**3GPP TSG RAN WG1 Meeting #102-e R1-2006993**

**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. |

## 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

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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. |

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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# 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

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| **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. |
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## 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. |

Additional questions if the above 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. |

# 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