**3GPP TSG RAN WG1 Meeting #102-e R1-2007192**

**Aug 17th – 24th, 2020**

**Agenda item: 7.2.2.1.1**

**Source: Moderator (Qualcomm Incorporated)**

**Title: FL summary for initial access signals and channels for NR-U**

**Document for: Discussion and Decision**

# Introduction

Multiple issues are discussed in the submitted papers for 7.2.2.1.1. After preparation phase email discussion, it was agreed to discuss the following:

[102-e-NR-unlic-NRU-InitSignalsChannels] Email discussion/approval on the following until 8/20; if necessary, endorse associated TPs by 8/25 – Jing (Qualcomm)

* PRACH configuration in multiple RB sets (Issue 4.4 in FL summary)
* Msg A PUSCH RB-set determination (Issue 4.5 in FL summary)

# Issue 4.4: PRACH configuration in multiple RB sets

## 2.1. Summary of proposals in submitted papers

In [7] (and [13]), [9] and [12], it is proposed to support FDM ROs in different RB sets

[10], [11] and [14] talk about if PRACH is configured over multiple RB sets, how to determine the RB set used for RAR UL grant. [10] proposes to use the RB set with actual PRACH transmission (no spec change) and [11] and [14] proposes to use the lowest index RB set with PRACH configured.

Proposal in [7]: Support RACH occasions over multiple consecutive RB sets based on *msg1-FDM*. Confine one RACH occasion within one RB set by applying *msg1-FrequencyStart* to *i*-th FDMed RACH occasion (1< *i* ≤ *msg1-FDM*) with the reference point of the start CRB of the RB set *s.*

============================ Start of TP for TS 38.211 ===================================

5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

, if or , if or

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

-  is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise,  is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;

- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part, if or . is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to start CRB of a RB set in the active uplink bandwidth part, if or . The quantity is given by the higher-layer parameter *frequencyStartMsgA-PUSCH* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

-  is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;

- is the start CRB of a RB set in which the PRACH transmission occasion with index is [6, TS 38.214].

-  is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.

============================ End of TP for TS 38.211 ==================================

Proposal 1 in [9]: In case when the long PRACH sequence (i.e., L\_"RA" =1151 or L\_"RA" =571) is configured, multiple FDMed ROs are supported in active UL BWP with multiple RB sets.

Proposal 2 in [9]: In case when the multiple ROs are configured in active UL BWP with multiple RB sets, RO offset is supported, and each RO is allocated with a gap as much as the RO offset from the lowest indexed PRB of each RB set.

Observation in [10]: No correction is needed for the case where PRACH is configured in more than one RB set.

Proposal in [11]: When PRACH is configured in more than one RB set, the RB set used for transmission of the PUSCH corresponding to Msg3 is the lowest indexed amongst the RB sets intersecting the PRACH allocation.

Proposal in [12]: If the number of configured FDMed PRACH resources is larger than 1,

* If long PRACH sequence is configured, the starting position of each RO within the corresponding RB set can be configured.
* If short PRACH sequence is configured, the RO which is configured to occupy frequency resource in two RB sets should be taken as an invalid RO.

Proposal in [14]: The lowest RB set of PRACH can be used for PUSCH transmission where PRACH is configured in more than one RB set.

## 2.2. 1st round Discussion

There are multiple questions for this issue.

Q1: Do we support multiple FDMed ROs in active UL BWP over multiple RB sets?

Q2: If the answer to Q1 is “yes”, do we support it for PRACH sequence of length 1151 and 571, or we also support it for PRACH sequence of length 139?

Q3: If the answer to Q1 is “yes”, the RB set to transmit PUSCH allocated by RAR UL grant is

* + - * Alt 1. The lowest indexed RB set with PRACH configured.
      * Alt 2. The same RB set that the PRACH is transmitted for the corresponding msg1.

