

Source: ZTE
Title: Coding of RA-RNTI for message 2
Agenda item: 5.1.1.3
Document for: Discussion and approval

1. Introduction

In stage 3 specification it is not concluded how to code the RA-RNTI. This contribution intend to propose the detail coding scheme of RA-RNTI.

2. Discussion

2.1.FDD mode

In RAN#58bis meeting it is agreed in RAN2 that Different RA-RNTI's are associated with different time-frequency RA resources mapped to the same response window (window within which the response needs to be given). And the relation is to 1-to-1. in RAN1#50 meeting it is agreed tht for FDD mode only one PRACH i.e. time-frequency RA resource exist in one TTI.(and FFS for TDD). So at least for FDD mode only timing information is needed to code the RA-RNTI.

In Annex1 a typical PRACH slot configuration from [1] is depicted. We can see the PRACH period ranges from 1ms up to 20ms whose granularity is 1ms. And RAN2 group has agreed that message 2 will be received in asynchronous way i.e. within a reception TTI window. Since UE may even send random preamble in consecutive subframe. UE does need to distinguish those RA-RNTIs whose reception window may overlap with each other.

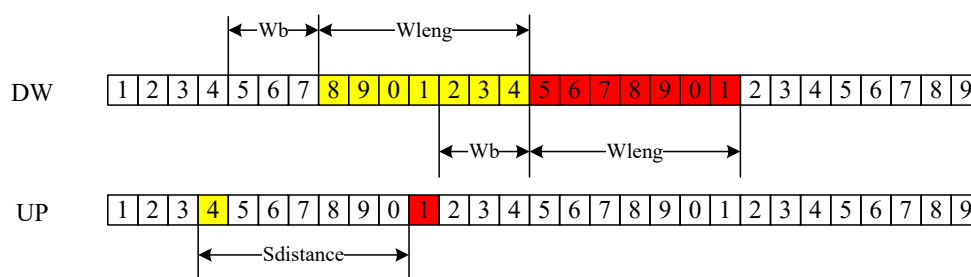


Figure 1 reception window

Since the reception TTI window of random access response is most likely the same for all random preamble within the same cell, from Figure 1 it is easy to tell that as long as Sdistance (distance between two subframe) is not smaller than Wleng the two reception window will not overlap with each other. So RA-RNTI can be defined as a value which is unique within Wleng.

If the maximum Wleng can be predefined or configured through signalling it is natural to define RA-RNTI like this way: $RA-RNTI = (SFN * 10 + subframe) \% Wleng$. Unfortunately in some case UE does not know SFN when sending random access preamble e.g. upon handover. While [2] point out about 38% of the PRACH load would be used for handover. And during MAC call reference in 21st September it is concluded that RA-RNTI will be used both for contention-based and contention-free random access procedure (C-RNTI for contention-free case is TBD). So this scheme does not work in these scenarios.

Actually SFN is unnecessary as long as the maximum value of Wleng is no more than one radio frame i.e. 10ms, because RA-RNTI can be unique within one radio frame. The maximum value of Wleng mainly related to the processing load of eNB and the scheduling flexibility in time domain especially for low bandwidth system e.g.

1.25Mhz. Since control plane requirement for all case is the same we intend to believe maximum value of Wlength will not be bigger than 10ms otherwise for some cases the control plane delay will claim for more than 10ms in the worst case.

