

**Agenda item:** 5.1.1.4.2 – 4 step RA Procedure  
**Source:** Cohere Technologies  
**Title:** Discussion on RACH procedure and Resources  
**Document for:** Discussion and Decision

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## 1 Introduction

In RAN1#87 meeting [1], a few agreements on the RACH procedure and on RACH resources were reached. Namely, the following agreements related to RACH resources were made:

**R1-1613545** WF on Load Balancing Across PRACH resources

**Agreements:**

- RAN1 studies further on
  - the support of different RACH resource subset size that is associated with one or multiple occasions for DL broadcast channel/signal
    - FFS: whether other parameters of each RACH resource subset can be different
    - FFS: How the different RACH resource subset size information is conveyed to UE
  - the support of same RACH resource subset size that is associated with one or multiple occasions for DL broadcast channel/signal and non-uniform transmission of DL broadcast channel/signal across different directions in a multi-beam scenario
  - Other mechanisms to load balance RACH resource subset is not precluded

**R1-1613539** WF on Remaining Issues on RACH Procedures

**Agreements:**

- Regardless of whether Tx/Rx reciprocity is available or not at gNB at least for multiple beams operation,
  - At gNB, the DL Tx beam for message 2 can be obtained based on the detected RACH preamble/resource and the corresponding association
    - UL grant in message 2 may indicate the transmission timing of message 3
- NR will support different PRACH configurations, e.g., considering different numerologies case and whether Tx/Rx reciprocity is available or not at gNB.

**R1-1613281** WF on RACH Procedure

**Agreements:**

- NR supports the following procedure(s) for msg1 re-transmission
  - Down selection or combination of power ramping, UE beam switching, and RACH resource switching
    - FFS: How to combine power ramping, UE beam switching, and RACH resource switching depending on number of TRP Rx beams, UE Tx beams, number of RACH resources
    - FFS: Whether to consider different procedures depending on the single-TRP/beam or multi-TRPs/beams
    - Other options for all frequency ranges are not precluded.

In this contribution, we provide our view on the RACH procedure and resources.

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## 2 Discussion

In the last 3GPP RAN 1 meeting, several proposals were made with regards to RACH resources. In most of them, the requirement for several different RACH sets, or RACH groups (as they termed in [2]), i.e. PRACH preambles (or signatures, as also termed) and RACH resources in frequency and time domain was raised. In addition, the requirement for varying dynamically in time, the amount of RACH groups per beam was brought up.

Namely, in [2], the need for support of multiple RACH preambles is described. In addition, the mapping between RACH sets and DL synchronization signals, as well as the selection of RACH set based on measurements done in DL beams is presented. In [3] it is mentioned that RACH resources, i.e. frequency and time resources, for variable sizes of PRACH preambles should be granted. Moreover, RACH resources considering the different frame types and TDD configurations should be considered as well. In [4] the need to support different numbers of RACH resources per beam was justified. Another reason for supporting several RACH sets of different size within a beam was mentioned in [5]. Therein, the need to support PRACH preambles of different bandwidths due to the existence of UEs with different bandwidth capabilities was mentioned.

For these reasons, as well as for supporting RACH procedures in both idle and connected mode, more than 1 RACH group per beam have to be available. It is suggested that at given RACH occasion in time, more than 1 RACH group, i.e. PRACH preamble set and frequency and time resources, per DL beam is supported.

**Proposal 1: At a given RACH occasion, the option for more than 1 RACH group within a given beam should be supported.**

One way to support different sets of PRACH preambles within a given beam is to multiplex the same set of PRACH signatures on the same frequency band and apply different code, or scrambling per PRACH signatures set. This option being the one using the lowest amount of radio resources, requires complex receiver though. In addition, this option may reduce orthogonality of sequences of different sets due to the different delay profile per path. Another drawback of this option is that it is restricting the option for UEs to choose the best frequency band for transmission of RACH.

The other option for supporting different RACH groups, hence, different sets of RACH preambles at the same RACH occasion is to provide the choice to UEs to select within more than one frequency band for RACH transmission. The different bands used for RACH at the same RACH instance can be of the same, or of different bandwidth. The RACH preamble sets used at the same RACH occasion, and being of the same bandwidth, use the same RRACH signatures. This option in some cases might require more frequency resources than the first option, has several advantages:

- i) It requires less complex receiver compared to the first option.
- ii) In the case of Tx/Rx reciprocity, UEs can choose the best uplink band for RACH transmission.
- iii) Or, in the absence of Tx/Rx reciprocity, UEs can choose the uplink band, which is estimated to result to the lowest error probability. Such an approach will simplify significantly the overall RACH procedure, since RACH failure will be in most of the cases, the result of collision.

