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Re:	IEEE P802.16-2004/Cor1-D1	
Abstract	The PRBS is correlated over time between cells. We suggest to correct it.	
Purpose	Adopt changes	
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Correction to PRBS

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1. Motivation

The PRBS function should takes care of sub-carriers randomization over frequency, time and between different cells. Good randomization of pilots is essential for good channel estimation in the presence of interference from other BS. With the current PRBS seed, the PRBS sequences of two BSs will be correlated over time and therefore although it is IDCELL dependant it doesn't supply separation between cells. We suggest a way to de-correlate the PRBS sequences of different cells.

2. Details

There is a problem with the sub-carrier randomization (PRBS sequence) defined in 8.4.9.4.1.

2.1. Desired Situation

One of the important features of this sequence is to randomize the pilots in frequency and in time domain, and between cells.
When estimating the channel (in UL or in DL), in order to obtain reasonable channel estimation gain (=SNR of chanel estimation / SNR of pilots), one may (or must) average on time domain, since there is not enough gain in frequency domain (depending on delay spread assumptions). This is especially important in scenario of interference, since the pilot boosting gain vanishes (pilots in other cell also boosted), and because of low SNR conditions at edge of cell, high channel estimation gain is needed, which necessitates de-spreading gain in both time and frequency.

We would expect that the PRBS will be uncorrelated between cells in frequency and in time. The important thing is how the (transmitted) PRBS sequence of cell x is seen after being de-rotated by the PRBS of cell y (in the receiver), i.e. the XOR between the two binary sequences.

2.2. Problem

The PRBS is a sequence generated by an LFSR whose seed is seed = (IDCELL | segment | symbol number). "|" indicates concatenation. An LFSR sequence is linear w.r.t. to its seed, which means that the XOR of two LFSR sequences is the LFSR sequence generated by the XOR of their seeds. So when xoring the PRBS-s of two cells, the symbol numbers in the seeds of cells x,y will cancel out, and what we'll end up is with a sequence which depends only on the XOR of the IDCELLs (and segment numbers).
As a results, the pilot on sub-carrier n from cell x and the same pilot n from cell y will have a constant relation (1 or -1), over all the OFDMA symbols (although each sub-carrier n will change from symbol to symbol).

The result of this is that there is no de-spreading gain in time domain. The major impact is on the pilots. The impact on the data is smaller (but there are some "bad" scenarios like repetition applied on a narrow allocation, in which all repetitions will have same phase across cells).

2.3. Solution

PRBS will be rotated n=(symbol offset)%32 times (i.e. the first N outputs will be thrown), and only the next output will be mapped to the first sub-carrier.

3. Changes summary

[Change lines 3-10 at p.114 as follows]

b3..b0 = 1111 (all ones) ~~In the downlink, Four least significant bits of symbol offset from the first data preamble~~
~~symbol in the frame (i.e., the symbol in the frame in which the DL-MAP startsfirst PUSC~~
~~symbol after the preamble is indexed 1). In the uplink set to the result of XOR (bit wise)~~
~~operation between the four LSBs of symbol offset from the first data preamble symbol in the~~
~~frame (i.e. the symbol in the frame in which the DL-MAP starts first PUSC symbol after the~~
~~preamble is indexed 1) and the four least significant bits of the Frame Number.~~

[Change lines 12-15 at p.114 8.4.9.4.1]

Change the second sentence of the last paragraph as indicated:

~~The PRBS shall be initialized so that its first output bit coincides with the first usable subcarrier (as defined in Table 313) as defined for the zone in which the symbol resides.~~
The PRBS shall be rotated n times, n=Symbol_Offset%32, before applying it to the subcarriers, where symbol offset is counted from the preamble in the downlink (i.e. the first symbol carrying the DL_MAP is indexed 1) and from Allocation start time in the uplink (i.e. the first symbol is indexed 0). As a result, the PRBS shall be used such that its n'th output bit will coincide with the first usable subcarrier as defined for the zone in which the symbol resides (E.g: if n=0 take the first output bit, if n=1 take the second bit, etc).