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Title: **Some minor modifications to the UTRA/FDD RACH scheme**

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1 Introduction

This paper proposes some modifications to the current structure of the UTRA/FDD RACH. The proposals are related to discussions in the RACH AdHoc group.

2 Current AICH

2.1 Current AICH structure

The current assumption for the acquisition indicator is that it is the acquired 16 symbol signature echoed on an ordinary downlink channel (the Acquistion Indicator Channel, AICH) using a spreading factor SF=256. The length of the acquisition indicator is thus 16*256 = 4096 chips. It should be noted that acquisition indicators are transmitted once per access slot, i.e. once every 1.25 ms. The AICH thus have a duty factor of 4/5, see Figure 1

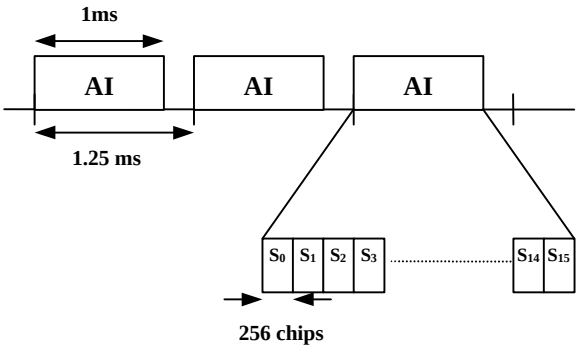


Figure 1 AICH structure

There are some special features of the AICH.

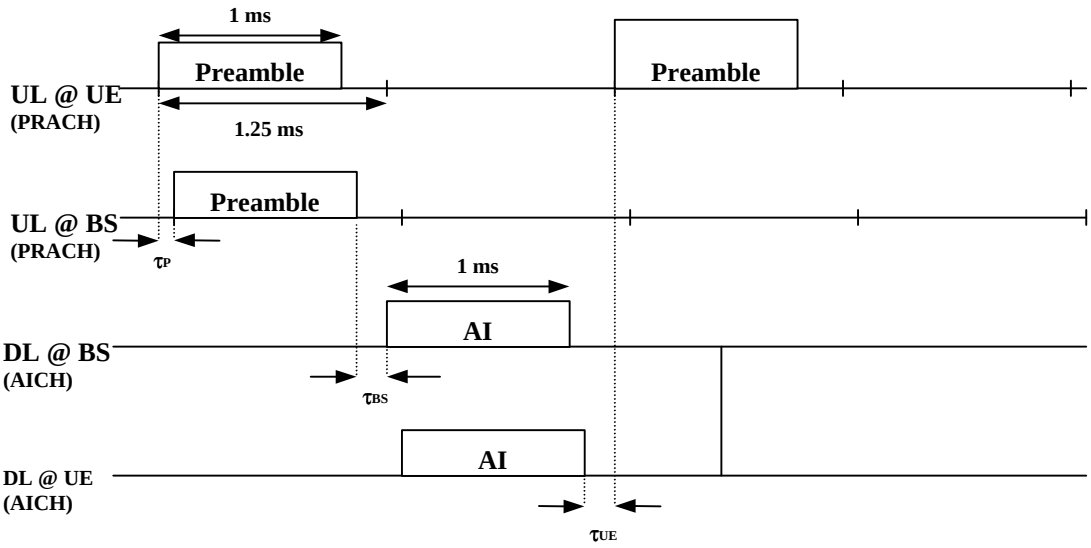
- The AICH uses on/off modulation. This means that an acquisition indicators is either transmitted (if the corresponding signature has been acquired) or not transmitted (if the corresponding signature has not been acquired).
- As the signatures are orthogonal, multiple acquisition indicators can be transmitted in parallel on one AICH. Note that this is equivalent to having 16 parallel orthogonal downlink channels, each with a spreading factor SF=4096.

Also note that, although the AICH is basically an ordinary downlink channel, it can still be non-orthogonal to other downlink channels, using the general option of multiple downlink scrambling codes. The use of a non-orthogonal AICH could be

beneficial in terms of avoiding code-limitation. At the same time, the interference from a non-orthogonal AICH should not be that severe, as the AICH is an on/off signal which would mainly be in the off state.

