**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-01]**

**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-01] Email discussion/approval on feature group structure for two-step RACH (25th – 29th May) – (DCM, Hiroki)

* Discuss and decide whether FG9-3 (Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA) is kept or removed
* Discuss and decide whether FG9-4 (MsgA operation in a band combination including SUL) is kept or removed
* Discuss and decide whether FG9-6 (up to X of msgBs per slot/within the msgB window) is kept or removed
* Discuss and decide whether any other new FG(s) is added or not
* Discuss and decide capability signaling design for FG(s) decided to be kept/added in this email discussion (if any)

1. Discussion on UE features for two-step RACH

## 2.1 FG[9-3]

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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 | [9-3] | [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 |

* **Necessity of FG[9-3]**
  + **FG is removed: [3], [6], [9], [11], [13]**
    - **FG 4-26 should be extended to support 2-step RACH: [3]**
  + **FG is kept: [2], [4], [5], [7], [10], [12]**
    - **FG is updated with only MsgA PUSCH: [2]**

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

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| [2] | **Proposal 2: For FG 9-3, we are fine to keep it with an update to clarify that only MsgA PUSCH is needed to be included in the FG, i.e. parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with msgA in PCell/PScell** |
| [3] | ***Proposal 1:*** If there is a common understanding that 4-26 and 6-16 can be applied to MsgA PRACH and MsgA PUSCH, then there is no need of introducing a different UE feature for Rel-16 2-step RACH. And FG 4-26 and 6-16 should be extended to support 2-step RACH.   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | | 6-16 | Supplemental uplink | 1) RACH (type 1 or type 2), PUSCH, PUCCH, SRS operations in a band combination including SUL  2) Supplemental uplink with same numerology between SUL and non SUL carriers | |
| [4] | **Proposal 2: We suggest keeping FG 9-3 as single FG** |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [7] | ***Proposal 1:*** Parallel transmission of msgA with other signals and msgA operation in SUL are needed. |
| [9] | **Proposal 2: The feature group 9-3 and 9-6 can be removed.** |
| [10] | **Observations**:   * FG 9-3 may clarify operation for 2-step in RRC connected, but the alternative of relying on Rel-15’s 4-26 also seems workable.   **Proposals**:   * Keep FGs 9-3, 9-4 |
| [11] | **Proposal 1:** **Remove FG of “Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”.**  **Proposal 2:** **For FG of “Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”, if some reason for this feature is identified and this feature is kept, this feature should focus on “Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”.** |
| [12] | **FG 9-3**  We think it should be kept, since msgA is associated with a new channel structure (i.e. PRACH+ TX Gap+ PUSCH) in NR Rel-16. |
| [13] | * 9-3: Do not introduce the FG. The FG does not make sense for initial access, as for such case the UE could simply rely on 4-step RACH. The gNB would anyway not know the capability during initial access. As optional FG, the potential use cases are much more limited, as gNB may potentially utilize the information of the capability in case of UE in RRC connected mode only. |

Based on above, following FL proposals are made.

**FL proposal 1:**

* **FG9-3 is kept in the UE features list for 2 step RACH**
  + **FG name and components for FG9-3 are changed to “Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”**
  + **“TBD” is removed from prerequisite feature groups for FG9-3**

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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 | 9-3 | Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell | Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PScell | 9-1 | 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 |

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 proposals:

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| Company | Comment |
| Samsung | During last meeting email discussion, and also in our tdoc, we have responsed the comments that “msgA PUSCH with TA=0 is a new UE requirement”, which is incorrect. Clearly by Rel-15 supported TA value range, UE should be able to transmit a PUSCH with TA=0, so it is not new feature at all. We are not ok to keep it. |
| Nokia, NSB | The FG does not make sense for initial access, as for such case the UE could simply rely on 4-step RACH. The gNB would anyway not know the capability during initial access. As optional FG, the potential use cases are much more limited, as gNB may potentially utilize the information of the capability in case of UE in RRC connected mode only. Hence we are not OK to keep it. |
| CATT | Actually MSGA PUSCH surely have some different behaviors such as TA, Intra-slot frequency hopping and data scrambling with nRAPID etc. with normal PUSCH.  For use cases of FG9-3, MSGA in RRC connection mode can be used for MSGA for other SI, transition from RRC\_INACTIVE, Handover, RRCconnection reestablishment, BFR and so on.  In addition, MSGA PUSCH overlapping with other UL signals in intra-band CA is being discussed under 2s RACH session. This means transmission behaviour of MSGA PUSCH is different with that of normal PUSCH. And UE behaviour between intra-band CA and inter-band CA are similar.  We prefer to FG9-3 as single FG.  FL proposal1 on FG9-3 is incomplete because MSGA PRACH can’t be addressed under inter-band CA case.  So there are two alternatives to fix this issue.  **Alt1: FL proposal1+ modification on 4-26 FG as below**   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA |   **Alt2: Change FL proposal1 as below**  “Parallel MsgA ~~PUSCH~~ and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”  We are fine with above two options. |
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Based on the discussion in Wednesday GTW session, following updated proposals are made.