Therefore, it is proposed that different RACH groups within a beam at a given RACH instance are transmitted at different bands. Bands can be of the same, or of different bandwidth.

**Proposal 2: Different RACH groups within a beam at a given RACH instance are transmitted at different bands. Bands can be of the same, or of different bandwidth, in which RACH preamble lengths of the same, or of different sizes are transmitted.**

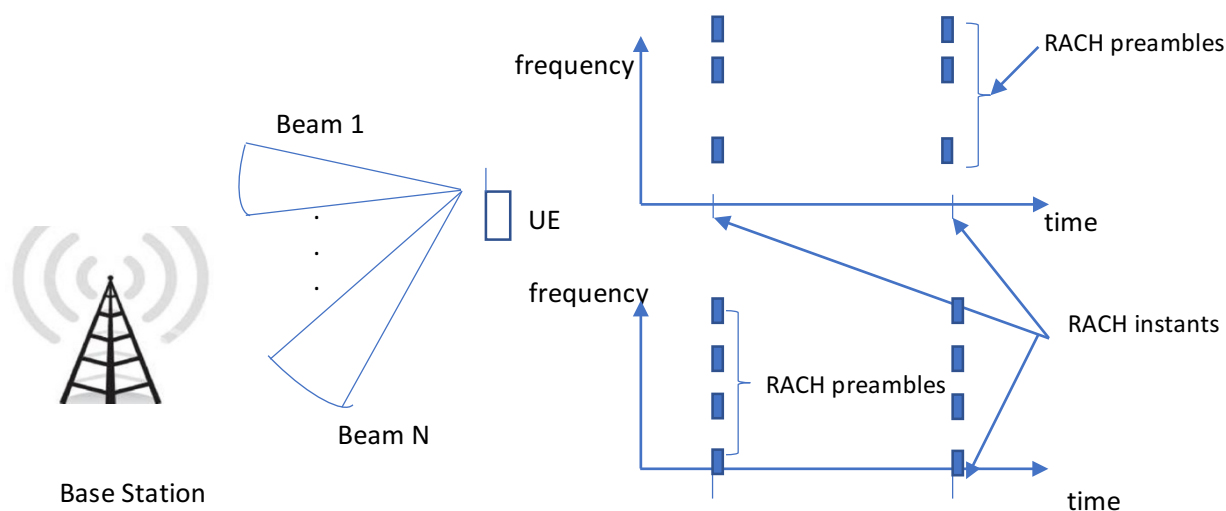
Examples of RACH transmission instants can be seen in Figure 1 and Figure 2. In the example of Figure 1, different RACH bands are of the same bandwidth. In the example of Figure 2, RACH bands of different bandwidths within the beam are used.

In case more than one frequency bands of the same bandwidth is used for transmission of different RACH groups within a beam at a given RACH instance, the set of PRACH preambles (or signatures) to be used within these different bands is the same.

**Proposal 3: In case more than one frequency bands of the same bandwidth used for transmission of different RACH groups within a beam at a given RACH instance, the set of PRACH preambles is the same within the different bands of the same bandwidth.**

Different frequency bands of different bandwidth used for transmission of different RACH groups within a beam at a given RACH instance use different sets of PRACH preambles (or signatures).

As mentioned in [4], at given instances, different numbers of users might be associated with the various DL beams. Or, even, within the same DL beam, different amounts of RACH resources might be needed and will be supported.



*Figure 1: Transmission of RACH preambles on different frequency bands within a given beam; RACH preambles of the same bandwidth; different numbers of RACH bands per beam.*

In case of Tx/Rx reciprocity, the amount of RACH resources used per beam corresponds to the amount of resources used for synchronization signals and or the amount of resources used for system information.

**Proposal 4: In case of Tx/Rx reciprocity, the amount of RACH resources used per beam is equivalent to the amount of resources used for synchronization signals and or the amount of resources used for system information. This correspondence is known to UEs via system information.**

In the absence of Tx/Rx reciprocity, the amount of RACH resources per beam is signaled to the UEs via system information.

