

Agenda item: 9.2.1.4
Source: Nokia, Alcatel-Lucent Shanghai Bell
Title: Considerations on NR RACH procedures
WID/SID: FS_NR_newRAT - Release 14
Document for: Discussion and Decision

1 Introduction

RAN1 has discussed the RACH procedure for NR in RAN1#86 and RAN1#86bis meetings and have agreed the following:

In RAN1#86, the following was agreed:

- *RACH procedure including RACH preamble (Msg.1), random access response (Msg.2), message 3, and message 4 is at least assumed for NR from RAN1 perspective.*

In RAN1 #86bis meeting, the following was identified:

- *RAN1 is studying and some companies see potential benefits of a simplified RACH procedure consisting of two main steps (Msg1 and Msg2) for UEs*
- *RAN1 has discussed the following:*
 - *The use of a UE identity in Msg 1*
 - *Msg 2: RA response that is addressed to the UE identity in Msg 1*
 - *FFS on the definition and choice of the UE identity*
 - *FFS on the applicability scenarios of simplified RACH procedure*

These are generally referred as 4-step and 2-step RACH procedures, respectively. Based on this, RAN1 approached RAN2 with an LS in [1] to take the above into considerations for NR RACH procedure work and requested feedback on the applicable scenarios for each approach as well as input for the FFS points.

In this contribution, possible variants of NR RACH procedures are presented in section 2.1 following with details of the 2-step RACH approach in section 2.2.

2 Discussion

2.1 Possible NR RACH procedures

As per RAN1 agreement, similar 4-step RACH procedure as in LTE is to be at least supported by NR as depicted in the following Figure 1 [2]. In the step 1. the UE transmits RA preamble in UL; in 2. gNB responds with Random Access Response providing UE with Timing Alignment information, initial UL grant, and Temporary C-RNTI; in step 3. UE transmits first scheduled UL transmission which may convey different information subject to the scenario that triggered the RACH procedure; finally in step 4. the Contention Resolution message is transmitted that identifies the UE ID which Msg3 transmission was detected upon which the procedure ends.

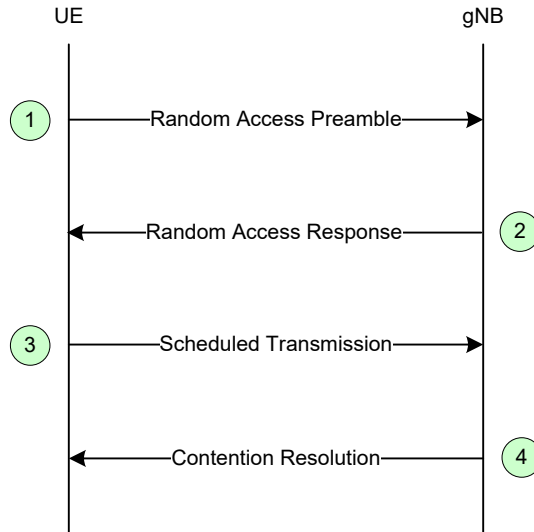


Figure 1: 4-step RACH procedure

It should be noticed the above called 2-step approach is not referring to the non-contention based RACH procedure in LTE. Indeed the non-contention based RACH procedure is also “2-step” approach where NW can identify the UE by the transmitted preamble (step 1) and address the UE directly with a UE specific response (step 2) in DL. This approach utilizes the same PRACH as the 4-step approach above. Generally, it is considered the non-contention based RACH procedure is also needed to be supported in NR for specific scenarios, like handover, DL data arrival etc.; this is depicted in the following Figure 2 [2].

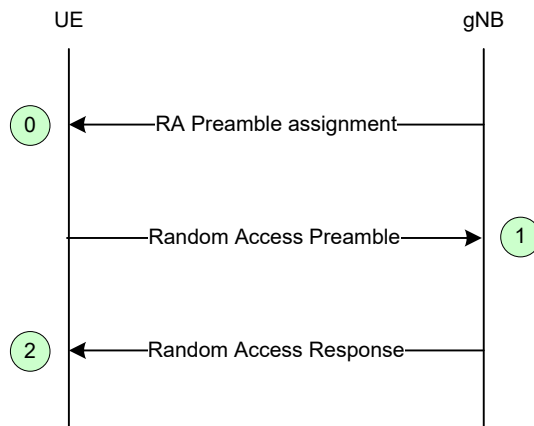


Figure 2: Non-contention based RACH procedure

Proposal #1: Non-contention based RACH procedure as depicted in Figure 2 is supported in NR.