### **Updated FL proposal 1:**

* **FG9-3 is removed from the UE features list for 2 step RACH**

Companies are encouraged to check above FL proposals and to provide feedback if any in below. Especially as discussed in Wednesday GTW session, we should clarify whether and in which condition MsgA PUSCH is dropped in caes of parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA.

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| Company | Comment |
| CATT | We prefer to keep FG 9-3 as single FG.  There are 2 cases including TA misalignment across CCs in inter-band CA and over max power issue of UL transmission which lead to MsgA PUSCH or SRS/PUCCH/PUSCH transmissions is dropped.  1) Different TA across CCs  Because TA of MSGA PUSCH is always 0, this will lead to TA misalignment between MsgA PUSCH or SRS/PUCCH/PUSCH transmissions across CCs  TA misalignment causes signal interference between MsgA PUSCH or SRS/PUCCH/PUSCH transmissions across CCs in gNB side.  2) Over max power of UE UL transmission  If total transmission power of MSGA PUSCH + SRS/PUCCH/PUSCH transmissions across CCs > MAX power of UE UL transmission，UE will drop 1 transmission between MSGA PUSCH and SRS/PUCCH/PUSCH transmissions  For CBRA of 2s RACH, MSGA PUSCH is contention-based and need be blindly detected. So if MSGA PUSCH transmission is interfered, MSGA PUSCH need ramp-up power in order that MSGA PUSCH can be successfully received by gNB.  It leads to that MSGA PUSCH + SRS/PUCCH/PUSCH transmissions across CCs exceed max power of UE UL transmission. In this case, UE need drop SRS/PUCCH/PUSCH transmissions.  PUSCH behavior in R15 has a little bit different because PUSCH is always controlled and configured by gNB and the detection of PUSCH can be well predicted. So different TA for PUSCH transmission across CCs and over MAX power issue can be avoided.  But configuration of 2s RACH is cell-specific and periodic, it is difficult for gNB to schedule between MSGA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs.  If we don’t have this FG9-3, MSGA PUSCH need follow R15 PUSCH behavior. Parallel MSGA PUSCH and SRS across CCs need follow FG 4-25.  But parallel MSGA PUSCH and PUCCH/PUSCH transmissions across CCs have to be supported although there are TA misalignment and over max power of UE UL transmission issues.  Actually parallel MSGA PUSCH and PUCCH/PUSCH transmissions in intra-band CA is under discussion in 2s RACH session ([101-e-NR-2step-RACH-01] Email discussion/approval w.r.t. MsgA overlapping with other UL signal). And UE behavior is similar between intra-band CA and inter-band CA. If TP on parallel MSGA PUSCH and PUCCH/PUSCH transmissions in intra-band CA is accepted, FG9-3 should be supported.  I put related contribution number (R1-2003503, R1-2003855, R1-2003365, R1-2003455 and R1-2004130) for your information in this meeting.  Description of TP is as follows:  ===============================================  For single cell operation or for operation with carrier aggregation in a same frequency band, a UE does not transmit PUSCH for Type-2 random access procedure and PUCCH/SRS or PUSCH not for Type-2 random access procedure in a same slot or when a gap between the first or last symbol of a PUSCH transmission for Type-2 random access procedure in a first slot is separated by less than  symbols from the last or first symbol, respectively, of a PUCCH/SRS or PUSCH not for Type-2 random access procedure transmission in a second slot where  for  or ,  for  or , and  is the SCS configuration for the active UL BWP.  ====================================================  My 2 open questions:   1. If MSG PUSCH behavior is similar with R15 PUSCH behavior, why need we propose above TP for intra-band CA case? 2. If parallel MSGA PUSCH and PUCCH/PUSCH transmissions in intra-band CA can’ t be permitted under some conditions, why can’t parallel MSGA PUSCH and PUCCH/PUSCH transmissions in inter-band CA be made as 1 UE feature group? |
| **Qualcomm-1** | We agree with CATT’s comments in general, and FG 9-3 should be kept. In addition, we’d like to point out the differences of FG 9-3 with respect to NR Rel-15:  1. In Rel-16, msgA has a new channel structure including PRACH+TXGap+PUSCH, wherein the mapping rule from PRACH resource to PUSCH resource is pre-configured by the network and the value of TXGap is determined by the mapping rule.  o There is no equivalent UE feature in Rel-15, which treats PRACH and PUSCH as a whole in discussing the parallel UL transmission across CCs in inter-band CA.  2. In Rel-16, UE assumes TA=0 for both PRACH and PUSCH transmission of msgA, regardless TA timer is running or not on the primary TAG.  o In Rel-15, when UE assumes “TA=0” for PUSCH, it means the TA timer is still running for the corresponding TAG. |