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| **Company** | **View** |
| Qualcomm | Q1: We see no harm to support FDMed ROs when there are multiple RB sets  Q2: To limit the spec impact, and also for short PRACH sequence, there are enough RO resources available in freq domain even in one RB set, we see no need to suppose multiple RB sets configuration for length 139 PRACH sequence  Q3: We believe it is simpler to use Alt 2 (same RB sets for msg1 and msg3), so we can distribute msg3 to different RB sets. |
| OPPO | Q1: it is expected to support FDM’ed ROs when there are multiple RB sets, but we think the RO, which the PRACH is transmitted, should be confined within a RB set  Q2: long PRACH sequence is expected to be supported.  Q3: when a RO, in which the PRACH is transmitted, is confined in a RB set, there is no issue to determine the RB set for PUSCH scheduled by RAR UL grant. Thus, we think Alt2 is fine. |
| Sharp | Q1: Yes.  Q2: We can support FDMed PRACH with length 1151 and 571 if interlaced transmission is not configured.  Q3: Alt.2. |
| Samsung | Q1: Yes. To provide similar flexibility of RO configuration as in licensed band, it is desirable to support FDM’ed ROs when there are multiple RB sets. We share the same view with OPPO that one RO should be confined within a RB set, otherwise, it can’t meet OCB requirement.  Q2: At least long PRACH sequence should be supported.  Q3: Alt 2 is sufficient |
| ZTE, Sanechips | Q1: Yes.  Q2: We support it for PRACH sequence of length 1151 and 571.  Q3: Alt 2. |
| Nokia, NSB | Q1: Considering that initial DL BWP is confined within 20MHz, It is very unlikely that UE cannot transmit PRACH somewhere else during initial access. For UE specific RACH configuration after RRC, there is no need for restriction. E.g. for short PRACH, multiple FDM ROs fit into one RB-set.  Q2 No need to restrict FDM ROs to short length, but UE should not transmit PRACH which overlaps with at least on RB of intra-cell GB.  Q3: Non of above, I suppose we address here the second FFS below. For that FFS our proposal is  *When PRACH is configured in more than one RB set, the RB set used for transmission of the PUSCH corresponding to Msg3 is the lowest indexed amongst the RB sets intersecting the PRACH allocation*  Agreement:   * As per prior agreement, initial UL BWP is 20 MHz   + FFS: The case of SUL in licensed band * For PUSCH scheduled by a RAR UL Grant (e.g., Msg3) or by DCI 0\_0 addressed to TC-RNTI (Msg3 re-transmission) when UL Resource Allocation Type 2 is configured, the PUSCH is transmitted as follows:   + PUSCH is transmitted in the same UL RB set of the active UL BWP as PRACH (Msg1) * FFS: The case where PRACH is configured in more than one RB set |
| Huawei, HiSilicon | Q1: yes. It is only for connected UE. Share the view that a RO should be confined within a RB set.  Q2: both long and short PRACH sequence can support.  Q3: Alt 2. Aligning the agreement in UL AI that msg 1 and msg 3 are in the same RB set. |
| LGE | Q1: Yes. In order to reduce the contention probability between multiple UEs (so that the access latency/UE power consumption is reduced), it is desirable to support the multiple FDMed ROs in the active UL BWP with multiple RB sets.  Q2: At least the PRACH sequence of length 1151 and 571 should be supported, and also the support of PRACH sequence of length 139 would also be beneficial in the same context with the above Q1.  Q3: Alt 2 as already agreed. On the configuration of multiple FDMed ROs for PRACH sequence of length 1151 and 571, with a given RO offset, each RO is allocated with a gap as much as the RO offset from the lowest indexed PRB of each RB set. |
| Ericsson | Q1: Okay to support for the *active* UL BWP  Q2: For short PRACH, Rel-15 already supports multiple FDM'd ROs, and these can be confined within an RB set by configuration with the existing spec. Hence, suppost for ROs in multiple RB sets should be restricted to length 1151 (15 kHz) and 571 (30 kHz).  Q3: Alt-2 is already agreed, hence we should not re-open this issue. |
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## 2.3. 2nd round discussion

Summary of the 1st round discussion

Q1. Do we support multiple FDMed ROs in active UL BWP over multiple RB sets?

* Note 1: This is for connected mode UE
* Note 2: Each RO will be confined within one RB set
* Support: Qualcomm, Oppo, Sharp, Samsung, ZTE, Sanechips, Nokia, NSB, Huawei, HiSilicon, LGE, Ericssoon
* Not support: None

Q2: If the answer to Q1 is “yes”, do we support it for PRACH sequence of length 1151 and 571, or we also support it for PRACH sequence of length 139?

* Only support length 1151 and 571 PRACH for RO over multiple RB sets: Qualcomm (for simplicity), Oppo (how about 139?), Sharp (when interlaced PUSCH/PUCCH not configured), Samsung (at least), ZTE, Sanechips, Ericsson
* Support length 139, 1151 and 571 PRACH for RO over multiple RB sets: Nokia, NSB, Huawei, HiSilicon, LGE (support 139 as well is beneficial)

Q3: If the answer to Q1 is “yes”, the RB set to transmit PUSCH allocated by RAR UL grant is

* Note: As Nokia pointed out, in previous agreement, the case where PRACH is configured in more than one RB set is still FFS
* Alt 1: None
* Alt 2: Qualcomm, Oppo, Sharp, Samsung, ZTE, Sanechips, Huawei, HiSilicon, LGE, Ericsson
* Alt 3 (Nokia version: When PRACH is configured in more than one RB set, the RB set used for transmission of the PUSCH corresponding to Msg3 is the lowest indexed amongst the RB sets intersecting the PRACH allocation): Nokia, NSB
  + Question to Nokia: Is this to cover the case that a single PRACH spans multiple RB sets issue? If we confine one PRACH to be within a RB set, will this reduce to Alt 1 or Alt 2?

FL Proposal 2.1:

* For connected mode UE, support configuring multiple FDMed ROs in active UL BWP over multiple RB sets, where each RO will be confined within one RB set.
  + FFS: This is supported for PRACH sequence length 1151 and 571 only, or PRACH sequence length 1151, 571 and 139

FL Proposal 2.2:

* When PRACH is configured in more than one RB set, the RB set to transmit PUSCH allocated by RAR UL grant is the same RB set that the corresponding PRACH is transmitted
* Note: This may not have spec impact

