Indigenous 5G Test Bed

Design Document
for
<MAC module - RACH>

Document: 5GTB-5GRAN-<MAC module - RACH>
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1. Introduction

The purpose of this document is to explain in detail the design specification and the data flow of random access procedure. Random access channel (RACH) is a transport channel the provides functionalities required by MAC module. Random access procedure is an initial access protocol. Initial access implies a sequence of process between UE and gNB (Network) to ensure that UE acquire uplink synchronization and obtain a specific ID (cell RNTI or "C-RNTI") for further radio access communication. This is one of the most critical parts in network stack because this is the first protocol which runs when UE is powered on.

a. Purpose – Why RACH is essential ?

The main purpose of RACH can be described as follows :

i. Achieve UP link synchronization between UE and gNB
ii. Obtain the resource for Message 3 (e.g., RRC Connection Request)

In 5G-NR, downlink synchronization process happens where the downlink synch signal is broadcasted to everybody and transmitted all the time periodically. Unlike the downlink synchronization process, the uplink synchronization should meet the following conditions in order to avoid wastage of energy and interference to other UEs :

i. The synchronization process should happen only when there is immediate necessity
ii. The synchronization should be dedicated to only a specific UE
RACH process is specially designed to meet these criteria.

Another purpose of RACH is to obtain resources for Message 3. The types of Message 3 includes:

I. RRCSetupRequest
II. RRCResumeRequest
III. RRCReestablishmentRequest
IV. RRCSystemInfoRequest

Based on the situation and trigger cases, Msg3 to be sent is determined.

b. Scope

The scope of this project is 5G NR Base Station and UE Development in particular implement the random access procdure according to 3gpp technical specification. Random access procedure involves four way handshake process. The main steps invloved in RA procedure are:

1. Random access procedure initialization
2. Resource selcection and preamble transmission
3. Random access response reception
4. Message 3 transmission
5. Contention resolution (In case of contention based random access)

The corresponding required action has to be carried out by the network such as preamble assignment, RAR transmission., etc. The deliverable of this work is implementation of the above mentioned steps and test the working of random access procedure for different trigger cases.

The random access procedure is triggered by a number of events: (Section 9.2.6,TS 38.300 v15.5.0 Rel 15)

1. **Initial access from RRC_IDLE; (CBRA)**
2. RRC Connection Re-establishment procedure;

3. **DL or UL data arrival during RRC_CONNECTED when UL synchronisation status is "non-synchronised";(CFRA)**
4. **UL data arrival during RRC_CONNECTED when there are no PUCCH resources for SR(Scheduling Request) available; (CFRA)**
5. SR failure;
6. Request by RRC upon synchronous reconfiguration (e.g. handover);(CFRA / CBRA)
7. Transition from RRC_INACTIVE;
8. To establish time alignment at SCell addition;
9. **Request for Other SI (see subclause 7.3);**
10. Beam failure recovery. (CFRA / CBRA)

STATUS UPDATE *: ** The red highlighted trigger cases: Implementation on process. ** The green highlighted trigger cases : nearing completion . Rest trigger cases are yet to be explored.*

There are two types random access procedure.

When UE transmits the PRACH preamble, it transmits it in specific pattern called as signature. There are 64 such signatures, out of which the UE randomly selects one. Due to this randomness, there is a possibility than more than one UE selects the preamble with same signature. They arrive at the base station (network) at the same time causing PRACH collision called contention. RA procedure which allows such contention is called contention based RA procedure (CBRA). Contention resolution has to be carried out in UE to ensure successful completion of random access procedure. In case of contention free RA procedure (CFRA e.g: handover), its a UE specific process. The Network informs each of the UE of exactly when and which preamble signature it has to use. It'll assign preamble in such a way that it doesn't collide.

The data flow for both the types of RA procedure is explained in detailed in the upcoming section.

