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Title: Code signaling in UTRA TDD downlink for the common midamble case
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Introduction

This text proposes to signal the number of channelization codes used in a downlink timeslot of the UMTS-TDD mode by modulating the midamble shifts available in the said timeslot. This information being highly valuable to make the blind channelization code detection and multiuser detection more effective. The proposed technique can be applied in downlink, in the case of a common midamble allocated by signaling as specified in 25.221 chapter 5.5.1.1.1.

Description

Eight different users in case of a burst of type 1, 3 in case of a burst of type 2 can be separated by their different time shifts of the same basic midamble sequence.
In case of common midamble allocation, all the users are seen through the same channel from each MS, therefore one midamble shift is sufficient to estimate the channel for all the users from any MS. Then the set of possible midamble shifts can be used as a signaling word. This text proposes to use it to signal the number of codes used in the time slot. This information can be dynamically updated in real time from slot to slot. The midamble power is equally shared between all the midamble shifts that are used without implying any channel estimate degradation.

The MS will then use this knowledge to improve its blind channelization code detection schemes if it uses a multiuser detector. The main advantage of this proposal is that the blind channelization code detection can be done in knowing the number of codes to be detected instead of being simply threshold driven.

Since in down link the choice of spreading factor is limited to 1 (1 user per time slot) or 16 (the maximum number of code used is then 16), a 5 bits word is sufficient to code this information in case of a burst type 1 but it can also be compressed over less bits and adapted to the use of burst type 2.
In case of a burst type 1 with 8 available midamble shifts, it is advantageous to code it over 8 bits and to limit the number of midamble shifts used simultaneously to 2. It allows an easier peak detection at the correlator output.

Let’s assume that the midambles are modulated by 1 or 0 to create a code word. If the midamble shift is present it is read as a 1 while it is read as a 0 if the said midamble shift is not used. Two coding schemes are presented in figure 1 and 2 for burst type 1 and burst type 2.

Case 1	0 0 0 0 0 0 0 1	1 code
Case 2	0 0 0 0 0 0 1 0	2 codes
Case 3	0 0 0 0 0 1 0 0	3 codes
Case 4	0 0 0 0 1 0 0 0	4 codes
Case 5	0 0 0 1 0 0 0 0	5 codes
Case 6	0 0 1 0 0 0 0 0	6 codes
Case 7	0 1 0 0 0 0 0 0	7 codes
Case 8	1 0 0 0 0 0 0 0	8 codes
Case 9	1 0 0 0 0 0 0 1	9 codes
Case 10	1 0 0 0 0 0 1 0	10 codes
Case 11	1 0 0 0 0 1 0 0	11 codes
Case 12	1 0 0 0 1 0 0 0	12 codes
Case 13	0 0 0 1 0 0 0 1	13 codes
Case 14	0 0 1 0 0 0 0 1	14 codes
Case 15	0 1 0 0 0 0 0 1	15 codes
Case 16	1 0 0 0 0 0 0 1	16 codes

Figure 1 : Coding example of the number of codes. K =8

Figure 1 proposes a coding rule applicable for a burst type 1. A compressed version adapted to the burst type 2 is presented in figure 2.

Case 1	0 0 1	1 or 2 codes
Case 2	0 1 0	3 or 4 codes
Case 3	0 1 1	5 or 6 codes
Case 4	1 0 0	7 or 8 codes
Case 5	1 0 1	9 or 10 codes
Case 6	1 1 0	11 or 12 or 13 codes
Case 7	1 1 1	14 or 15 or 16 codes

Figure 2 : Coding example of the number of codes. K =3

At the MS side, the correlator output gives one or several channel estimates from which the number of codes used in the time slot can be directly derived. Let's consider the example illustrated in figure 3, according to the table given in figure 1, the MS knows that 12 codes have been sent in the time slot.

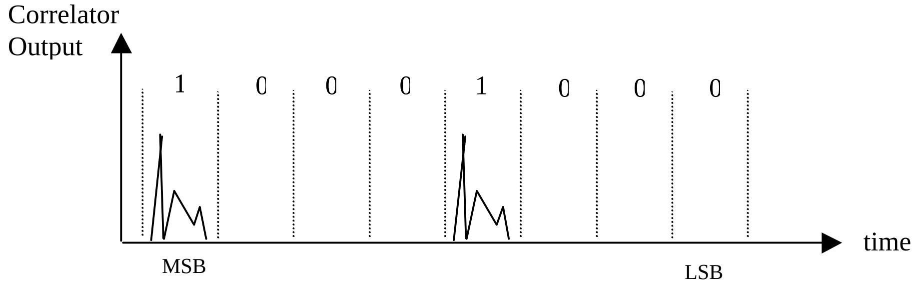

Figure 3 : Example of midamble transmission

In any timeslot, the number of codes used is known by all the MS without increasing the signaling overhead.

Impact of the number of code knowledge

The advantage of knowing the number of codes can be shown by a simple case :

Let's consider that the multipath aspects of the radio channel are compensated by using the available channel estimate, the channel is then equivalent to a pure AWGN one and we can use the classical gaussian distribution properties to evaluate the false detection and no detection probabilities for one code.

Let's write T the Eb/No threshold, s the spread signal whose Eb/No value is S, n_i is the AWGN noise of average power No.
The false detection probabilities and the no detection probabilities are presented in a literal way for the cases of threshold driven blind channelization code detection and of code number assisted blind channelization code detection in table 1.

Blind channelization Code Detection with the use of a threshold	**Blind channelization Code Detection with the use of the number of codes**
<u>False detection probability :</u> $P_{FD} = P(n > T)$ $= Q(T)$	<u>False detection probability :</u> $P_{FD} = P(n > S)$ $= P(n > S)$ $= Q(S)$
<u>Probability of non detection :</u> $P_{ND} = P(s + n < T)$ $= P(n > S - T)$ $= Q(S-T)$	<u>Probability of non detection :</u> $P_{ND} = P(s + n < No)$ $= P(n > S)$ $= Q(S)$

<u>Table 1</u>

Table 1 clearly states that the non detection and false detection probabilities are significantly decreased in case of blind channelization code detection using the number of codes.

When applied to the case of a midamble with $(S)_{dB}$ = 5dB and $(T)_{dB}$ taking values from 1 dB to 3 dB, these expressions give the results displayed in table 2.

Threshold driven BCCD 1dB	**2dB**	**3dB**	**BCCD with the use of the number of codes**
<u>False detection probability :</u> P_{FD} = 1.0e-1	5.6e-2	2.3e-2	<u>False detection probability :</u> P_{FD} = 7.8e-4
<u>Probability of non detection :</u> P_{ND} = 6.0e-3	2.3e-2	5.6e-2	<u>Probability of non detection :</u> P_{ND} = 7.8e-4

<u>Table 2</u>

Moreover the complexity of the Blind channelization Code Detection is reduced in case of iterative algorithms (research stops as soon as the corresponding number of codes has been found).

Conclusion

This contribution presents a method to signal the number of codes used in a downlink slot, in case of common midamble, by modulating the midamble shifts.

- It enhanced significantly the channelization code detection process which is a key issue in case of joint detection receiver.
- It can be updated in real time since it is layer 1 only process and its computational complexity is negligible .
- It is obtained for free since the global power emitted on the midambles is unchanged and it implies no signaling overhead.

Therefore we recommend to introduce this technique in the case of downlink timeslots with common midamble.