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| **Company** | **View** |
| Ericsson | FL Proposal 2.2 is not needed since the spec already captures this (because PRACH is limited to a single RB set). In 38.213 Section 8.3:  - for RB set allocation of a PUSCH transmission, the RB set of the active UL BWP is the RB set of the PRACH transmission associated with the RAR UL grant  So, as per FL Proposal 2.1, if ROs are confined to a single RB set, then the PRACH transmission is obviously confined within one RB set, and the above behaviour from 38.213 applies. |
| Nokia, NSB | We do not Support 2.1, because we do not think there is a need to change mapping of PRACH at such late stage.  Consequence is that long PRACH can be present only in one RB-set.  I can see that there are follow up question, potential RRC parameters, and I am not sure this would be the end of it.  For short PRACH, we could allow FDMed ROs, but the ones overlapping with multiple RB-sets could be dropped, not used by UE. |
| Qualcomm | Can Nokia clarify when you say “long PRACH can be present only in one RB-set”, you mean long PRACH occasions are all in one RB set, or each PRACH is in one RB set?  For short PRACH sequence, we can already handle 8 freq domain ROs with 15KHz and 4 freq domain ROs with 30KHz, given we can configure at most 8 freq domain ROs. We see there is even less motivation to allow the set of ROs cross multiple RB sets.  Agree that the spec impact might be larger than we are expecting. |
| Samsung | Support both proposal 2.1 and 2.2.  For long PRACH, if we confine all ROs in one RB set, that means, there is no FDM, the flexibility and capacity of PRACH within a certain time period would be much smaller than that over licensed band.  The modification of SSB-RO mapping is very limited, i.e. SSB-RO mapping is performed within each RB set, and the same mapping is applied to all RB sets containing ROs. |
| ZTE, Sanechips | Perhaps Nokia means that if we allow ROs in multiple RB sets, and if there is no restriction that each RO will be confined within one RB set, then the consequence is that for long PRACH sequence, all ROs except the first one will cross the RB set boundary. However, if we have this restriction, we need to define new RRC parameters for the frequency offset for each RO in different RB set, which will further lead to other unexpected spec impact such as RA-RNTI calculation. In addition, there is a case that 4-step RACH and 2-step RACH will share the RO, then FDMed RO over multiple RB set also need to consider the mapping between MsgA PRACH and PUSCH, and the MsgA PUSCH RB set configuration, the spec impact is unexpected, so we may need further investigation before we make the changes. |
| Samsung | For Nokia and ZTE’s comment of potential new RRC parameters, actually, we can reuse the existing RRC parameters without adding any new RRC parameter to support ROs over multiple RB sets. As we rely to Q4, the frequency offset for each RO can be derived by existing RRC parameter *msg1-FrequencyStart*, the number of RB sets for long PRACH is equal to *msg1-FDM*.  For ZTE’s comment of potential standard impact such as RA-RNTI calculation, I guess the concern is, if we change SSB-to-RO mapping scheme, then, how to determine f\_id is also changed, so it may impact RA-RNTI. But, in our understanding, they’re two separate/independent issue. We can still follow Rel-15 f\_id ordering within the active BWP, i.e. f\_id is the index of the PRACH occasion in the frequency domain (0 ≤ f\_id < 8) as defined in TS 38.321, while add only one sentence to restrict SSB-to-RO mapping performed in each RB set. Therefore, no impact on RA-RNTI calculation and only very minor spec change for SSB-to-RO mapping is expected. |
| LG | First of all, we are supportive with FL proposals 2.1 and 2.2 themselves.  Regarding the SSB-to-RO mapping issue, our view/comments are provided as the answer to Q4 and Q5 below. |
| OPPO | We support proposal 2.1 and 2.2. |
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Additional questions if the above proposals are agreeable:

Q4: When multiple FDMed ROs in active UL BWP over multiple RB sets are configured, how to indicate/configure the starting RB for ROs in each RB set

Q5: When multiple FDMed ROs in active UL BWP over multiple RB sets are configured, how to associate SSBs and PRACH sequences.

* When connected mode UEs are configured with more RB sets for PRACH, the SSB to PRACH mapping for initial access UEs and connected UEs are different. The same PRACH in an RO in an RB set usable for both initial access UE and connected mode UE may map to two different SSBs following the mapping.

