associated with any RRC configurations, which is preferable to be avoided per RAN2 LS guidance on UE features.  Component 6b for RRC connected UEs, which is monitoring msgB PDCCH with CRC masked by C-RNTI, or any other components that may be specific to RRC connected UEs, needs to be separate FGs given different requirements on whether need for gNB to know it.  **Need for the gNB to know if the feature is supported**  ***Observation 1*: the input of need for the gNB to know if the feature is supported requires separation of components for RRC connected UEs for proper signaling design in RAN2.**  ***2.3 Other issues related with NR-U***  ***Proposal 2*: msgB reception in FG 9-1 needs to be limited with msgB window of up to 10ms.** |
| [9] | **Proposal 1: keep current components in FG9-1 and update the component #3 and #5 to support CFRA.**   1. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA and CFRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 2. Validation of MsgA PRACH and PUSCH 3. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH for 2-step CBRA and CFRA |
| [10] | **Observations**:   * For FG 9-1:   + It is unclear what to do with the highly detailed description currently used:     - Will it be captured in 38.306 or 38.331?     - What will RAN2 do with such a description?     - If something is missing, is it not supported?   + It seems more useful to discuss what the dependencies are, as this should establish what Rel-15 features are needed to support 2-step RACH and is more likely to help RAN2 in their work.   **Proposals**:   * For 9-1, start with the following (Alt 2 from the beginning of RAN1#100bis) as a baseline, and focus on Rel-15 dependencies for 9-1   Alt 2 simplified basic feature group:   1. MsgA PRACH and PUSCH transmission 2. MsgB monitoring, reception, and feedback 3. Power control for MsgA PRACH, MsgA PUSCH, and PUCCH for HARQ-ACK feedback to a MsgB |
| [12] | * **FG 9-1** * We are fine to remove components 3b and 3c. * We think it is necessary to keep the rest of the components for clarity/accuracy of UE implementation. |

Based on above, following FL proposals are made.

### **FL proposal 1:**

* **Components of FG9-1**
  + **Modify component 3 and 6 to support SSB-based CFRA**
  + **Modify component 2 as “msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration”**
  + **Modify compornent 6 as “monitoring *msgB-ResponseWindow* up to 40ms …”**
  + **Add a note “Components are not exhaustive list and whether/how to capture them is up to RAN2”**

### **FL proposal 2:**

* **Need for the gNB to know if the feature is supported for FG9-1**
  + **Clarify that “Yes (but gNB does not need to know whether FG9-1 is supported or not for UEs before RRC connection)”**

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA and CFRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring without msgB window extension and decoding for 2-step CBRA and CFRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |  | Yes (but gNB does not need to know whether FG9-1 is supported or not for UEs before RRC connection) | N/A | UE cannot initiate a 2-step RACH process, and thus would not be expected understand the 2-step RACH configurations | per band | N/A | N/A | N/A |  | Optional with capability signalling |

Companies are encouraged to check above FL proposals and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposal 1: Ericsson

Cannot accept the proposal 2:

|  |  |
| --- | --- |
| Company | Comment |
| CATT | Regarding FL proposal 1, we propose to simplify FG9-1 components as below   1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA resource configuration and waveform determination for 2-step CBRA 3. Validation of MsgA PRACH and PUSCH 4. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 5. msgB monitoring without msgB window extension and decoding for 2-step CBRA and CFRA 6. PUCCH transmission for HARQ-ACK feedback to a msgB 7. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |
| Ericsson | We are not OK with FL proposal 1. As captured above from R1-2004350, we have the following comments:   * For FG 9-1:   + It is unclear what to do with the highly detailed description currently used:     - Will it be captured in 38.306 or 38.331?     - What will RAN2 do with such a description?     - If something is missing, is it not supported?   + It seems more useful to discuss what the dependencies are, as this should establish what Rel-15 features are needed to support 2-step RACH and is more likely to help RAN2 in their work.   Therefore, our proposal is start with the following (Alt 2 from the beginning of RAN1#100bis) as a baseline  Alt 2 simplified basic feature group:   1. MsgA PRACH and PUSCH transmission 2. MsgB monitoring, reception, and feedback 3. Power control for MsgA PRACH, MsgA PUSCH, and PUCCH for HARQ-ACK feedback to a MsgB   Regarding the modified component 6, if the extended window is a UE capability, it will have little benefit for initial access with UEs in idle/inactive, since the network may not know the capability. So we prefer to not have ‘without msgB window extension’ in 9-1.  We are OK with FL proposal 2. |
| Qualcomm | * For FL Proposal 1:   + When “CFRA” is included in component 3 and 6 of FG 9-1, we think it is better to be clarified as “SSB-based CFRA.” * FL Proposal 2 looks good to us. * We don’t think further simplification is needed for FG 9-1. |
| Nokia, NSB | * For FL proposal 1, we do not agree to add the text: **Modify component 6 to “msgB monitoring without msgB window extension and decoding for 2-step CBRA”.** This collides with RAN2 agreements on msgB window extension. * FL Proposal 2 is not necessary in our view. The exact protocol for gNB to become aware of the capability is not in scope of this discussion. For example, the gNB may become aware of the support simply due to the fact the UE used 2-step RACH for initial access (provided all necessary conditions in specs are fulfilled as well). * Structure of the FG 9-1 itself is reasonable to us and no further simplification is needed. |
| NTT DOCOMO | Regarding FL proposal 1, if component 6 is modified to “msgB monitoring without msgB window extension and decoding for 2-step CBRA”, it would be based on FG 10-2f in NR-U whether or not to support extened msgB window. It means extended msgB window cannot be used in some cases, e.g., for initial access. We need to confirm whether everyone is fine with this restriction or not and whether FG 10-2f can be applied to 2-step RACH case or not. |
| Huawei | Ok with FL proposal. The issue for msgB window extension is exactly due to the discussion from NR-U. |
| Moderator (NTT DOCOMO) | According to inputs so far, I still think it is reasonable to minimize updates from the current FG9-1.  For FL proposal 1, possible update is to remove following sub-bullet to support msgB monitoring with msgB window extension even in initial access.   * **Modify component 6 to “msgB monitoring without msgB window extension and decoding for 2-step CBRA”**   If this update is not acceptable, we should clarify that msgB monitoring with msgB window extention cannot be used in initial access.  I think FL proposal 2 does not need any update.  Please provide your further feedbacks if any by 5/28 12:00 UTC on updated proposals. |
| Intel | For FL proposal 1, our initial proposal is to consider a simplified description as follows:   1. MsgA PRACH and PUSCH configuration, validation and transmission 2. MsgB monitoring, reception, and HARQ-ACK feedback 3. Power control for MsgA PRACH, MsgA PUSCH, and PUCCH for HARQ-ACK feedback to a MsgB   If majority of companies support a detailed description of FG9-1, we are also fine. But we would like to make some suggestions in current FG9-1:   * Suggest to remove component 1 “RACH type selection for CBRA according to SSB-based RSRP threshold”. It is described in 321, not RAN1 spec. * Suggest to update component 2 as “msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and ~~fully or partially~~ shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration”. or simply mention “MsgA PRACH resource configuration”. It is not necessary to mention too much details as these are clearly defined in the RAN1 spec. * Suggest to update component 5 as “Mapping between MsgA PRACH preamble ~~of MsgA PRACH~~ and PUSCH occasion with DMRS resource ~~of MsgA PUSCH~~”. This is to align the RAN1 description. * Suggest to remove component 6.   We are okay with FL proposal 2. |
| NTT DOCOMO | We are fine not to add “without msgB window extension” to compornent 6. In our understanding, it means that msgB window up to 40ms is supported as 2-step RACH basic feature, separately from NR-U. In order to clarify it, it would be better to modify compornent 6 “msgB monitoring within msgB window up to 40ms and decoding for 2-step CBRA and CFRA”. Also, for the purpose of above clarification, we prefer to keep component 6. |
| Ericsson |  |
| Qualcomm | We think CFRA in component 3 and 6 of FG 9-1 should be clarified as “SSB-based CFRA.” |
| Samsung | For #3, we are fine as adding CFRA, and we may not need to have “SSB-based” since the CFRA is only for SSB now, and if ran2 decided to support cfra, it can include that as well. as long as the spec is clear on that part.  For #6, we think the addition of “within msgB window up to 40ms” or “**without msgB window extension**” is not needed. Since #6 is actually talking about how and what UE needs monitor for RAR, it is not related to the length of RAR window, it’s the same for either 10ms or 40ms; |
| CATT | Regarding compoment 3 and 6, general description is enough and msgB window extension needn’t be addressed.  Our proposal is as below  3.msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA and CFRA  6. msgB monitoring ~~without msgB window extension~~ and decoding for 2-step CBRA and CFRA |
| NTT DOCOMO | Our intention of modification on compornent 6 “msgB monitoring within msgB window up to 40ms” is to clarify that msgB window up to 40ms is a part of basic feature. Otherwise, someone considers it is basic feature, but other may consider it is based on the reporting of FG 10-2f, and hence we think that it is important. If the concern is to modify compornent 6, is it acceptable to add additional compornent? e.g., RAR extension up to 40ms by decoding of the 2-bit SFN indication in DCI 1\_0. |
| Apple | For the simplification of FG9-1, we support current structure, FG9-1was already reduced from 30 components to 8 components. it provides certain level of information of this feature, which is helpful from implementation perspective.  For MsgB monitoring window, we agree with FL that the component 6 needs to be updated to avoid confusion caused by NR-U, the update could like “~~msgB~~ monitoring ~~within msgB window~~ *msgB-ResponseWindow* up to 40ms and decoding for 2-step CBRA and CFRA ” .  We are ok with proposal 2. |
| Qualcomm | For FG 9-1, we share the same views as Apple that the 8 components should be kept. From UE’s perspective, FG 9-1 has been simplified into the most compact form for a 2-step RACH procedure. Further simplification will cause ambiguity in UE/gNB implementation, and does not save the capability signaling overhead at all.  Although there is (almost) no chance to support CSI-RS based 2-step CFRA in FG 9-1, we can accept “CFRA” for the progress of the discussion.  To conclude, we are ok with both Proposal 1 and Proposal 2, but cannot agree with unnecessary simplification of FG 9-1. |
| Moderator (NTT DOCOMO) | Based on the feedbacks and discussion over emails, FL proposal 1 is updated to add a note for clarification. |
| Nokia, NSB | We are generally OK with the FL proposals, but we are not comfortable with “support SSB-based CFRA” in components 3 and 6. It would be more straightforward and clear if it says “CFRA”, as it makes it clear that all CFRA solutions in R16 for 2-step RACH are in scope of the FG. As for the proposal to modify component 6 with “monitoring msgB-ResponseWindow up to 40ms …”, we are not objecting to it, but it is over-specifying the feature to some extent, as it suffices to say the use supports monitoring msgB-ResponseWindow, and the length is that determnined by RAN2 for R16. |