| Samsung | In short, we think it should adopt the “Updated FL proposal 1: FG9-3 is removed from the UE features list for 2 step RACH”, sorry that we are not convinced by the “reasons” by catt or qc. In response to CATT comments:  I thought we were discussed clearly during offline, but it seems not.  Your first comments on TA mis-alignment are incorrect. What do you mean “TA misalignment causes signal interference between MsgA PUSCH or SRS/PUCCH/PUSCH transmissions across CCs in gNB side”, TA command is given by gNB, is UE has the capability of multiple TAG, gNB is able to configure different TA, and UE is able to transmit with different TA, the purpose is to make sure the UL signals to arrive at gNB side at the same time, so interference are not there. Note that, for the case gNB have different TA configured UE UL signals, it could be cases the receiving gNB is not at the same place, similar to mutipe TRP;  And your second comment on power limitation makes me even more confusing, in we have discussed the power priority of msgA prach and msgA pusch, if the total required power is exceeding the max power, UE drop the lower priority UL signals or transmited with reduced power, isn’t this normal behavior???  In additional to your open questions, as I already told me you before, it also involved the cross discussion from multiple agenda item and agreements from multiple agenda item. For intial access and UL group people, we make the spec to clearly specify the the UE behavior if the PRACH and ul signals are too close; if time allows, we for sure could do the same thing for inter-band, but as I told you, that the inter-band case was not raised at that time, and from implementation point of view, it is not an issue. At very very late stage, some company raised the feature on PRACH and other UL signals. You should ask them for the answers for rel-15; for your open question 2, that’s not even the points, the point is what UE is capable of doing and what UE already report to gNB, is already good enough for handling the msgA PUSCH vs other UL signals situation.  In response to QC comments:  We called it msgA, doesn’t mean it is a new intact channel. We called msg2, do you think the PDCCH and PDSCH in msg2 are the same channel??? Their resource, power control etc are quite different, if msgA PRACH and msgA PUSCH is same channel, why do we need to put different power priority on them?  For the second comments, yes, it’s applicable may caused the transmission of TA=0 in different TAG timer running situation, but we are talking about the UE capability on PUSCH transmission with TA=0, this will not change the capability whether UE can or cannot transmit PUSCH with TA=0; |
| **Qualcomm-2** | Thanks for the continued discussion. However, we don’t agree with the comments of Samsung as above.  To give a simple specific example, assume intra-band contiguous UL CA, where the UE implements a single common FFT for two carriers (this is a supported Tx architecture). The UE can support PRACH transmission simultaneous with PUSCH because the PRACH waveform is, or at least can be, generated in time domain directly, without going through Tx FFT. But the same UE cannot support PUSCH+PUSCH because with one common FFT, two PUSCH with different timings cannot be generated. This is a very specific example but holds in general to UEs that are single TAG capable. They may support unaligned concurrent PRACH because that can be generated with different hardware but not concurrent unaligned PUSCH.  Some further clarification is as follows:   1. FG 4-26 is about “Parallel PRACH and SRS/PUCCH/PUSCH transmission across CCs in inter-band CA.” For msg1 or msgA PRACH transmission, it goes without saying that UE always assumes NTA=0 TTA=0, and the PRACH waveform (including CP and guard time) is generated differently from that of PUSCH. 2. FG 4-26 is different from FG9-3 under discussion for 2-step RACH, because if UE supports FG 4-26 and FG 9-1, it does not necessarily mean UE supports FG 9-3.    * Example: When UE selects 4-step RACH, it supports FG 4-26; when UE selects 2-step RACH, it supports FG 9-1 but always drops the PUSCH/PUCCH/SRS signals on cross CC when conflicting with msgA PUSCH for inter-band CA. 3. As stated in Clause 4.3.1 of TS 38.211, the start of UE’s UL frame will apply the valid TA command, except for msgA transmission on PUSCH where NTA=0 TTA=0 shall be used. 4. For UE in RRC connected state and supporting inter-band CA, UE can initiate two-step RACH procedure on PCell/PScell and NTA=0 TTA=0 is assumed for both msgA PRACH and msgA PUSCH, regardless the TA timer is running or not for the PCell/PScell. 5. If the TA timer for the cross carrier is still running, UE will apply the NTA received in the preceding DL frames, which leads to N\*TA≠0 T\*TA≠0 , if PUSCH/PUCCH/SRS is transmitted on the cross CC. 6. When the cross CC and the PCell/PScell belong to the same TAG, there is an UL timing misalignment between msgA PUSCH (TTA=0) and other UL signals (T\*TA≠0).   Therefore, an independent FG should be defined for UE’s capability in NR R16 2-step RACH, to support parallel transmission of msgA PUSCH and PUSCH/PUCCH/SRS signals across CCs for the scenario of inter-band CA. |
| **Samsung** | Thanks for the discussion, and pls find my comments in below:   * + Regarding your example in the main part. First, you are assuming the intra-band contiguous UL CA. we have specified this behavior in the 38.213, I guess you know this:   “For single cell operation or for operation with carrier aggregation in a same frequency band, a UE does not transmit PRACH and PUSCH/PUCCH/SRS in a same slot or when a gap between the first or last symbol of a PRACH transmission in a first slot is separated by less than  symbols from the last or first symbol, respectively, of a PUSCH/PUCCH/SRS transmission in a second slot where  for  or ,  for  or , and  is the SCS configuration for the active UL BWP.”  This is exactly why during rel-15, when we discussed this issue, the Ngap bring up by some company (including QC) even when PRACH and other UL is different slot still need Ngap symbols, and the common understanding is inter-band, UE can handle it.   * + Regarding your comments in (1), I don’t agree the part “For msg1 or msgA PRACH transmission, it goes without saying that UE always assumes TTA=0,” PRACH transmission is always assuming the N\_ta=0, this is same for all PRACH in all RRC state, since you already find some description for msgA PUSCH in 211 as you commented in (3), you can also find the one in 211 for PRACH in section 5.3.2, OFDM baseband signal generation for PRACH   “- a timing advance value shall be assumed;”   * + Regarding your comments in (2), I don’t say if UE support FG 4-26 and FG9-1, then UE support FG9-3. This is not my point, my point is, signaling of FG9-3 will not help anything,     1. If UE did not have ability to transmit PUSCH TA=0 and other UL signals with TA≠0, i.e., UE has single TAG capability. What can UE/gNB do? During initial access, there is no such case. During connected mode, if still CBRA, even gNB knows this FG9-3, but gNB cannot know when UE send the msgA, so it cannot scheulde the other UL signals to avoid it. So it is still upto UE implementation to drop one of them. (not necessarily to drop UL signals, UE can drop msgA PUSCH as well) The best best chance is during handover case CFRA 2step RACH, because both msgA PUSCH and other UL are basically scheduled by gNB; however, if gNB already know UE has single TAG capability, and gNB also know the msgA assuming TA=0 and other UL signals with valid TA, gNB can already do the schelduing avoid it without this FG9-3.   + Regarding your comments in (4)(5)(6), they are simly the fact for msgA PUSCH, like the mis-allignment of TA. It doesn’t contribute the necessity of FG9-3, and also doesn’t impact whether UE/gNB handle it no matter such FG9-3 is signaled or not.   Again, thank you for the discussion. Pls undersanding I am NOT purely objecting to introduce a FG, I am open to it as long as the necessity can be justified. Thank you. |
| **Qualcomm-3** | Thanks for the continued discussion.  However, what you mentioned as the common understanding is NOT the agreement of NR Rel-15. Actually, what was agreed in NR Rel-15 is exactly opposite to what you said. “Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA” is an optional UE feature requiring capability signaling, as indicated by FG 4-26.  Maybe our example about” intra-band contiguous UL CA” has confused you, but the point is not about intra-band CA. It is about UE’s challenge to generate two UL channels (say PUSCH1+PUSCH2)using one common FFT, when PUSCH1 and PUSCH2 belong to the same TAG but somehow have different UL timings. As we commented above, “intra-band contiguous UL CA” is a very specific example but holds in general to UEs that are single TAG capable, regardless the CA is intra-band or inter-band. In this situation, it is UE’s capability to apply more than one FFTs for UL signals within the same TAG.  On the other hand, there seems to be a conflict between “TTA=0” (Clause 4.3.1, TS 38.211, V16.1.0) and “NTA=0” (Clause 5.3.2, TS 38.211, V16.1.0). Based on the RAN1#99 agreement, NTA=0 should be assumed for both msgA PRACH and msgA PUSCH. Therefore, we think a CR is needed to correct “TTA=0” into “NTA=0” for Clause 4.3.1, TS 38.211, V16.1.0.  Having said that, our conclusion stays the same for “Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”, which is recapped as follows:   1. For msgA PRACH and msgA PUSCH, UE always assumes “NTA=0” and ignores the TA command of gNB (say NTA\_new) 2. On the cross-CC belonging to the same TAG of msgA PUSCH, UE can apply the TA command of gNB (NTA\_new), if there is PUSCH/PUCCH/SRS transmission parallel to msgA PUSCH 3. It is UE’s capability to transmit msgA in parallel with PUSCH/PUCCH/SRS signals across CCs for interband CA with MsgA in PCell/PSCell   Therefore, an independent FG should be defined for UE’s capability in NR R16 2-step RACH, to support parallel transmission of msgA and PUSCH/PUCCH/SRS signals across CCs for inter-band CA with MsgA in PCell/PSCell |
| **Samsung** | Thanks for the discussion.  Yes, I understand your comments on the optional UE feature, as I also discussed with CATT, this UE feature is a very late stage proposed one, we probably need to check with the company who propose it. I was not handling this during that stage, so sorry I cannot give the answer on this. But I can ensure that during our RAN1 dicussion, we did not think inter-band is an issue at least due to this TA issue. See following agreement :  RAN1#92bis and RAN1#93    We did not specify the case of inter-band CA eventually. If we find it’s an issue, we will do it. But I have to admit, it is also unclear to me why make it is a UE optional feature, it could be some company identify someother issue but cannot make the change in the spec, so make it as a UE optional feature. So my point is: the FG4-16 is not due to TA=0, and different from other UL signals. So even given the fact the FG4-16 existance, will not impact and did not justify the FG9-3.  Regarding the T\_TA, and N\_TA, yes, you are right, I also notice the type0, and agree that it should be correted. Had proposed to Li offline, may handle in the editoral CR.  Regarding your analysis:  For a), right; for b), agree, if UE applied the TA, then UE could choose to drop the msgA PUSCH; or UE can choose to transmit msgA PUSCH and apply TA=0, and drop other UL signals;  for c), this is the same effect of “single TAG” capability, as we analyzed in the preivous comments, there is no additional usage for having this FG9-3. Or do you find any usage of having this FG9-3? |