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| **Company** | **View** |
| Samsung | Q4: We can reuse the existing RRC parameters *msg1-FrequencyStart* and *msg1-FDM*, the number of RB sets for long PRACH = *msg1-FDM*, the 1st RB set for ROs and starting RB for 1st RO in 1st RB set is determined by *msg1-FrequencyStart*. The offset between a starting RB for a RO in a RBG set and the starting RB of the RB set is the same for all RB sets.    Q5: SSB-to-PRACH mapping is performed within a RB set, and the same mapping is applied for each RB set, thus the same mapping is achieved for both initial access UEs and connected UEs.  Therefore, the expected standard impact is controllable. |
| LG | Q4: We have similar view with Samsung in term of RO mapping over multiple RB sets. Given the RRC parameters *msg1-FrequencyStart* and *msg1-FDM*, the number of FDMed ROs is equal to *msg1-FDM* as in legacy where each RO is allocated to different RB set, and the offset between the starting RB of 1st RO and the starting RB of 1st RB set determined by *msg1-FrequencyStart* is the same for other ROs and their RB sets.  Q5: A fundamental question exists on the sub-bullet. Is it an issue only in the NR-U situation or also in the existing L-band? Our thinking is that even in L-band case, the same SSB-to-RO mapping issue would occur if some of ROs in the active BWP for the connected mode UE is configured to be overlapped with the ROs in the initial BWP. We think such overlapping is to be avoided by gNB not only for L-band but also for NR-U, in order to avoid different SSB mapping for a same RO between idle UE and connected UE (please let me know if I have misunderstanding or I’m missing something).  Regarding Samsung’s proposal in terms of SSB-to-RO mapping, it seems a same mapping based on single RB set is repeated over multiple RB sets, but it looks like the previous proposal on multiple TX opportunities for PRACH which was already agreed not to introduce. |
| Sharp | Q4: We have similar view as Samsung that *msg1-FrequencyStart* indicates single RB-offset value between the lower edge of RB-set and starting RB of RO. On the other hand, this may also require new RRC parameter for switching legacy behaviour (i.e., contiguous ROs in frequency) and the new behaviour.  Q5: Wee see that no change is necessary. |
| OPPO | Q4: we agree with Samsung.  Q5: if the active UL BWP includes initial UL BWP, we see two options:   1. The network configures a RO configuration in the active UL BWP which is identical to that of initial UL BWP, i.e. active UE and idle UE share the same RO. 2. The network configures a RO configuration in the active UL BWP which is non-overlapped with that of initial UL BWP.   The above two options can be realized by network implementation. |
| Qualcomm | Q4: We do like Samsung proposal on reusing existing RRC parameters. One issue we see in Samsung proposal is there is no way to identify which RB set is the first RB set the PRACH is mapped to. In other words, the design seems to mandate the first RB set in the active UL BWP is the first RB set to map PRACH.  We propose an alternative method that can further support the identification of first RB set for PRACH in the UL BWP.  Step 1. The msg1-FrequencyStart is kept as is, to identify the location of the first RB of PRACH.  Step 2. The first RB will fall in one of the RB sets, and this RB set is the first RB set with PRACH mapped, and the offset from the first RB of the first PRACH to the lower end of the RB set is identified  Step 3. The offset from step 2 is applied to later RB sets to map the remaining PRACH if more frequency domain ROs are configured  Q5: We do support the method proposed by Samsung on per RB set SSB to RO mapping. In our view, the key benefit of having multiple ROs over multiple RB sets is to support using the RB sets FDM with the RB set used for initial access RO, which cannot be efficiently used before. If we need to allocation orthogonal ROs from the ones allocated for initial access, we will need to spend more resource on PRACH and is not preferred in unlicensed channels. And unless with totally TDM initial access ROs and connected UE ROs, it is hard to separate them. |
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## 2.4. 3rd round discussion

FL Proposal 2.1:

For connected mode UE, at least for PRACH sequence length 1151 and 571, support configuring multiple FDMed ROs in active UL BWP over multiple RB sets, where each RO will be confined within one RB set.

* Alt 1. Repurpose *msg1-FrequencyStart* as the offset of each RO from the lowest CRB from each RB set, and fix the first RO to be at the lowest RB set in the UL BWP
  + Supported by TP1 in 2.5
* Alt 2. Legacy *msg1-FrequencyStart* indicates the position of the first RO and first RB set with RO in the UL BWP. The RB offset between the lowest CRB of the first RB set with RO and the lowest RB of first RO is applied to higher RB sets in the UL BWP
  + Supported by TP2 in 2.5
* FFS: If this is also supported for PRACH sequence length 139.

FL Proposal 2.2:

When PRACH is configured in more than one RB set, the RB set to transmit PUSCH allocated by RAR UL grant is the same RB set that the corresponding PRACH is transmitted

* Note: No spec impact identified

FL Proposal 2.3:

For SSB to PRACH mapping when multiple RB sets are configured

* Alt 1. Legacy mapping. No spec impact
* Alt 2. SSB to PRACH mapping is done per RB set. Supported by TP3 in 2.5

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| **Company** | **View** |
| Ericsson | Our view is to avoid adopt legacy behaviour as much as possible. Configuration of multiple FDM'd ROs is supported in the spec today; the only thing that needs to change is to adjust the starting RB for each RO such that the RO is confined within the RB set. We don't want to touch the legacy SSB-to-RO mapping.  Hence, our preferences are as follows:   * FL Proposal 2.1: **Alt-2** for simplicity and commonality with Rel-15. * FL Proposal 2.2: **Support in general**; however, should this also apply also for PUSCH scheduled by DCI 0\_0 addressed to TC-RNTI (for PUSCH re-transmission for CBRA?). If the answer is yes, still no spec impact identified since the TC-RNTI case is already captured in 38.214 Section 6.1.2.2.3. * FL Proposal 2.3: **Alt-1** for commonality with Rel-15. Alt-2 is out-of-scope for the WI since the following was listed as an optimization in RAN#84 (RP-191581):   + "Msg1 enhancements with more opportunities in freq domain (over multiple LBT subbands) and time domain" * By the way, we have the same question as LGE regarding Q5. It seems like the scenario Jing raises can occur for licensed bands as well, and we would like to keep as much commonality between licensed/unlicensed as possible. * Still need time to check the details of the TP |
| LG | We largely agree with Ericsson for all the FL proposals 2.1, 2.2, and 2.3.   * On FL proposal 2.1: **Alt-2** for flexibility and simplicity * On FL proposal 2.2: **Support** with no further spec impact * On FL proposal 2.3: **Alt-1** for commonality with Rel-15 (as Ericsson commented, Alt-2 looks like the previous SI proposal on Msg1 enhancement with more TX opportunities in F-domain)   In addition, we also think more time is necessary to check the TP details. |
| Samsung | For proposal 2.1, we support Alt-2.  Alt-2 is aligned with the intention of our previous respond in Q4, i.e. 1st RB set for ROs is determined by *msg1-FrequencyStart* (1st RB set for ROs may not be the 1st RB set of an active BWP depending on the value of *msg1-FrequencyStart*). For the remaining (*msg1-FDM* -1) RB sets, the offset between a starting RB for a RO in the RB set and the starting RB of the RB set is the same as that in the 1st RB set.  We’re fine with TP2, except ‘lowest RB set’ for n0. It reads like lowest PRACH transmission occasion may occupy more than 1 RB set, and n0 is lowest RB set of the PRACH. To avoid confusion, we suggest to delete ‘lowest RB set’. Besides, maybe explicit description in the spec that a UE does not expect a PRACH transmission occasion overlapping with more than one RB set is needed ?  - is the RB set index of the ~~lowest~~ RB set that the lowest PRACH transmission occasion in frequency domain is overlapping with.  We support proposal 2.2.  For proposal 2.3, if it is the common understanding that the same case may happen in licensed band which already can be handled by gNB implementation, we’re fine to support Alt-1 to avoid minimize standard impact. Otherwise, we prefer Alt-2. We want to clarify that it is not out of scope, because Alt-2 does not mean UE performs LBT over multiple RB sets and chooses one RO with successful LBT to transmit, it only means there’re several ROs over multiple RB sets, and UE simply follow legacy behaviour, i.e. UE choses one of the RO, and then, performs LBT. It is noted that, by legacy SSB-to-RO mapping, it is possible that more than one FDMed ROs associated with the same SSB can be in the same RO time domain resource, UE chooses one of them and performs LBT. |
| Huawei, HiSilicon | For proposal 2.1, we prefer **alt-2** which has least standard impact and more flexibility in the configuration in frequency domain.  For proposal 2.2, we support it.  For proposal 2.3, we acknowledged the benefit mentioned by Samsung and Qualcomm. It also allows multiple RO in frequency domain. However, considering the limited time in R16 maintenance phase, we prefer **alt 1** considering its commonality with Rel 15. |
| Ericsson2 | We think TP#2a below is a simpler, cleaner, more precise way to specify by having one formula for the case of L = 571/1151 instead of two separate formulas. |