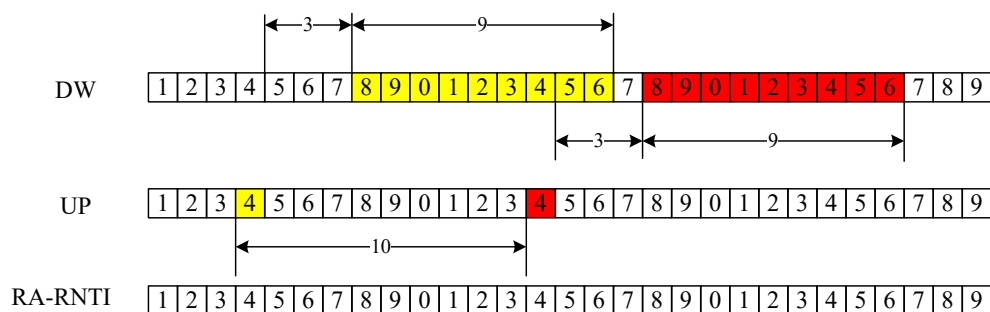


Figure 2 RA-RNTI = Subframe Number

In Figure 2, RA-RNTI is defined as the subframe number within radio frame. For two PRACH slots within 10ms the message 2 can be distinguished by RA-RNTI because their subframe number is different. For two PRACH slots beyond 10ms message 2 will not be received at the same time since reception window will not be overlapped. For example the reception window of subframe 4 and will overlap with that of subframe 8 in the same radio frame, but will not overlap with that of subframe 4 in next radio frame and further.

If RA-RNTI is defined as subframe number, 4 bits is needed for FDD mode assuming minimum PRACH period is 1ms. In order to reduce the coding bits, relative sequence of PRACH slots within same radio frame can be used to code RA-RNTI. In Annex 1 in case system bandwidth is 10Mhz then 2 PRACH slot is configured in e.g. subframe 0 and 5, then their corresponding RA-RNTI could be 0 and 1 respectively i.e. only 1 bit is enough. So if RA-RNTI length really matters, such kind of optimization could be used. if not, to limit the RA-RNTI length according to the minimum PRACH period is simpler and much more robust.

Another factor is maximum value of Wlength. For example if $Wlength \leq 5ms$ is feasible then RA-RNTI can be defined as $subframe\ number \% 5$. in this way 1 bit can be saved. And relative sequence can also be defined within half frame. If considering case 12,13 and 14 in Annex 1, there is no more than 3 PRACH slots within half frame. Thus 1 bit can be saved compared to code 5 PRACH slots within whole radio frame.

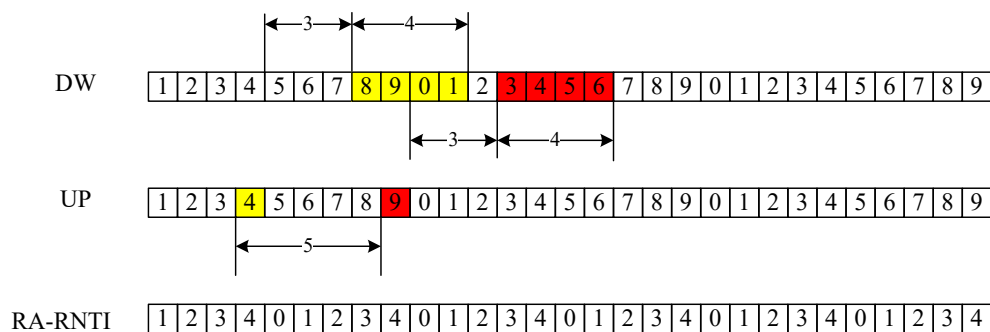


Figure 3 RA-RNTI=subframe number%5

2.2. TDD mode

For TDD mode it is FFS whether more than one PRACH slot will be configured in the same TTI. Assuming typical UL/DL allocation is 2/3 for type1 TDD and 2/4 for type2 TDD the uplink capacity is reduced to half compared to FDD mode. And if assuming TDD mode own similar spectrum efficiency at least 2 PRACH channel are needed. So regarding coding of RA-RNTI multiple PRACH shall also be taken into account.

Basically the absolute position of PRACH in frequency domain (or initial position in case frequency hopping) could be used for coding RA-RNTI. For 20Mhz at least 4 bits are needed. since not so much PRACH will be configured relative sequence information as in time domain could be better. The relative sequence could be the relative position in the frequency domain or the appearance sequence in the signalling just like UMTS does. Thus maybe only 1 bit is enough.

In the time domain the same scheme is also available except some limitation of the position of the uplink subframe. In Annex 2 some typical configuration is listed for both type 1 and type 2 TDD.

The whole RA-RNTI is coded as combination of position information of frequency domain and time domain. Since total slots number is fixed within radio frame, position information of frequency domain shall be coded in the higher bits for future extension. For example the length of RA-RNTI is 4 bits within which 1 bit stands for position information of frequency domain and 3 bits for position information of time domain. If total PRACH capacity is assumed similar for FDD and TDD mode RA-RNTI can also be designed the same size for equivalent bandwidth scenario.