1. Conclusion

**FL proposal 1:**

* **Components of FG9-1**
  + **Modify component 3 and 6 to support SSB-based CFRA**
  + **Modify component 2 as “msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration”**
  + **Modify compornent 6 as “monitoring *msgB-ResponseWindow* up to 40ms …”**
  + **Add a note “Components are not exhaustive list and whether/how to capture them is up to RAN2”**

**FL proposal 2:**

* **Need for the gNB to know if the feature is supported for FG9-1**
  + **Clarify that “Yes (but gNB does not need to know whether FG9-1 is supported or not for UEs before RRC connection)”**

Reference

[1] R1-2003197 Summary on email discussion [100b-e-NR-UEFeatures-Remaining] NR\_2step\_RACH Moderator (NTT DOCOMO, INC.)

[2] R1-2003415 Discussion on UE features for 2-step RACH vivo

[3] R1-2003459 Discussion on the remaining issues of the UE features for two-step RACH ZTE, Sanechips

[4] R1-2003603 Discussion of NR Rel-16 UE features for two-step RACH CATT

[5] R1-2003752 Discussion on UE features for two-step RACH Intel Corporation

[6] R1-2003893 UE features for two-step RACH Samsung

[7] R1-2004137 Discussion on UE features for NR 2step RACH LG Electronics

[8] R1-2004146 Rel-16 UE features for 2-step RACH Huawei, HiSilicon

[9] R1-2004240 Views on NR 2-step RACH UE feature Apple

[10] R1-2004350 UE Features for Two-Step RACH Ericsson

[11] R1-2004400 Discussion on UE features for Two-step RACH NTT DOCOMO, INC.

[12] R1-2004476 Discussion on two step RACH UE features Qualcomm Incorporated

[13] R1-2004559 On UE features or 2-step RACH Nokia, Nokia Shanghai Bell

Appendix: latest version of UE features list for 2 step RACH [1]

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |  | Yes | N/A | UE cannot initiate a 2-step RACH process, and thus would not be expected understand the 2-step RACH configurations | per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-3] | [Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA] | [Parallel MsgA and SRS./PUCCH/PUSCH transmissions across CCs in inter-band CA with msgA in PCell/PScell] | 9-1  TBD | Yes | N/A | UE cannot transmit an MsgA and other UL transmissions in parallel across CCs in inter-band CA | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-4] | [MsgA operation in a band combination including SUL] | [MsgA operations in a band combination including SUL] | 9-1, 6-16 TBD | Yes | N/A | UE does not support msgA operations in a band combination including SUL | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-6] | [up to X of msgBs per slot/within the msgB window] | [up to X of msgBs per slot/within the msgB window] | TBD | Yes | N/A |  | [Per band] | N/A | N/A | N/A |  | Optional with capability signalling |