The proposals are updated to below after further email discussion

Proposal:

For connected mode UE, at least for PRACH sequence length 1151 and 571, support configuring multiple FDMed ROs in active UL BWP over multiple RB sets, where each RO will be confined within one RB set.

* (Alt 2) Legacy msg1-FrequencyStart or *msgA-RO-FrequencyStart-r16* indicates the position of the first RO as in Rel-15, and thus implicitly indicates the ~~first~~ lowest-indexed RB set configured with an RO in the UL BWP. The RB offset between the lowest CRB of the ~~first~~ lowest-indexed RB set configured with an RO and the lowest RB of first RO is applied to higher indexed RB sets in the UL BWP for configuring the positions of the remaining ROs
* Supported by TP2 in 2.5

Note: the number of FDM’d ROs is provided by *msg1-FDM* as in Rel-15.

* FFS: If this is also supported for PRACH sequence length 139.

Proposed conclusion (as there is no spec impact):

When PRACH is configured in more than one RB set, the RB set to transmit PUSCH allocated by RAR UL grant is the same RB set that the corresponding PRACH is transmitted

* Note: No spec impact identified

Proposed conclusion:

For SSB to RO ~~PRACH~~ mapping when multiple RB sets are configured

* (Alt 1.) Legacy mapping. No spec impact

## 2.5. TP for proposals

============================ Start of TP1 for TS 38.211 ===================================

5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

, if or , if or

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

-  is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise,  is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;

- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part, if or . is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to start CRB of a RB set in the active uplink bandwidth part, if or . The quantity is given by the higher-layer parameter *frequencyStartMsgA-PUSCH* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

-  is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;

- is the start CRB of a RB set in which the PRACH transmission occasion with index is [6, TS 38.214].

-  is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.

============================ End of TP1 for TS 38.211 ===================================

============================ Start of TP2 for TS 38.211 ===================================

5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

, if or , if or , and

, if or , and

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

-  is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise,  is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;

- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part. The quantity is given by the higher-layer parameter *frequencyStartMsgA-PUSCH* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

-  is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;

- is the RB set index of the RB set that the lowest PRACH transmission occasion in frequency domain is configured.

- is frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to start CRB of RB set in the active UL bandwidth part,if or

- is the start CRB of RB set is [6, TS 38.214]

-  is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.

============================ End of TP2 for TS 38.211 ===================================

============================ Start of TP2a for TS 38.211 ===================================

\*\*\* Unchanged text omitted \*\*\*

5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

-  is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise,  is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;

- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part. The quantity is given by the higher-layer parameter *frequencyStartMsgA-PUSCH* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

-  is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;

-  is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.

- is the start CRB index of UL RB set [6, TS 38.214]

- is the index of the RB set which contains the lowest PRACH transmission occasion in frequency domain indicated by . The UE expects that is configured such that each PRACH transmission occasion is fully contained within an RB set.

\*\*\* Unchanged text omitted \*\*\*

============================ End of TP2a for TS 38.211 ===================================

============================ Start of TP3 for TS 38.213 ===================================

8.1 Random access preamble

----------Unchanged text omitted-----------

SS/PBCH block indexes provided by *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon* are mapped to valid PRACH occasions in the following order where the parameters are described in [4, TS 38.211].