3. Conclusion

In this document reception window is assumed no bigger than 10ms. based on this RA-RNTI is proposed to be coded according to the position of PRACH slot within its radio frame or even half radio frame. the main advantage of the solution is to avoid reading SFN in any scenario especially for inter-eNB handover and its simplicity. the RA-RNTI can be defined as subframe number or slot number within unique scope i.e. radio frame or even half radio frame if feasible in time domain both for FDD and TDD mode. For TDD multiple PRACHs in the frequency domain shall also be taken into account and relative sequence is proposed as higher bit of the combined RA-RNTI.

4. reference

- [1] R1-073436 Random Access Slot Configurations, Texas Instruments, RAN1#50
 [2] R2-070205 LTE cell load / PRACH load estimations, Samsung, RAN2#56bis

5. Annex1

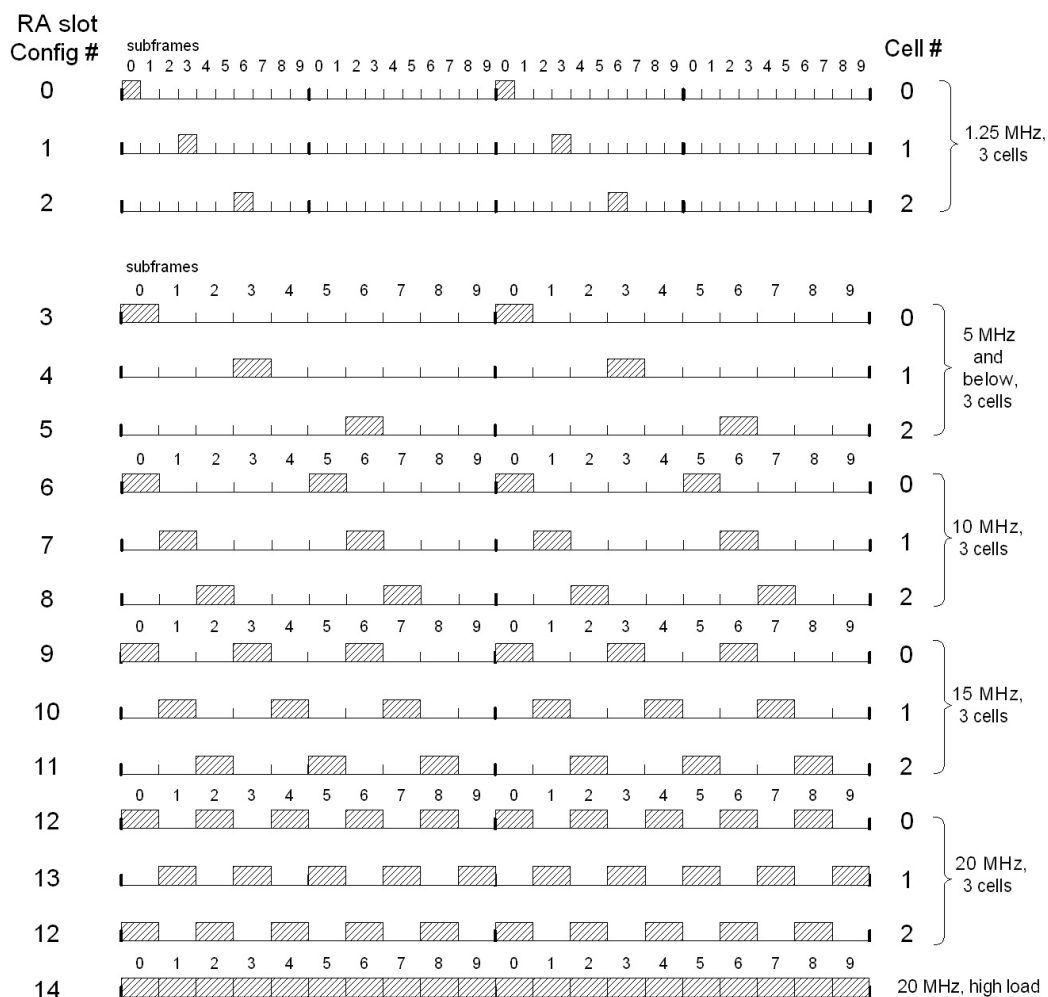
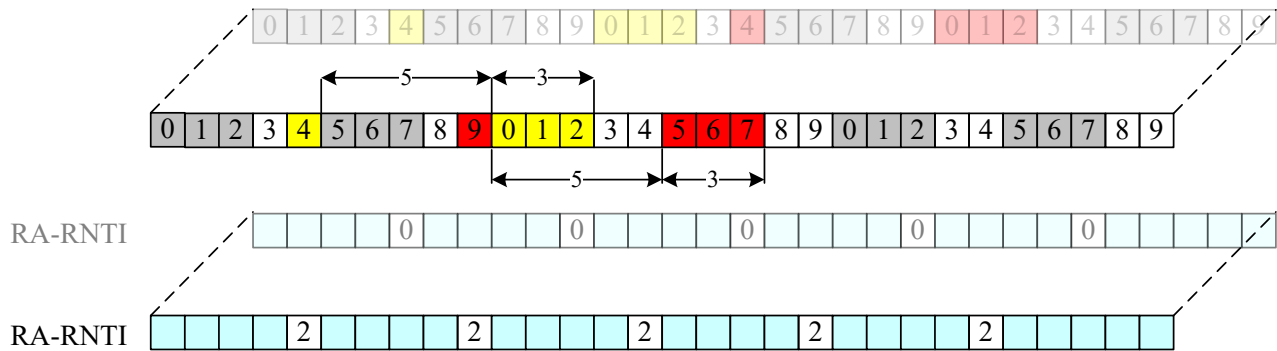