2.2 Current AICH timing

Figure 2 shows the current AICH timing. Both the premble and the acquisition indicator (AI) have a length of 1 ms. It should be possible for the UE to retransmit the preamble every second access slot. This means that the time available for processing in MS and BS is 2*0.25 ms minus 2*τp, where τp is the propagation delay.



τ_p: propagation delay
τ_{BS}: BS processing time
τ_{UE}: UE processing time

Figure 2 Current AICH timing

The exact timing of the AI transmission is not yet specified. However, the timing can only be adjusted in steps of 256 chips, in order to preserve orthogonality between the AICH and other downlink channels.

3 New proposals

3.1 Adding more information to the acquisition indicator

As already described, the current AICH uses a 2-valued on/off modulation where the two possible values implies the following actions by the UE:

S_i: Preamble with signature S_i acquired. Transmit message.

0: No preamble required (retransmit preamble).

Note that, according to document S1-14, the signature should be reselected for each preamble retransmission.

Within the RACH AdHoc group, there have been proposals that the AICH should allow for more elaborate signaling. Especially, the possibility to signal that the preamble has been acquired but the UE should anyway retransmit the preamble, has been proposed. The main motive for this is the case when the preamble is received with sufficient power but there is no available RA-message receiver. In this, there would be excess interference, if the UE continues the power ramping.

We propose that the possibility for this kind of signaling is included in the UTRA/FDD RACH scheme by extending the AICH to 3-valued modulation.

As the current AICH uses on/off modulation, non-coherent threshold detection is possible. Nevertheless, it is clearly beneficial from a performance point-of-view to carry out coherent detection of the AICH. Coherent detection is possible because the common pilot symbols of the PCCPCH can be used as phase reference.

Assuming that coherent detection is used, 3-valued modulation can be introduced for the AICH with very little loss of performance. The difference between a 2-valued and a 3-valued AICH is illustrated in Figure 3. It should be noted that the same thresholds could be used in the two cases.

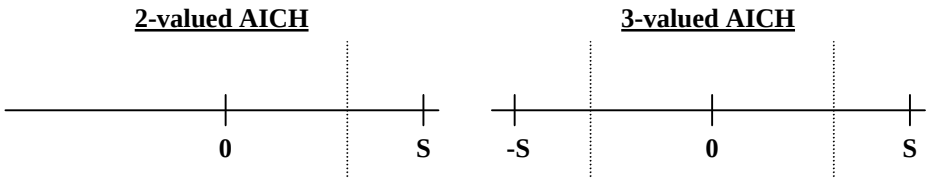


Figure 3

With a 3-valued AICH, the the different signal alternatives should imply the following actions by the UE:

$+S_i$: Preamble with signature S_i acquired. Transmit message.

± 0: No preamble acquired (retransmit preamble with increased power)

$-S_i$: Preamble with signature S_i acquired. Wait and retransmit preamble with no increase of power.

There are some possible alternatives for the third case:

- Should the UE retransmit the preamble in the next available slot or after a random time?
- Should the UE retransmit the preamble with unchanged or somewhat reduced power?

These questions should be further discussed.

The negative effect of introducing 3-valued modulation for the AICH should be very limited. The following error events may occur.

$+S_i \rightarrow 0$: This is the missed-detection event. Assuming the same threshold for the 2-valued and 3-valued AICH, the probability for this is obviously unaffected by the introduction of the third signaling alternative.

$0 \rightarrow +S_i$: This is the false-alarm event. The probability for this is obviously also unaffected by the introduction if a third signaling alternative.

$0 \rightarrow -S_i$: In this case, the UE will retransmit the preamble with unchanged/reduced power, instead of with an increased power. The effect may be a slight increase in the delay. However, it should be noted that the probability for this even should be similar to the false-alarm probability, i.e. in the order $10^{-2} – 10^{-3}$. The effect on the average delay should thus be small.