- First, in increasing order of preamble indexes within a single PRACH occasion

- Second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions if *intraCellGuardBandUL-r16* is not configured, and in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions within each RB set if *intraCellGuardBandUL-r16* is configured

- Third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slot

- Fourth, in increasing order of indexes for PRACH slots

----------Unchanged text omitted-----------

============================ End of TP3 for TS 38.213 ===================================

# Issue 4.5 Msg A PUSCH RB set determination

## 3.1. Summary of proposals in submitted papers

In [7] (and [13]), it is proposed to confine each Msg A PUSCH inside one RB set.

Proposal in [7]: For 2-step RACH, a Msg A PUSCH is confined within one RB set which is the same RB set for its associated Msg A PRACH.

=========================== Start of TP for TS 38.213 ===================================

8.1A PUSCH for Type-2 random access procedure

=========================== Unchanged Text Omitted ===================================

A UE determines time resources and frequency resources for PUSCH occasions in an active UL BWP from *msgA-PUSCH-Config* for the active UL BWP. If the active UL BWP is not the initial UL BWP and *msgA-PUSCH-Config* is not provided for the active UL BWP, the UE uses the *msgA-PUSCH-Config* provided for the initial UL BWP. If a UE is configured with interlaced PUSCH, the RB set for a MsgA PUSCH transmission is the RB set of the associated Msg A PRACH transmission.

A UE determines a first interlace for a first PUSCH occasion in the RB set in active UL BWP or first RB for a first PUSCH occasion in an active UL BWP respectively from *interlaceIndexFirstPO-MsgA-PUSCH* or from *frequencyStartMsgA-PUSCH* that provides an offset, in number of RBs in the active UL BWP, from a first RB of the RB set in the active UL BWP or of the active UL BWP. A PUSCH occasion includes a number of interlaces within the RB set or a number of RBs provided by *nrofInterlacesPerMsgA-PO* or by *nrofPRBs-perMsgA-PO*, respectively. Consecutive PUSCH occasions in the frequency domain of an UL BWP are separated by a number of RBs provided by *guardBandMsgA-PUSCH*. A number of PUSCH occasions in the frequency domain of an UL BWP is provided by *nrMsgA-PO-FDM*.

============================= End of TP for TS 38.213 ==================================

## 3.2. 1st round discussion

Please provide your view on the following:

Q1. Do we need to restrict MsgA PUSCH in one RB set, for either interlaced PUSCH or legacy PUSCH?

Q2. Do we need to restrict MsgA PUSCH to the same RB set as the PRACH transmitted?

Proposal: For 2-step RACH, the MsgA PUSCH is in the same RB set as the associated MsgA PRACH transmission

|  |  |
| --- | --- |
| **Company** | **View** |
| Qualcomm | Q1. For interlaced PUSCH, we believe it is beneficial to restrict the Msg PUSCH in one RB set only. For non-interlaced PUSCH, introduce this restriction may require substantial spec change, and is not preferred.  Q2. If we introduce this restriction, we will need to change the PRACH to PUSCH mapping mechanism. Even without this limitation, consider we have separate Cat 4 LBT for MsgA PRACH and MsgA PUSCH anyway, restricting them to the same RB set is an optimization at most. We prefer not to introduce this restriction |
| OPPO | Q1: We expect that MsgA PUSCH is transmitted within a RB set.  Q2: MsgA PUSCH and the associated PRACH are in the same RB set. |
| Sharp | Q1: The restriction seems good for the interlaced PUSCH. For RA type 0/1, the restriction is not necessary.  Q2: Yes. It has commonality with 4-step RACH.  Proposal should be applied to RA type-2. |
| Samsung | Q1: For interlaced Msg A PUSCH, we need to define which RB set(s) is. It is beneficial to restrict PUSCH in single RB set which is sufficient for Msg A PUSCH payload and it avoids multiple LBT over multiple RB sets. For legacy PUSCH, it would also be beneficial to restrict it within one RB set to avoid multiple LBT.  Q2: We prefer to restrict MsgA PUSCH in the same RB set of transmitted PRACH to have a common design for 2-step and 4-step RACH. Though separate Cat-4 LBT is performed for Msg A PUSCH and PRACH, it is more likely to access the channel for Msg A PUSCH if LBT for PRACH in the same RB set is successful.  QC raises up a good point that some modification for the PRACH to PUSCH mapping mechanism is expected. In our view, we can add the restriction that the mapping is performed in each RB set. If companies have strong concern on the potential standard impact of modify PRACH to PUSCH mapping, we’re open to consider determining RB sets for POs according to RB sets for ROs (+ one PO confined in one RB set), and then reuse the legacy PRACH to PUSCH mapping mechanism within the RB sets. |
| ZTE, Sanechips | Firstly, We need to clarify the meaning of MsgA PUSCH in Q1 and Q2, we think it refers to a PO(PUSCH occasion), not a PO group(including multiple POs associated with a PRACH slot).  Q1: We support to restrict only MsgA interlaced PUSCH within a RB set. As for legacy PUSCH, it’s difficult to guarantee each PO in one RB set if multiple FDMed POs are configured. This is because that the frequency gap between neighbour POs is 1 or 0 PRB and it’s probably for one PO to cross the RB set boundary. I think it can be left to gNB configuration to avoid multiple LBT for legacy PUSCH.  Q2: There is no need for such restriction.  As mentioned by Qualcomm and Samsung, it may lead to unexpected spec impact to make such restriction under current MsgA PRACH and PUSCH mapping method. One RO in a RB set can be mapped to multiple POs in the same or different RB sets. There is no need to keep it the same as 4-step RACH because there is no mapping relationship between Msg1 and Msg3 as in 2-step RACH. Besides, the benefit is very limited due to the separate LBTs for MsgA PRACH and PUSCH. |
| Nokia, NSB | Q1: We think for interlace PUSCH of MSG A, same behaviour should apply as for MSG3 agreed last meeting for TYPE-2 RA  Q2: PRACH and interlace PUSCH of MSG A are both in the same RB-set |
| Huawei, HiSilicon | Q1: We think it should be restricted for both interlaced and non-interlaced Msg A PUSCH.  Q2: it would be simple for gNB implementation if msg A PUSCH and PRACH are in the same RB set. |
| LGE | On Q1, it seems undesirable to restrict MsgA PUSCH in only one RB set since many TDMed POs would be required to support the association with multiple ROs, and the TDMed POs might restrict flexible DL-UL configuration from gNB perspective.  On Q2, it seems undesirable to restrict MsgA PUSCH only to the RB set with PRACH transmission as well since the RO-to-PO mapping might not be efficient compared to the original 2-step RACH design as QC already commented.  For these reasons, we prefer to support PO allocation over multiple RB sets based on configuration without any modifying/changing of the current RO-to-PO mapping design.  Specifically, by considering one interlace in one RB set as unit interlace, multiple POs (over multiple RB sets) can be allocated with adjacent unit interlaces, where the unit interlaces (over multiple RB sets) are ordered in RB set first - RB interlace second manner. |
|  |  |