Figure 1: Random Access time slots configurations

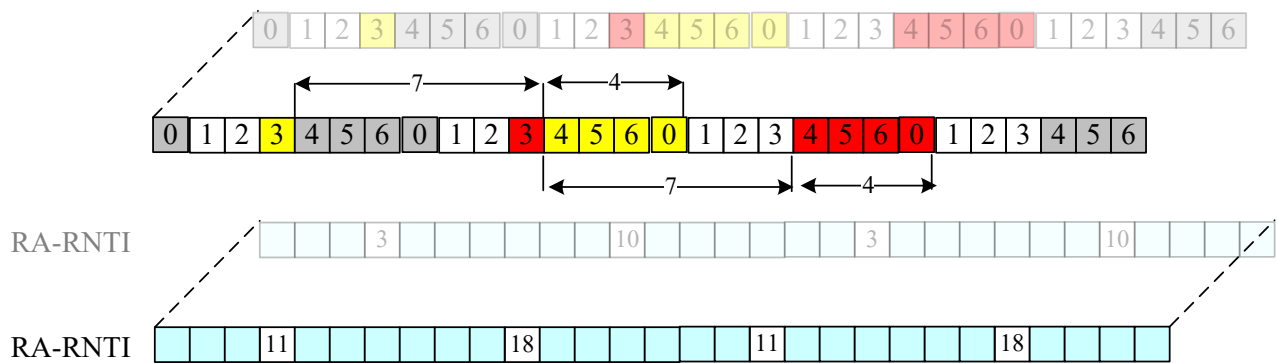
6. Annex2



RA-RNTI for HCR TDD (DW/UL is 3/2)

Assuming:

- Two PRACH channel
- Two PRACH slots within one radio frame
- Wlength is 3TTIs , unique scope is 5TTIs i.e. half frame, relative sequence both for frequency domain and time domain
- 2 bits RA-RNTI
 - 1 bit for relative sequence in frequency domain; 0 for PRACH in light colour while 1 for another one
 - 1 bit for relative sequence in time domain; 0 for PRACH slot within half frame



RA-RNTI for LCR TDD (DW/UL is 4/3)

Assuming:

- Two PRACH channel
- Two PRACH slots within one radio frame
- Wlength is 4ms, unique scope is 10ms, subframe nubmer for time domain and relative sequence for frequency domain
- 4 bits RA-RNTI
 - 1 bit for relative sequence in frequency domain; 0 for PRACH in light colour while 1 for another one
 - 3 bits for relative sequence in time domain;
 - the coded slot number n in send half frame equal to n+7, where n=0,1...6
 - if short PRACH format is used the coded slot number equal to 0 and 7 respectively for the 1st and 2nd UpPTS