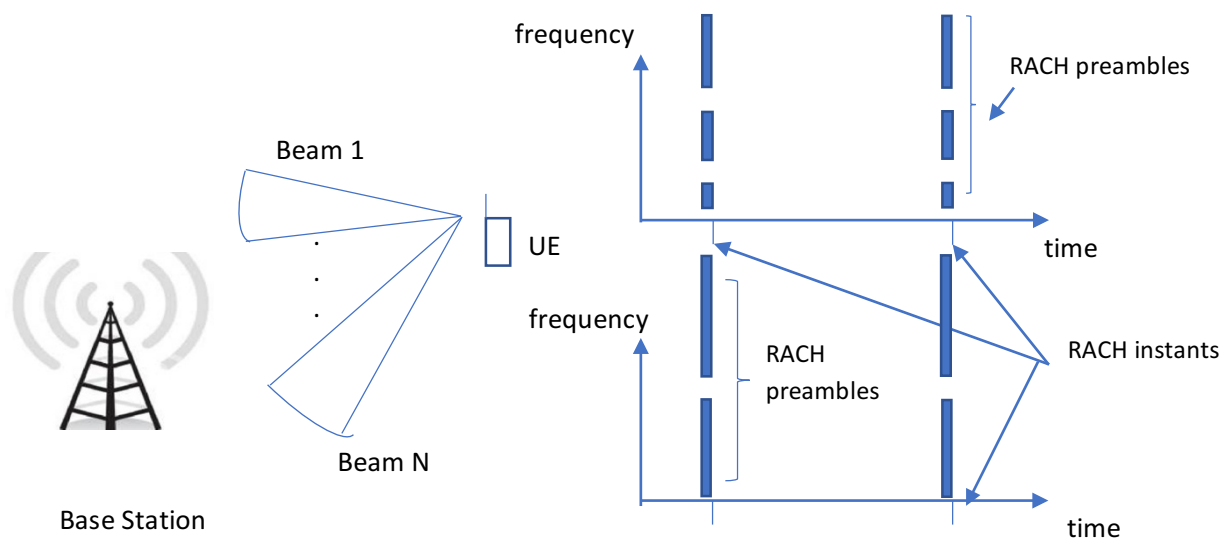


Figure 2: Transmission of RACH preambles on different frequency bands within a given beam; RACH preambles of different bandwidth within a beam; different numbers of RACH bands per beam.

**Proposal 5: In the absence of Tx/Rx reciprocity, the amount of RACH resources per beam is signaled via system information.**

### 3 Conclusion

In this contribution, we have discussed the RACH procedure and RACH resources and we have concluded on the following proposals.

**Proposal 1: At a given RACH occasion, the option for more than 1 RACH group within a given beam should be supported.**

**Proposal 2: Different RACH groups within a beam at a given RACH instance are transmitted at different bands, in which RACH preamble lengths of the same, or of different sizes are transmitted.**

**Proposal 3: In case of more than one frequency bands of the same bandwidth used for transmission of different RACH groups within a beam at a given RACH instance, the set of PRACH preambles is the same within the different bands of the same bandwidth.**

**Proposal 4: In case of Tx/Rx reciprocity, the amount of RACH resources used per beam is equivalent to the amount of downlink resources used for synchronization signals and or the amount of resources used for system information. This correspondence is known to UEs via system information.**

**Proposal 5: In the absence of Tx/Rx reciprocity, the amount of RACH resources per beam is signaled via system information.**

### 4 References

- [1] RAN1 Chairman's note, 3GPP TSG RAN WG1 Meeting#87, Reno, USA, November 2016.
- [2] R1-1611273, "Unified RACH Procedure", ZTE, ZTE Microelectronics, 3GPP TSG RAN WG1 Meeting#87, Reno, USA, November 2016.
- [3] R1-1611373, "NR RACH Preamble Design Considerations", CATT, 3GPP TSG RAN WG1 Meeting#87, Reno, USA, November 2016.
- [4] R1-1613545, "Way Forward on Load Balancing across PRACH resources", Intel, 3GPP TSG RAN WG1 Meeting#87, Reno, USA, November 2016.
- [5] R1-1612469, "RACH procedure considering flexible UE Bandwidth", Samsung, 3GPP TSG RAN WG1 Meeting#87, Reno, USA, November 2016.