| **Qualcomm-4** | Thanks for the comments of SS, and the effort to remind the FL for a really needed CR.  However, we are not sure if the complaints about R15 WI are within the context of R16 UE feature discussion. Per our understanding, specifying a new UE feature for R16 2-step RACH should be based on the UE features agreed in R15. If you don’t agree with FG4-26, maybe you should propose it for R15 CR before the R16 UE feature discussion starts ? It is a bit too late to object to FG4-26 now, and use that objection to question or argue against FG 9-3.  Moreover, we don’t agree with the second part of SS’s comments on our analysis b). Again, FG 9-3 discusses UE’s capability for inter-band CA, and please don’t mix it with UE’s procedures for single CC or intra-band CA.  For c), it is upon UE’s capability to apply two FFTs for concurrent UL signals: one FFT is for msgA PUSCH, and the other FFT is for parallel PUSCH/PUCCH/SRS. |
| **Samsung** | Thx for the discussion.  I don’t object FG4-26, I just commented that I am not fully understand the motivation to have it, and since we have discussed the handling of the PRACH and other UL signals due to the TA issue, I can only guess the reason is some others. If this reason is valid and also applied to msgA PUSCH as well, we can consider to have FG9-3.  Further, for b) I don’t mixed it with intra-band, with no clearly specify UE behavior during the inter-band case, UE can do per it’s implementation, it is not always necessary to cancel the normal UL signals or cancel the msgA PUSCH, if you read the agreement I pasted above, our RAN1 agreement is also to leave it to UE implementation, if UE is capabale to transmit both, it transmits both; if UE is capablie of transmit only one TA, it just transmits one. This is agreement for intra-band, is actually same as did not specify any particular UE behavior, which is same as inter-band case.  For c), of course it’s upto UE, one important point made during that agreement discussion is that, from gNB point of view, it doesn’t really matter which one UE have to choose, because any signal UE transmitted has possibility to be missed, or wrongly detected, so the key part is how UE to handle it, and because UE has different capability, so it’s natural to leave it to UE implementation. This is the fundamental reason of our RAN1 agreement. Imaging if in case, gNB scheduled the UL signals and UE happens triggerd to send PRACH in the same slot, if it is only capable to transmit one, then just transmit one, if PRACH is dropped, then dropped; if UL signals are dropped, then dropped. And if UE can transmit both, then transmit both. Nothing needs additionally handled. And certainly don’t need this FG9-3. |
| **Qualcomm-5** | We support FL’s proposal to keep FG 9-3. In addition to our comments above, we think whether or not UE supports FG 9-3 will impact gNB’s procedure as well as the response UE expects to receive from gNB.  Specifically, for a RRC connected UE:   * if UE indicates it supports FG 9-3, gNB can configure PRACH and PUSCH resource for msgA in time/frequency using dedicated RRC signaling. In addition, gNB can schedule other UL signals overlapping with msgA in time but cross CC. After UE transmis msgA and UL signals, it will expect msgB (in response to msgA) and other DL signal (in response to SRS/PUCCH/PUSCH); * if UE indicates it does not support FG 9-3, gNB can avoid the overlapping of msgA and other UL signals, either in RRC configuration or UL scheduling. As a result, gNB will receive either msgA on PCell/PScell, or aother UL signal cross CC, but not both.   Therefore, it is beneficial to keep FG 9-3 to avoid potential ambiguity in UE/gNB implementation. |
| **Samsung** | Thx for the discussion, but I already think about this case and analysis this case and replied to you several days ago. Pasted below.  “*The best best chance is during handover case CFRA 2step RACH, because both msgA PUSCH and other UL are basically scheduled by gNB; however, if gNB already know UE has single TAG capability, and gNB also know the msgA assuming TA=0 and other UL signals with valid TA, gNB can already do the schelduing avoid it without this FG9-3.*”  The benefits you claimed for FG9-3 can already be done by single TAG signaling.  As you describled by your self, pasted below.. PRACH can be generated even with single TAG capability, so separate 4-16 on PRACH vs other signals is added. But PUSCH cannot be generated.  “*But the same UE cannot support PUSCH+PUSCH because with one common FFT, two PUSCH with different timings cannot be generated. This is a very specific example but holds in general to UEs that are single TAG capable.*” |
| **Qualcomm-6** | Thanks for the comments of Samsung (SS).  However, we are sorry SS has overlooked the main points of our replies/comments eariler. Our analysis is NOT what SS claimed. Some further comments from Qualcomm:   * By the use of dedicated RRC signaling, gNB can configure PRACH and PUSCH resources for 2-step CBRA or 2-step CFRA. That is, the benefits of FG 9-3 are not limted to CFRA scenario. * By knowing UE’s capability to support FG9-3 or not, gNB could adapt its transmission and reception procedures more efficiently. Namely,   + the transmitter of gNB can use different scheduling and UL resource configurations based on UE’s capability for FG9-3   + the receiver of gNB can use different processing procedures/algorithms based on UE’s capability for FG9-3 * To reply SS’s question on our earlier *arguments* (copied below), please note our goal was to explain the differences between FG9-3 and FG4-26. That is, if UE supports FG9-1 and FG4-26, it not necessarily means FG 9-3 will be supported by UE automatically. For more details, please check our comments in the 2nd and 3rd rounds of reply.   “*But the same UE cannot support PUSCH+PUSCH because with one common FFT, two PUSCH with different timings cannot be generated. This is a very specific example but holds in general to UEs that are single TAG capable.*” |