## 3.3. 2nd round discussion

Summary of 1st round discussion

Q1. Do we need to restrict MsgA PUSCH in one RB set, for either interlaced PUSCH or legacy PUSCH?

* Interlaced PUSCH only: Qualcomm, Sharp, ZTE, Sanechips, Nokia, NSB,
* Both interlaced PUSCH and legacy PUSCH: Oppo, Samsung, Huawei, HiSilicon,
* No restriction: LGE

Q2. Do we need to restrict MsgA PUSCH to the same RB set as the PRACH transmitted?

* No restriction: Qualcomm, ZTE, Sanechips, LGE
* With restriction: Oppo, Sharp, Samsung, Nokia, NSB, Huawei, HiSilicon

On restricting each MsgA PUSCH in one RB set, there is majority view to support it at least for interlaced PUSCH. There is also support for non-interlace PUSCH

FL proposal 3.1

* When interlaced waveform is configured for Msg A PUSCH, and when more than one RB set is configured in the active UL BWP for connected mode UE, restrict the Msg A PUSCH within one RB set
* FFS: If the above also applies when non-interlaced MsgA PUSCH is configured
* FFS: If we restrict MsgA PUSCH to the same RB set as the PRACH transmitted

FL proposal 3.2

* When 2-step RACH is configured for NR-U, all ROs for PRACH are confined with one RB set and the corresponding PUSCH occasions are confined within the same RB set

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| **Company** | **View** |
| Ericsson | While we don't have fundamental objections to this issue assuming that we had enough time, we are concerned about the scope of the changes involved here. It seems like there are several complicating issues that will need to be discussed, and we are concerned that the scope can be a bit large for this late stage of maintenance.   * One issue is the introduction of partial interlace allocation (RB set) that is not supported in the spec today.   + As we found in the UL agenda item, there can be some complicating details to handle * Another issue is how the RO to PO mapping may be affected   + This could become complicated   + Depending on the ambition level, it seems like a proper design might involve the need for a new RRC parameter, e.g., RB set index for the POs?   Regarding the case of non-interlacing, it seems as though restriction to single RB set can be achieved by configuration, hence no changes are needed. |
| Nokia, NSB | Agree with Steve, if many changes are required, this proposal is late. |
| Qualcomm | Share the same view as Ericsson and Nokia. This may involve too much spec change than we can handle at this phase. On the other hand, if we do have multiple RB set PRACH, we need to find a solution.  Added proposal 3.2 above to restrict if 2-step RACH is configured for NR-U, we only use one RB set, so the legacy behaviour works. |
| Samsung | We think potential standard impact for interleaved Msg A PUSCH is limited.  In 1st round comment, our 1st preference is to perform mapping within each RB set, while we’re open to consider mapping across RB set if such way can work without additional standard impact. After further thinking triggered by Q5 by FL, we think keep the same mapping principle for both SSB-to-RO and RO-to-PO is more desirable, i.e. perform both mappings within each RB set. Then, it seems no additional standard effort.  Therefore, we don’t think proposal 3.2 is needed. |
| ZTE, Sanechips | Agree with Steve. Considering the spec impact and the limited benefit, we also don’t want to change so much at this late stage, FL’s proposal 3.2 looks good to us. |
| LG | As we already commented in the 1st Round discussion, confining all the ROs and POs within only one same RB set is too restrictive and undesirable. We think the following could be the way to avoid such undesirable restriction, without any impact or change to the current RO-to-PO mapping.  First of all, considering one interlace in one RB set as a unit interlace, the unit interlaces are indexed in {interlace index-first, RB set index-second} manner, for example, the interlace x in the RB set y can be the unit interlace index (y–1)M + x, where M is the number of interlaces for the given SCS.  Given that, the RRC parameters as the starting interlace index, number of interlaces per PO, number of FDMed POs, are interpreted based on the unit interlace index. By doing so, the POs can be allocated over multiple RB sets, and given that, the current RO-to-PO mapping is just applied for the POs without any change. |
| OPPO | We think the current spec 38.213 subclause 8.1A is not very clear. With proposal 3.1, we believe that it will make 38.213 8.1A clearer. But if proposal 3.1 is not supported, we think 8.1A still needs further clarification. In this sense, we support proposal 3.1.  For proposal 3.2, first of all we think restricting all the RO into the same RB set is too much restricted. Thus, we think this restriction might not be necessary. Then, we are open to discuss the second restriction to limit the MsgA-PUSCH and its associated RO in the same RB set. |
| Qualcomm2 | Consider the amount of changes needed, we prefer Proposal 3.2 and leave multiple RB set 2-step RACH for future enhancement. This may still need some spec change, such as adding a few “UE does not expect …”. |
| Samsung 2 | Once the standard support for multiple ROs over multiple RB sets is stable, it is very simple to support Msg A PUSCH within one RB set. For example, restricting Msg A PUSCH within the same RB set of transmitted PRACH, or defining the RB sets for all POs is the same as the RB sets for ROs and reuse the legacy mapping. For either way, the standard change is minor. |
| Huawei, HiSilicon | We are fine with proposal 3.1.  As for proposal 3.2, limiting all RO in one RB set maybe too restrictive. We are fine to discuss it after we reach agreement in 2.4. |

