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Available PRACH and AICH access slots, with new chiprate

1. Introduction

This paper proposes a method by which the allowed access slots of PRACH and AICH can be defined and signalled to UEs. It will be beneficial that there is a method how to define that there are less than maximum 15 access slots per two frames available, since in this way the hardware resources can be optimised in the base station.

At the moment TS 25.214 defines that BCH contains information about the available access slots. It should be however specified clearly how it is done, since the signaling should contain both possibilities of having either 3 or 4 access slots between two preambles, or preamble and message.

2. Parameters sent on BCH

We propose that UE defines the next available access slot with the help of three parameters sent on BCH:

- AICH transmission timing parameter
- SFN of the present frame
- Parameter A, which defines the available sub-RACH channels

3. Basic idea of the method

Parameter A contains four bits. The A parameter values 0000≤A≤0111 are used with AICH transmission timing parameter value 0, and values 0000≤A≤1111 with AICH transmission timing parameter value 1. If a certain bit position in parameter A has value 1, it means that corresponding sub-RACH channel is available. Sub-RACH channel_# can have a value among {0,1,2,3}. The LSB of parameter A corresponds to sub-RACH channel_# = 0, and the MSB of parameter A corresponds to sub-RACH_channel_# = 3. Table 1 and 2 show which access slots belong to which sub-RACH channel.

For transmitting the first preamble, UE randomly selects the sub-RACH channel from the available ones, with the help of A parameter and AICH transmission timing parameter.

After selecting randomly the sub-RACH channel, UE derives the next available access slot with the help of SFN and AICH transmission timing parameter value:

- If AICH transmission timing parameter value is 0, the available access slots of frame SFN are defined by Access= 3*N +(SFN modulo2) + sub RACH channel_#, where N has values of the range 0 ≤N≤ 4, and sub-RACH channel_# is the selected sub-RACH channel, with the condition that only the values between 0 ≤ Access ≤ 7 are valid in frames with even SFN and only the values between 8 ≤ Access ≤ 14 are valid in frames with odd SFN. The available access slot to which there is smallest distance is selected.

- If AICH transmission timing parameter value is 1, the available access slots of frame SFN are defined by Access= 4*N + (SFN modulo 8) + sub RACH channel_#, where N has values of the range 0 ≤N≤ 3, with the condition that only the values between 0 ≤ Access ≤ 7 are valid in frames with even SFN and only the values between 8 ≤ Access ≤ 14 are valid in frames with odd SFN. The available access slot to which there is smallest distance is selected.

Frame number	Sub-RACH channel_#=0 (A=001) Access	Sub-RACH channel_#=1 (A=010) Access	Sub-RACH channel_#=2 (A=100) Access
SFN modulo 2 = 0	0, 3, 6	1, 4, 7	2, 5
SFN modulo 2 = 1	9, 12	10, 13	8, 11, 14

Table 1. The available access slots, Access, for different sub-RACH channels, when AICH transmission timing parameter = 0.

Frame number	Sub-RACH channel_#=0 (A=0001) Access	Sub-RACH channel_#=1 (A=0010) Access	Sub-RACH channel_#=2 (A=0100) Access	Sub-RACH channel_#=3 (A=1000) Access
SFN modulo 8 =0	0, 4	1, 5	2, 6	3, 7
SFN modulo 8= 1	8, 12	9, 13	10, 14	11
SFN modulo 8= 2	1, 5	2, 6	3, 7	0, 4
SFN modulo 8= 3	9, 13	10, 14	11	8, 12
SFN modulo 8= 4	2, 6	3, 7	0, 4	1, 5
SFN modulo 8= 5	10, 14	11	8, 12	9, 13
SFN modulo 8= 6	3, 7	0, 4	1, 5	2, 6
SFN modulo 8= 7	11	8, 12	9, 13	10, 14

Table 2. The available access slots, Access , for different sub-RACH channels, when AICH transmission timing parameter = 1.

4. Selecting the access slot for sending the consecutive preambles after the first one

There are two alternative methods how the access slots are selected for sending the consecutive preambles, after the first preamble: deterministically or randomly.

In both methods the idea of transmitting the first preamble is the same. MS randomly selects the sub RACH channel among the available ones. With e.g. transmission timing =0 and A=111 , then MS can choose randomly among values {0,1,2} to select the sub-RACH channel. If transmission timing =1 and A=1111, then MS can choose randomly among values {0,1,2,3} to select the sub-RACH channel. If A<111 or A<1111, there is of course smaller group from which the random selection is done.

Method1: deterministic transmission of consecutive preambles

In this method, after the first preamble, MS transmits consecutive preambles either three or four access slots apart, depending on the value of AICH transmission timing parameter value. So after the first random selection of the sub RACH channel, the consecutive preambles are transmitted in deterministic way without any additional randomness.

Method 2: random transmission of consecutive preambles

In this method every time UE wants to transmit a new preamble, UE selects randomly the sub RACH channel among available values {0,1,2} or {0,1,2,3}, depending on parameter A and the transmission timing parameter values, 0 or 1, respectively. After that UE selects the next available access slot in the selected sub-RACH channel. In this method, the AICH-to-preamble timing will be τ_{a-p} or larger (see TS 25.211) and preamble-to-preamble timing will be 3, 4 or 5 access slots with AICH transmission timing set to 0, and 4,5,6 or 7 access slots with AICH transmission timing set to 1. This means that preamble-to AICH timing t_{p-a} and AICH-to-message timing t_{a-m} would be strictly as specified now in TS 25.211, section 7, and only the AICH to preamble timing would vary.

Evaluating pros and cons of Method 1 and Method 2

With method 2 the first feeling could be that there might be some benefit of reducing the collision probability. But the improvement in the collision probability is difficult to calculate, since following things should be taken into account: transmitter power level of UEs, their location in the cell, number of preamble codes available etc. So our opinion is that the collision probability reduction might be negligible. On the contrary, the method 2 means that the power ramping process delay is increased.

So based on this reasoning, we propose that method 1 is used, where UE makes the random selection between available sub-RACH channels only when transmitting the first preamble. After that, the timing of consecutive preambles is deterministic, using the values τ_{p-p}, τ_{p-m}, τ_{p-a} and τ_{a-p} as defined presently in TS 25.211.