2. System Design

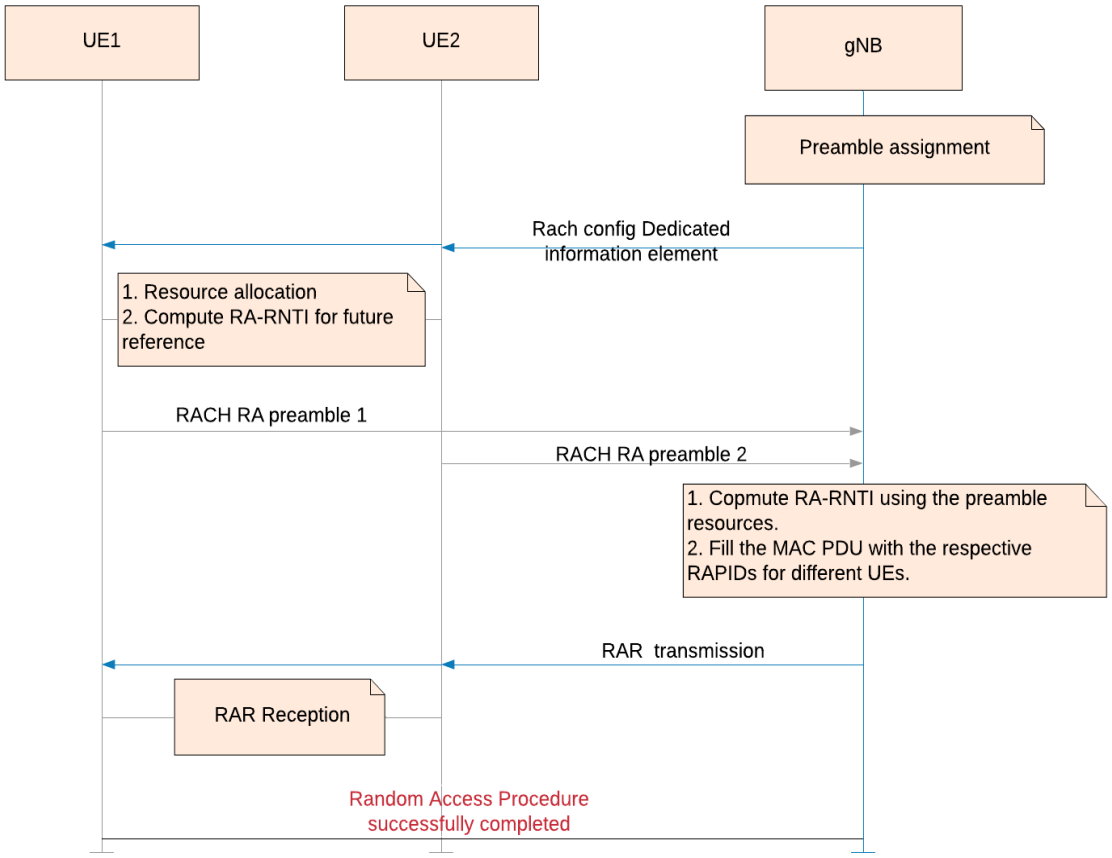

Figure 1: Uplink and Downlink data flow for Contention free random access procedure.

Contention Based Random Access Procedure

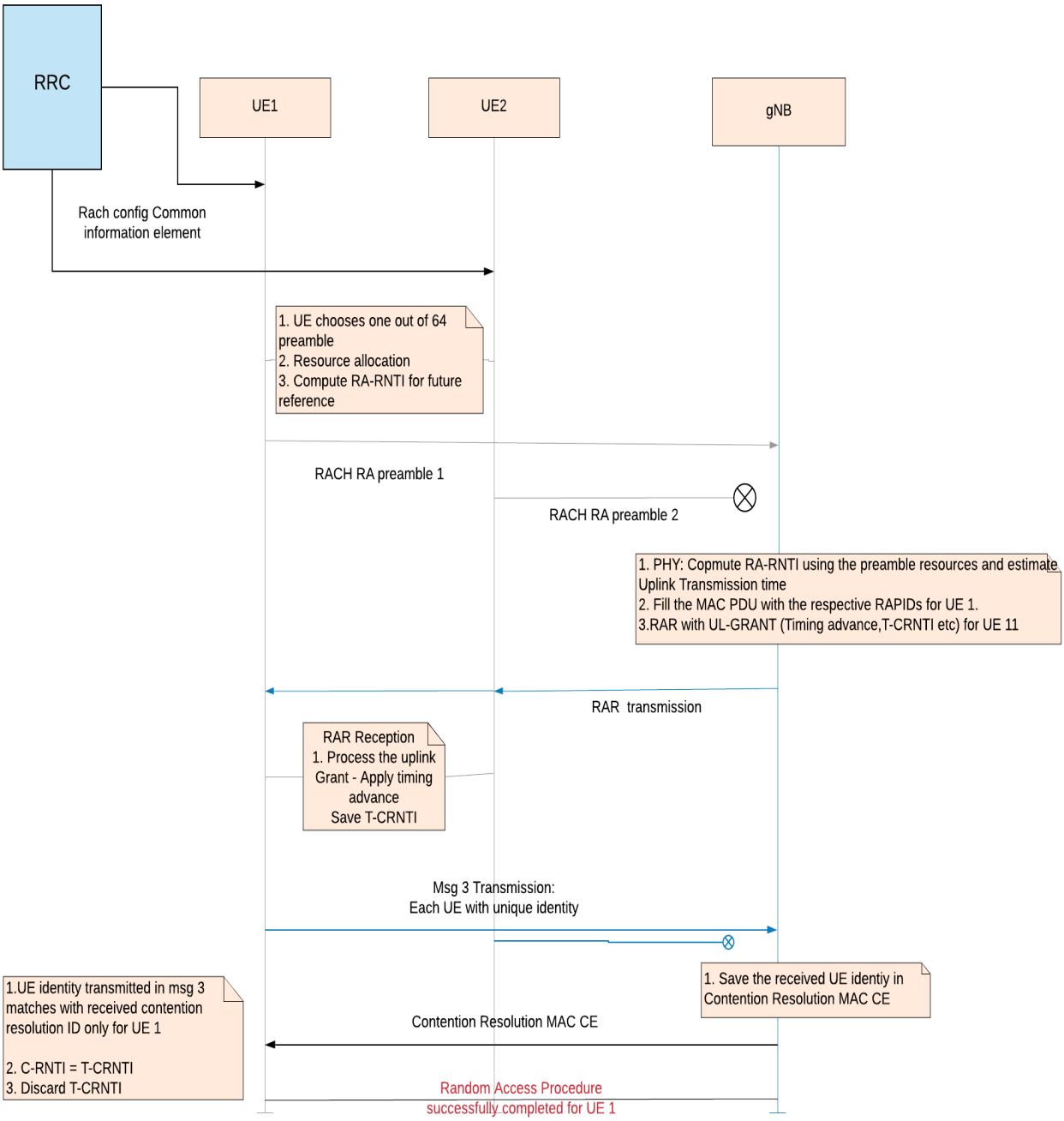

Figure 2: Uplink and Downlink data flow for Contention based random access procedure.