Additional questions if the above Proposal 3.1 is agreeable

Q3: How to determine the resource used for each MsgA PUSCH in each RB set. For interlaced MsgA PUSCH.

* For interlaces MsgA PUSCH, how to determine the RB set index and starting interlace of each MsgA PUSCH.
* If non-interlaced MsgA PUSCH over multiple RB sets is also supported, how to determine the RB set index and starting RB for each MsgA PUSCH.

Q4: If we agree to restrict MsgA PUSCH to be in the same RB set as the MsgA PRACH transmitted, how to associate MsgA PRACH to MsgA PUSCH

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| **Company** | **View** |
| Ericsson | As stated above, it is clear that there can be quite a few complicating issues to consider, and the scope seems rather large for this late state of maintenance. |
| Samsung | Q3: RB set index of MsgA PUSCH is the same RB set as the MsgA PRACH transmitted. The starting interlace of 1st Msg A PUSCH in each RB set is *interlaceIndexFirstPO-MsgA-PUSCH*(existing RRC parameter).  Q4: With a RB set, the legacy RO-to-PO mapping mechanism is reused. |
| LG | Q3: As already answered and explained in the above table, the RB set and the starting interlace for MsgA PUSCH can be determined by the unit interlace index.  Q4: As already commented in the 1st Round discussion, restricting MsgA PUSCH to the same RB set with PRACH transmission is undesirable due to inefficient RO-to-PO mapping. The RB set for MsgA PUSCH is to be determined just according to the current RO-to-PO mapping as we explained in the above table. |
| Sharp | Q3: For interlaced PUSCH, we support the proposal. For non-interlaced PUSCH, no change is necessary.  Q4: If we find large impact on specification, we think that restriction on PRACH resource into one RB-set for 2-step RACH can be considered. |
| OPPO | Q3: in our understanding, Samsung and LG’s views are different. We can further discuss which one is to be considered.  Q4: we propose to deprioritize Q4. |
| Samsung 2 | For Q3, please check one example from our proposal as below. It is applicable to both the case with or without the restriction that Msg A PUSCH is in the same RB set as the MsgA PRACH transmitted, as long as the set of RB sets for ROs is the same as that of POs.  Example: assuming interlace index *interlaceIndexFirstPO-MsgA-PUSCH* =2, number of interlaces per PO *nrofInterlacesPerMsgA-PO* =1, number of FDMed PO *nrMsgA-PO-FDM*=8, RB sets for POs is RB set 2 & 3 of the active BWP which is determined by ROs. Then, for RB set 2, 4 ROs (RO 1~4) is interlace 2, 3,4,5 within RB set 2 respectively, and for RB set 3, 4 ROs (RO 5~8) is interlace 2,3,4,5 within RB set 3 respectively. |

# Reference

[1]. R1-2005330, Remaining issues on initial access signals and channles, vivo

[2]. R1-2005597, Remaining issues on the initial access signals for NR-U, ZTE, Sanechips

[3]. R1-2005789, Maintenance on initial access signals and channels, Huawei, HiSilicon

[4]. R1-2005904, Remaining issues on Initial Access Signals and Channels for NR-U, Nokia, Nokia Shanghai Bell

[5]. R1-2005910, Initial access signals and channels, Ericsson

[6]. R1-2006017, Discussion on the remaining issues of initial access signal/channel, OPPO

[7]. R1-2006092, Initial access signals and channels for NR-U, Samsung

[8]. R1-2006288, Remaining issues on initial access signals, Spreadtrum Communications

[9]. R1-2006298, Remaining issues of initial access signals and channels for NR-U, LG Electronics

[10]. R1-2005808, Maintenance on UL signals and channels, Huawei, HiSilicon

[11]. R1-2006371, Remaining Issues on UL Signals & Channels for NR-U , Nokia, Nokia Shanghai Bell

[12]. R1-2006019, Discussion on the remaining issues of UL signals and channels, OPPO

[13]. R1-2006094, UL signals and channels for NR-U, Samsung

[14]. R1-2005599, Remaining issues on the UL channels for NR-U, ZTE, Sanechips