| **Samsung** | Thx. But apparently, I am not overlooked your comments, as I commented in reply to your Qualcomm-2, “Regarding your comments in (2), I don’t say if UE support FG 4-26 and FG9-1, then UE support FG9-3. This is not my point, my point is, signaling of FG9-3 will not help anything”  I fully understand your intention on the example, to differentiae the case FG9-3, and FG4-16.  It seems you like everything to be explicitly detailed explained, pls find my comments inline below on your benefits.   * By the use of dedicated RRC signaling, gNB can configure PRACH and PUSCH resources for 2-step CBRA or 2-step CFRA. That is, the benefits of FG 9-3 are not limted to CFRA scenario.   [SS]: what are the benefits for CBRA? gNB has no idea when and which resource UE gonna do 2step RACH, how could gNB use FG9-3 to arrange scheduling or reception? With further check with RAN2, even for CFRA case, gNB explicictly configures the msgA PRACH and msgA PUSCH, gNB still don’t know when UE gonna transmit msgA; how could gNB use FG9-3 to arrange scheduling or reception?   * By knowing UE’s capability to support FG9-3 or not, gNB could adapt its transmission and reception procedures more efficiently. Namely,   + the transmitter of gNB can use different scheduling and UL resource configurations based on UE’s capability for FG9-3   [SS]: with mentioned above, gNB has no idea when UE gonna transmit msgA PUSCH or PRACH, how could gNB avoid such scheduling “collision”?   * + the receiver of gNB can use different processing procedures/algorithms based on UE’s capability for FG9-3   [SS]: without knowing when UE gonna transmit msgA, how gNB could use “different processing procedures/algorithms” for them? The gNB will operate normally for detection of msgA and normally detection of other signals. |
| **Qualcomm-7** | We are not sure about the technical issues that bother Samsung, and we don’t agree with their judgement either. As confirmed by Nokia, LG, and other companies, there are benefits to keep FG 9-3 for both UE/gNB implementation. We have shared our analysis from various technical perspectives, as shown above in this document.  Companies’ comments to support FG 9-3 can also be found in the corresponding email thread and Tdocs (e.g. [2], [4], [5], [7], [10], [12]).  For the progress of the technical discussion, we will comment once more for clarification:   * For a RRC connected UE, the PRACH/PUSCH resources for msgA transmission can be configured by gNB via dedicated RRC signaling, for either CBRA or CFRA.   + When UE initiates CBRA/CFRA, it will select from the PRACH/PUSCH resources configured by gNB.   + Since UE is connected, gNB knows exactly which UE and which resources have been configured.   + Once the configuration is done on PCell/PScell.     - UE’s msgA arrival will occur on those pre-configured time instants, and gNB will attempt msgA detection on those instants.     - In some scenarios, gNB is aware of the trigger events of RACH, and can further reduce the instants of msgA detection. * If UE reports “support for FG 9-3,” gNB can schedule parallel UL transmissions cross CC for inter-band CA, using configured grant or dynamic grant.   + In time domain, the UL resources allocated by CG or DG can overlap with those pre-configured msgA resources.   + From gNB perspective     - parallel UL transmissions from the UE are likely to occur on pre-configured time instants known to gNB     - gNB will attempt to decode both on those time instants * If UE reports “no support for FG 9-3,” gNB will avoid scheduling PUSCH/PUCCH/SRS of the UE on those UL resources, which potentially overlap in time with pre-configured PRACH/PUSCH resources on PCell/PScell   + Instead, gNB can allocate the UL resources to other UEs which do not have parallel transmissions cross CCs, or to other UEs that can support FG 9-3   + For the UE that does not support FG 9-3, gNB will NOT attempt to decode parallel UL transmission for msgA and other UL signals |
| **Samsung** | First, for these discussed this issue and showed position, already summaried by Hiroki, with additionall [4] CATT is also fine to remove it.   * + **FG is removed: [3], [6], [9], [11], [13]**     - **FG 4-26 should be extended to support 2-step RACH: [3]**   + **FG is kept: [2], [4], [5], [7], [10], [12]**     - **FG is updated with only MsgA PUSCH: [2]**   Second, you have this mis-undertanding seems due to you believe knowing the dedicated resource configuration meaning gNB can know when UE actually transmit. But I am keeping telling you; given the dedicated RACH resource doesn’t imply gNB to knows when UE will actually send msg.1 or msgA. The CFRA resource would be valid until T304 timer expiry. Before the expiry, gNB has to keep detecting the potential occasion for the transmission of msg.1 or msgA. As shown in following figure, gNB can know potentially UE will transmit the PRACH in the configured dedicated RO, but exacting timing (meaning the exact which RO) is undetermined. It is based on how fast UE can process the handover command (RRC messages) and initiation of the PRACH. |