The new 2-step approach under study in RAN1 can be depicted as in the following Figure 3.

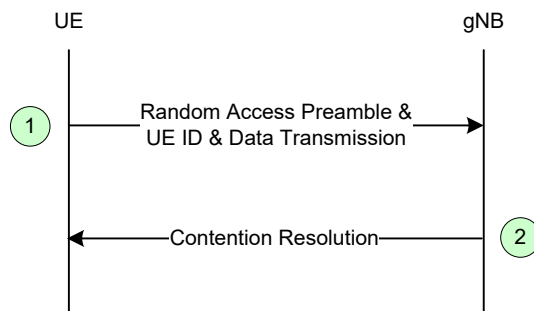


Figure 3: 2-step RACH procedure

In the 2-step approach, the NW can configure (e.g., via system information signalling) PRACH preamble resources and contention based data resources that may be associated with one or multiple PRACH preambles. In step 1. the UE should transmit the PRACH preamble and a data transmission in the associated data resources that should at least identify the UE by means of a UE ID (as Msg3 in 4-step approach). In step 2. the Contention Resolution message is transmitted by the gNB similarly to Msg4 in 4-step approach identifying a specific UE if the data part of Msg1 that contains UE ID is correctly decoded by the gNB. Hence, in principle the 2-step approach can pare down the round trip required for the gNB to transmit RAR in response to a detected PRACH preamble and UE to transmit the Msg3 in the RAR scheduled UL grant and consequently reduce the latency of the procedure. However, the drawback of such scheme is that the associated data resources may not be used by any UE when no UE is performing RACH using these resources.

Observation #1: 2-step RACH procedure can reduce the RACH procedure latency compared to 4-step approach with a side effect the associated data resources may not be used by any UE.

It should be noted the 2-step and 4-step approaches could be supported in parallel in the NW utilizing also the same preamble resources. As discussed above, the UL data resource in the 2-step approach could be associated with one or multiple PRACH preambles – for instance, the NW may not be able to reserve as many dedicated UL data resources as there is PRACH preambles available. In fact, with the latter approach the 2-step procedure can be backed up with the 4-step procedure if gNB can determine multiple separate preamble transmissions that mapped to the same data resource and consequently the data could not be decoded. In principle, this can be applied also in case a single preamble maps to a certain UL data resource (if the data decoding failed at the gNB), however, if multiple UEs picked the same preamble/data resource, the Msg3 would also collide.

With this case, in addition to the Contention Resolution message, the UE could listen to a possible RAR for the transmitted PRACH preamble index. Alternatively, the UE always listens to RAR message (with both 2- and 4-step approaches) which in case of 2-step approach could comprise of either Contention Resolution message or Msg3 UL grant allocation.

Observation #2: 2-step RACH procedure can fall back to 4-step procedure if gNB can determine multiple UEs transmitted within the same UL data resource or the data transmission decoding failed.

2.2 Details of the 2-step RACH procedure

2.2.1 Use cases and scenarios

RAN1 requested RAN2 input on the use cases and scenarios applicable for the 2-step RACH procedure. Generally, the 2-step approach could be used in all scenarios applicable for the 4-step RACH procedure, as in principle the approach is a pure latency reduction technique. However, as there may not be always possibility (e.g., due to load conditions in the cell) for the NW to allocate opportunistic data resources corresponding to all the PRACH preamble resources, it makes sense to consider specific use cases which could benefit the most from the 2-step approach. Thus, the NW should have means to restrict the attempts made with the 2-step RACH approach.