$-S_i \rightarrow 0$: In this case, the UE will retransmit the preamble with increased power, instead of with an unchanged/reduced power. This is exactly what will happen if the third signaling alternative was never introduced, i.e. the introduction of the third signaling alternative should have no negative effect.

We conclude that 3-valued modulation can be introduced for the AICH with basically no negative effect on performance.

3.2 Flexible AICH timing

Figure 2 illustrates the current timing for AICH transmission. Within the RACH AdHoc group, concerns have been raised about the timing requirements of the AICH transmission. Especially, there have been concerns over the time available for BS processing of the received preamble and subsequent AICH transmission.

Significantly more time would be available for BS processing, if the MS should be able to retransmit the preamble only every third access slot, see Figure 4. We propose that both these two alternatives should be supported by the MS. This implies that, given the transmission of a preamble in a certain access slot, there should be two possible timing when the MS should expect the corresponding acquisition indicator. Which of these to use, should be broadcast on the BCH.

The possibility for a flexible AICH timing allows for a flexible trade-off between BS complexity and RACH latency.

It should be noted that it would be meaningless to have multiple AICH-timing options that do not differ a multiple of an access slot. This would simply mean that the timing requirements on the UE would be different for the two timing options. In that case, the UE must anyway be designed the handle the worst-case timing. It should be noted that, with the proposed timing alternatives, the UE timing is the same in the two cases.

Also note that the required BCH overhead for flexible timing is only one bit. This should be negligible, compared to the overall BCH overhead needed to transmit the different parameters needed for RACH transmission, such as available RACH codes, available RACH signatures, PCCPCH transmit power, and uplink interference level.

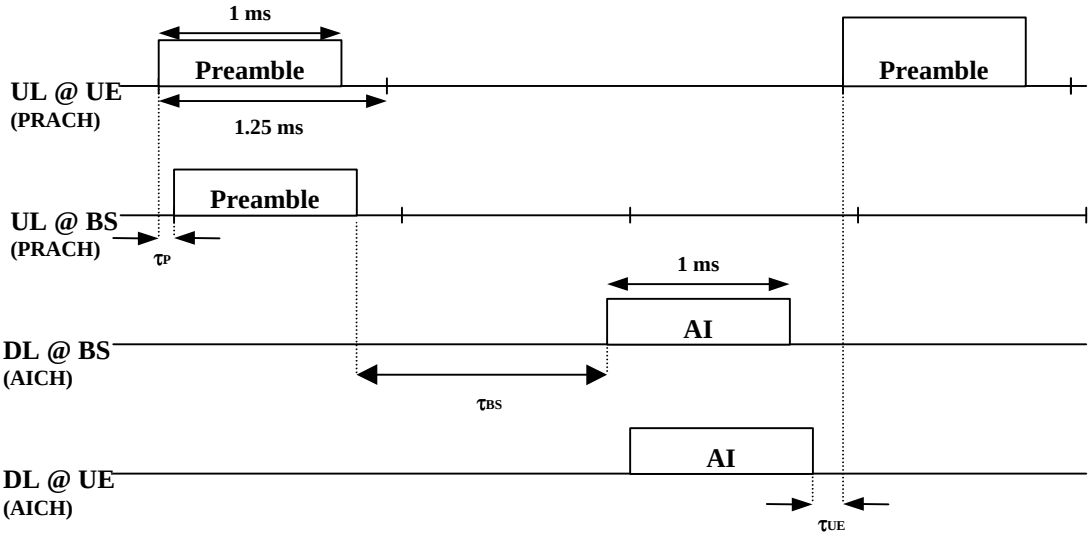


Figure 4 Proposed alternative AICH timing

4 Proposal

We propose that 3-valued AICH modulation as described above is adopted for the UTRA/FDD random-access scheme. The details of the UE actions corresponding to the reception of the 3-valued AICH should be further discussed.

We also propose that flexible AICH timing as described above is adopted for the UTRA/FDD random-access scheme.