## 2.2 FG[9-4]

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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 | [9-4] | [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 |

* **Necessity of FG[9-4]**
  + **FG is removed: [2], [3], [6], [13]**
    - FG 6-16 should be extended to support 2-step RACH: [3]
  + **FG is kept: [4], [5], [7], [10], [12]**

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

|  |  |
| --- | --- |
| [2] | **Proposal 3: For FG 9-4, no need to introduce separate FG for 2-step RACH.** |
| [3] | ***Proposal 1:*** If there is a common understanding that 4-26 and 6-16 can be applied to MsgA PRACH and MsgA PUSCH, then there is no need of introducing a different UE feature for Rel-16 2-step RACH. And FG 4-26 and 6-16 should be extended to support 2-step RACH.   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | | 6-16 | Supplemental uplink | 1) RACH (type 1 or type 2), PUSCH, PUCCH, SRS operations in a band combination including SUL  2) Supplemental uplink with same numerology between SUL and non SUL carriers | |
| [4] | **Proposal 3: We suggest keeping FG 9-4 as single FG** |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [7] | ***Proposal 1:*** Parallel transmission of msgA with other signals and msgA operation in SUL are needed. |
| [10] | **Observations**:   * FG 9-4 seems needed, since there are specific parameters used with SUL for 2 step.   **Proposals**:   * Keep FGs 9-3, 9-4 |
| [12] | * **FG 9-4**   + It is OK to keep this FG. |
| [13] | * 9-4: Do not introduce the FG. Reasoning is essentially the same as for 9-3. |

Based on above, following FL proposals are made.

**FL proposal 2:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

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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 | 9-4 | MsgA operation in a band combination including SUL | MsgA operations in a band combination including SUL | 9-1, 6-16 | 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 |

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 proposals:

|  |  |
| --- | --- |
| Company | Comment |
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Based on the discussion in Tuesday GTW session, following agreements were made.

**Agreements:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

## 2.3 FG[9-6]

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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 | [9-6] | [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 |

* **Necessity of FG[9-6]**
  + **FG is removed: [9], [10], [11], [13]**
    - **Clarify that this feature is for RRC\_CONNECTED UE, and if UE follows Rel-15 feature on the number of unicasts PDSCH reception, i.e., 5-11, 5-11a and 5-11b, this feature can be removed: [11]**
  + **FG is kept: [8], [12]**
    - **RAN2 to make final decision on whether this separate FG is needed: [8]**
  + **FFS (wait for RAN2 LS): [2], [3], [5], [6],**
* **Name of FG[9-6]**
  + **FG 9-6 is modified as up to X of msgBs per slot within the msgB window when msgB carries SuccessRAR with RRC configuration: [8]**
* **Type of FG[9-6]**
  + **Per band: [12]**