Some specific use cases and scenarios that can specifically benefit from the lower latency in the RACH procedure are considered hereinafter:

- UE in the RRC_CONNECTED state:
 - Scheduling Request via RACH procedure when TAT has expired or dedicated SR resources are not configured for the UE – Msg1 would include at least the UE's C-RNTI and potentially BSR.
 - Opportunistic small data transfer – basically equals to the previous one but requires sufficiently larger UL data resource to transmit also the higher layer data, in the extend of tens to hundreds of bytes.
- UE in the new RRC_INACTIVE state:
 - State transition from RRC_INACTIVE to RRC_CONNECTED state to achieve the minimum state transition latency.
 - Small data transmission in the RRC_INACTIVE state.
- UE in the RRC_IDLE state:
 - Connectionless data transmission use cases.

It is acknowledged also the initial RRC connection establishment, re-establishment, resume, or any other procedures requiring RACH can basically benefit from lower latency in the RACH procedure. Hence, it could be made up to NW decision to configure procedures/services/UE types, etc. that can at any given time use the 2-step approach and restrict the others access via the 4-step approach. It should also be NW decision whether to configure the 2-step resources at all in a cell.

Observation #3: Generally, all the use cases/scenarios requiring RACH access can benefit of the lower latency the 2-step RACH approach provides, however, specific use cases can be considered that may specifically benefit of it.

Observation #4: Depending on the use case, the requirement for the UL data resource size varies from tens of bits to hundreds of bytes.

Proposal #2: It is up to NW decision to configure/restrict the usage of the 2-step RACH approach for certain procedures/services/UE types/etc.

Proposal #3: The 2-step RACH resources are optionally configurable by the NW.

2.2.2 UE identities

As discussed above, principally the 2-step RACH procedure can be applied in any use case/scenario requiring RACH access. Thereby, the possibility to indicate different sized UE IDs should generally be supported which separation can be achieved, e.g., by means of MAC signalling as in the current LTE RACH procedure (the CCCH message and C-RNTI are indicated by separate LCID values). The different IDs are specifically needed to address the UEs in different states – like C-RNTI in RRC_CONNECTED or S-TMSI in RRC_IDLE etc.

A good starting point for the minimum allocation of the Msg1 UL data resource is the LTE's Msg3 minimum allocation size of 56 bytes (to be able to convey at least the UE ID) which should then be extensible up to support transmission of full IP packets (~hundreds to a few thousand bytes).

Observation #5: Given the several use cases/scenarios, different sized UE IDs should generally be supported by the 2-step RACH procedure.

Proposal #4: 2-step RACH procedure is not restricted to be used with certain UE ID size.

3 Conclusions

In this contribution, possible NR RACH procedures are discussed and details of the new 2-step RACH procedure are discussed in response to RAN1 LS. Based on this, the following observations and proposals are made.

Observation #1: 2-step RACH procedure can reduce the RACH procedure latency compared to 4-step approach with a side effect the associated data resources may not be used by any UE.

Observation #2: 2-step RACH procedure can fall back to 4-step procedure if gNB can determine multiple UEs transmitted within the same UL data resource or the data transmission decoding failed.

Observation #3: Generally, all the use cases/scenarios requiring RACH access can benefit of the lower latency the 2-step RACH approach provides, however, specific use cases can be considered that may specifically benefit of it.

Observation #4: Depending on the use case, the requirement for the UL data resource size varies from tens of bits to hundreds of bytes.

Observation #5: Given the several use cases/scenarios, different sized UE IDs should generally be supported by the 2-step RACH procedure.

Proposal #1: Non-contention based RACH procedure as depicted in Figure 2 is supported in NR.

Proposal #2: It is up to NW decision to configure/restrict the usage of the 2-step RACH approach for certain procedures/services/UE types/etc.

Proposal #3: The 2-step RACH resources are optionally configurable by the NW.

Proposal #4: 2-step RACH procedure is not restricted to be used with certain UE ID size.

References

- [1] R1-1610992, *LS on NR RACH Procedure*, RAN1/Huawei
- [2] 3GPP TS 36.300, *Overall description; Stage 2; (Release 14)*