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

|  |  |
| --- | --- |
| [2] | **Proposal 4: For FG 9-6, wait for RAN2’s further discussion and conclusion on it before introducing the FG.** |
| [3] | Regarding the FG 9-6, as captured in the LS to RAN2 that this may be related to the payload size of MsgB, we can decide whether or not to support this FG after we get the feedback from RAN2, or left it to RAN2 for the final decision. |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | * *[9-6] [up to X of msgBs per slot/within the msgB window] [up to X of msgBs per slot/within the msgB window]*   Wait for RAN2 further reply. |
| [8] | ***Proposal 1***:  **FG 9-6 is modified as up to X of msgBs per slot within the msgB window when msgB carries SuccessRAR with RRC configuration**   * **It is kept without square bracket from RAN1 perspective assuming the maximum payload size can be as large as msg4 of 4-step RACH; a UE must report a value for this FG if reports support of FG 9-1 (similar to *pdsch-ProcessingType1-DifferentTB-PerSlot*)**   **RAN2 to make final decision on whether this separate FG is needed, e.g. after confirming that the maximum payload size of msgB would be similar to msg2 of 4-step RACH** |
| [9] | **Proposal 2: The feature group 9-3 and 9-6 can be removed.** |
| [10] | **Observations**:   * FG 9-6 does not seem to have a clear need yet to us, since the use case for multiple MsgBs in a slot is not really established.   **Proposals**:   * Do not define FGs 9-5, 9-6 |
| [11] | **Proposal 4:** **For FG of “up to X of msgBs per slot/within the msgB window”,**   * **Clarify that this feature is for RRC\_CONNECTED UE.** * **If UE follows Rel-15 feature on the number of unicasts PDSCH reception, i.e., 5-11, 5-11a and 5-11b, this feature can be removed.** |
| [12] | * **FG 9-6** * The type of this FG should be **per band**. * It is OK to be kept. |
| [13] | * 9-6: Do not introduce the FG. When monitoring for the MsgB, the UE will simply monitor configured search spaces for DCI. Also, for initial access the gNB would not know this feature and would hence not be able to act accordingly. For connected mode, it would not make much sense to have limitations compared to initial access. It should be noted that there are no UE features for restrictions on monitoring for Msg2 for 4-step RACH. |

Based on above, following FL proposals are made.

**FL proposal 3:**

* **FG[9-6] is removed from the UE features list for 2 step RACH**

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 proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Cannot accept the proposals.  Alternative 1: keep this FG from RAN1 perspective and revisit it depending on RAN2 reply LS;  Alternative 2: remove it from 2-step RACH UE feature list and revisit it on discussion of FGs proposed in [101-e-NR-UEFeatures-Others-01] where the following is proposed   * Defines whether the UE capable of processing time capability 1 supports reception of up to two, three or seven unicast PDSCHs for several transport blocks with PDSCH scrambled using C-RNTI, msgB-RNTI, TC-RNTI, or CS-RNTI in one serving cell within the same slot per CC that are multiplexed in time domain only. This FG is reported per FS.   + Note PDSCH(s) for MsgB/Msg.4 is included. |
| Samsung | We have included the question to LS to ran2 and ask for their input; we don’t think it is approperate to make this proposed move without getting their reply. Then what’s the point to send the LS question? Suggest to keep it in bracket at least for now. |
| Nokia, NSB | We are not supportive of the FG itself, however we tend to agree that it is fair to keep it in bracket for now so that RAN2 has an opportunity to reply to the LS sent last meeting about this very FG. |
| Qualcomm | We think this FG should be kept for further discussion. |

Based on the discussion in Wednesday GTW session, following agreements were made.

**Agreements:**

* **FG[9-6] is kept with bracket in the UE features list for 2 step RACH**
  + **Add a note “RAN2 to make final decision on whether this FG is needed or not considering the maximum payload size of msgB”**

## 2.4 Others

* **Necessity of FG “MsgA PUSCH frequency hopping with non-zero guard period”**
  + **No need (i.e., included in the basic feature): [3], [5], [10], [11], [12], [13]**
  + **Adopt this FG or maybe put in FG9-1: [6]**

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

|  |  |
| --- | --- |
| [3] | Regarding the FG 9-5, from gNB vendor’s point of view, we do not think it is necessary to differentiate the intra-slot frequency hopping with and without guard period, and thus it should be included in the basic feature group. |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [10] | **Observations**:   * FG 9-5 is not so desirable since performance enhancing feature such as frequency hopping need to be widely supported for the net gains in a cell to be achievable.   **Proposals**:   * Do not define FGs 9-5, 9-6 |
| [11] | **Proposal 3:** **MsgA PUSCH frequency hopping with non-zero guard period should not be separate feature group from basic feature group.** |
| [12] | * **FG 9-5** * We don’t think it is needed. |
| [13] | * 9-5: Confirm deletion of FG. Frequency hopping is supported by default, If this FG is introduced, there would be a potential segmentation of the UEs according to the feature. Since the MsgA PUSCH Occasion would be derived with reference to the guard period, it would not be possible to have multiplexing of UEs supporting this FG and UEs not supporting this FG. Hence, for gNB to support UEs supporting this feature, it would need to create two separate PUSCH configurations, which would be an extreme waste of resources. Hence, either all UE support the guard period between hops, or no UE support the guard period between hops (which would be equivalent to dropping the feature completely from specifications). |

Based on above, it seems not necessary to discuss again on the necessity of FG9-5 “MsgA PUSCH frequency hopping with non-zero guard period” as it was already removed from the UE features list for 2 step RACH.

Nevertheless, companies can provide comments if any below.

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| --- | --- |
| Company | Comment |
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1. Conclusion

**Updated FL proposal 1:**

* **FG9-3 is removed from the UE features list for 2 step RACH**

**Agreements:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

**Agreements:**

* **FG[9-6] is kept with bracket in the UE features list for 2 step RACH**
  + **Add a note “RAN2 to make final decision on whether this FG is needed or not considering the maximum payload size of msgB”**

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]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |