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Source(s)	Tao Li, Jiang Li, Thomas Li, Jim Carlo FutureWei (Huawei North America Division) 3255-4 Scott Blvd.Suite 101, Santa Clara, CA 95054 Voice: 408-712-9326 Fax: 408-988-8059 mailto: John_Lee@Huawei.com
Re:	IEEE P802.16Cor1/D3
Abstract	Preamble Design of IEEE 802.16-2004 has a problem in scenarios described in B.4 of IEEE 802.16-2004 frequency reuse of 1 for OFDMA. A simple modification is proposed to fix this problem.
Purpose	For adoption
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Preamble Design Fix for 802.16 OFDMA

Tao Li, Jiang Li, Thomas Li
HUAWEI

1. Introduction

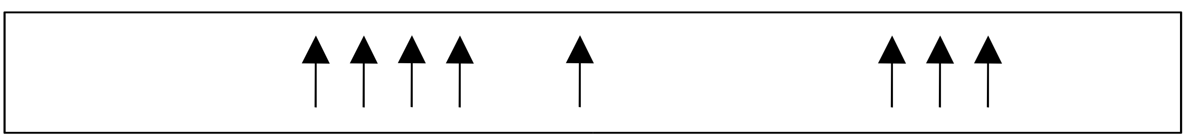
Current IEEE 802.16-2004 preamble design used in the 2048, 1024, 512 and 128 FFT OFDMA mode has a unique mapping rule between the preamble PN sequence and subcarriers. This unique mapping leads to a repetition pattern in time domain, which may ease the receiver design for acquisition. However for the scenarios (Synchronous Configuration and Coordinated Synchronous Configuration) described in B.4 of IEEE 802.16-2004 *Frequency reuse of 1 for OFDMA,* when a Service Subscriber (SS) is in the vicinity of borders of 3 cells where SS can observe 3 preambles from 3 different segments of 3 cells , the repetition pattern of preamble in time domain no longer exits, which may lead to higher failure rate for acquisition or receiver need to change the design with high cost in term of more complicated design and higher power consumption.

2. Problem Statement

We use 1024 FFT mode as an example to show the mapping rule between preamble PN sequence and subcarriers, which is specified in equation (109) of IEEE 802.16-2004. We copy it for convenience.

$$\text{PreambleCarrierSet}_n = n + 3k , \qquad (109)$$

where
n = 0, 1, 2 for segment 0, 1, 2, respectively,
k = 0, 1, 2, …, 283, for 1024 FFT size mode.



Left 86 guard band 0 1 2 3 . . . 6 . . . . 849 850 851 Right 86 guard band
Preamble PN -1 0 0 1 . . . -1 . . . . -1 0 0

Fig. 1 Preamble PN sequence mapping to Subcarriers, an example in 1024 FFT mode

A detailed example is shown in Fig. 1. It can be seen that the preamble PN sequence mapping to the subcarriers in every 3 subcarrier pace. Because of this unique mapping structure between the preamble PN sequence and subcarriers in frequency domain, the preamble shows the repetition pattern in time domain.
A simple and robust acquisition technique such as autocorrelation will take the advantage of repetition pattern in time domain. In Fig. 2, it can be seen that the good autocorrelation property of time domain preamble signals. In the vicinity of borders of 3 cells as shown in Fig. 3, the SS can observe 3 overlapped preambles from 3 different segments with relative same power (in synchronous configurations as described in B.4 of IEEE 802.16-2004). This is equivalent to map 3 different carrier sets into the subcarriers as shown in Fig. 4

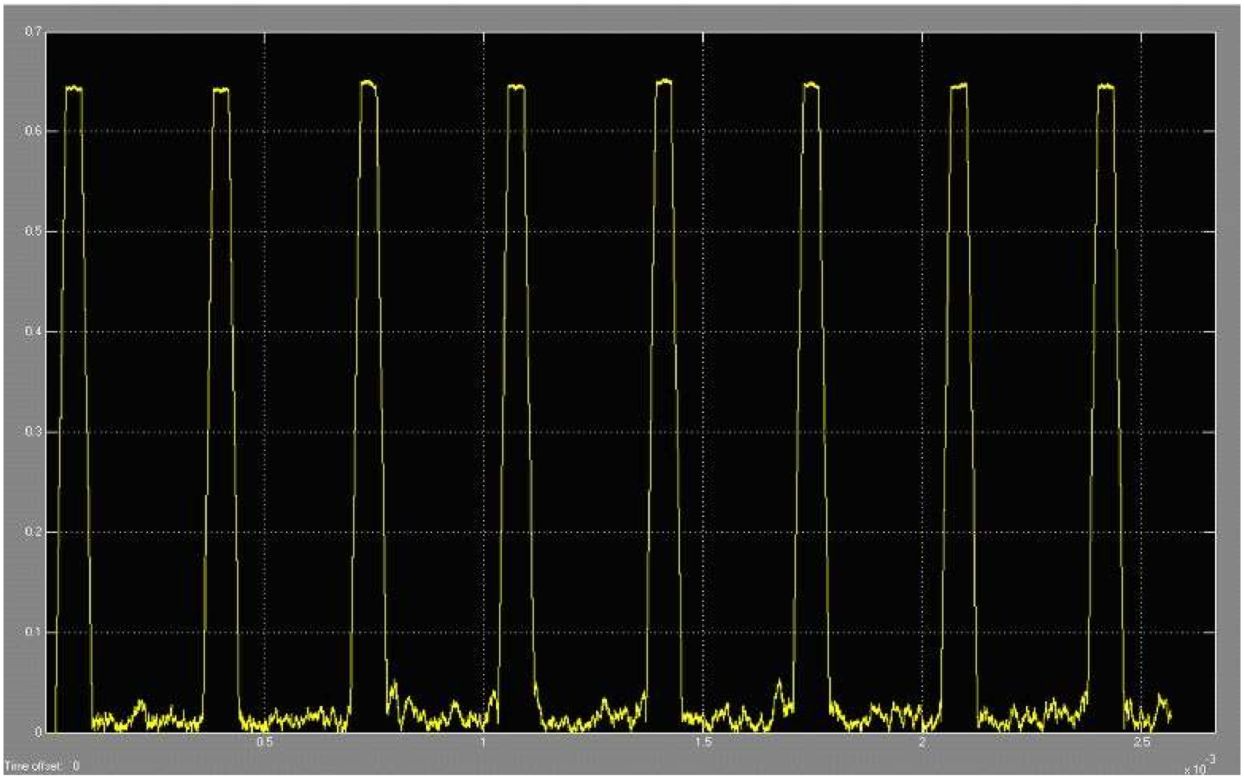
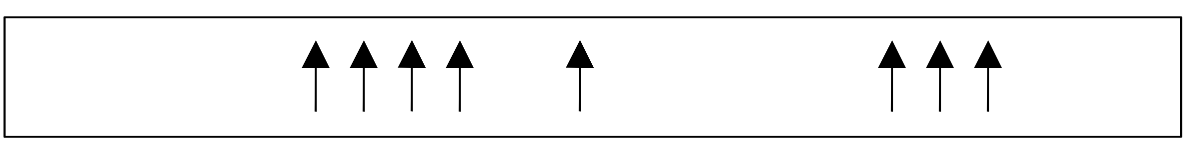


Fig. 2 Autocorrelation of preamble in one segment of a cell

Fig. 3 Reuse 1 configuration, 3 cells, 3 segment per cell



Left 86 guard band 0 1 2 3 . . . 6 . . . . 849 850 851 Right
86 guard band
Preamble PN -1 1 -1 1 . . . -1 . . . . -1 -1 1

Fig. 4 3 overlapped preambles in frequency domain in 3 cell border vicinity

In this situation, the repetition pattern of preamble in time domain no longer exits. The simple autocorrelation scheme may not work in this scenario as shown in Fig. 5. More complicated acquisition technique has to be used or SS will experience high acquisition failure rate.

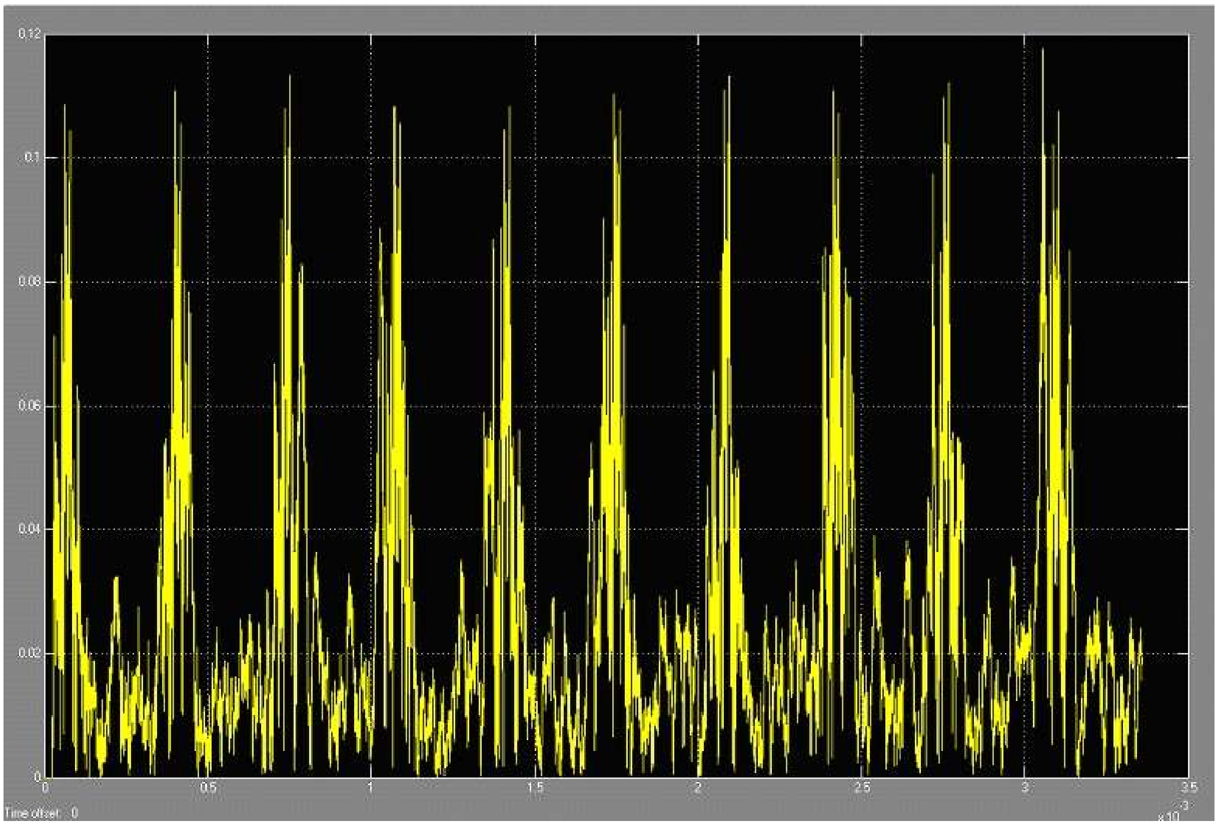


Fig. 5 Autocorrelation of 3 overlapped preambles

3. Proposed Fix for Preamble Design

To solve the problem of SS receiving multiple preambles in the vicinity of the border of 3 cells, and keep initial acquisition simple and robust, the preamble and subcarrier mapping formula has been modified so that time domain repetition pattern will be retained. That is to puncture the preamble bit when k is odd by forcing them to zeros. Take 1024 FFT mode as an example, it is shown in Fig. 1 that a preamble PN sequence maps to subcarrier at every 3 subcarriers pace. Now we modify this mapping rule by puncture or zero out half of the PN bit stream when k is odd in equation (109) and double amplitude of the remaining PN sequence, which will make total energy of preamble sequence unchanged. The modification of equation (109) is shown as follows.

$$\text{PreambleCarrierSet}_n = n + 3k, \qquad (109)$$

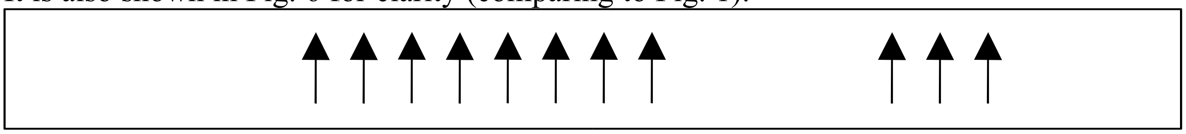
Punctured (forced to zero) when k = 1, 3, …

where

n = 0, 1, 2 for segment 0, 1, 2, respectively,

k = 0, 1, 2, …, 283, for 1024 FFT size mode.

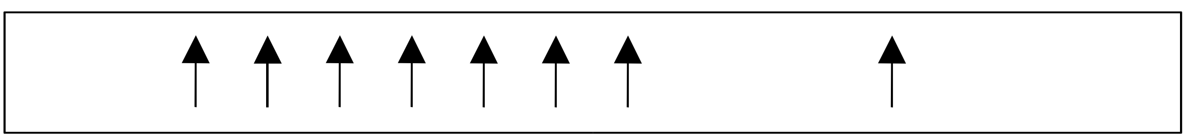
It is also shown in Fig. 6 for clarity (comparing to Fig. 1).



Left 86 guard band	0	1	2	3	4	5	6	7	. . . .	849	850	851	Right 86 guard band
Preamble PN	-1	0	0	0	0	0	-1	0	. . . .	-1	0	0	

Fig. 6 Modified preamble PN mapping to subcarriers with puncturing

The benefit of doing so is that when SS in the situation that several preambles are observed in the vicinity of 3 cell overlapping area. The frequency preamble pattern shown in Fig. 4 will be changed to the patterns shown in Fig. 7. So in the receiver end if same autocorrelation operation is used, the autocorrelation of the received preamble is shown in Fig. 8. It can be seen that the autocorrelation shows a very obvious peak, i.e., frame can be easily detected.



Left 86 GB	0	1	2	3	4	5	6	. . . .	851	right 86 GB
3 Pre_PN	-1	1	-1	0	0	0	-1	. . . .	0	

Fig. 7 3 overlapped preamble PN in frequency domain

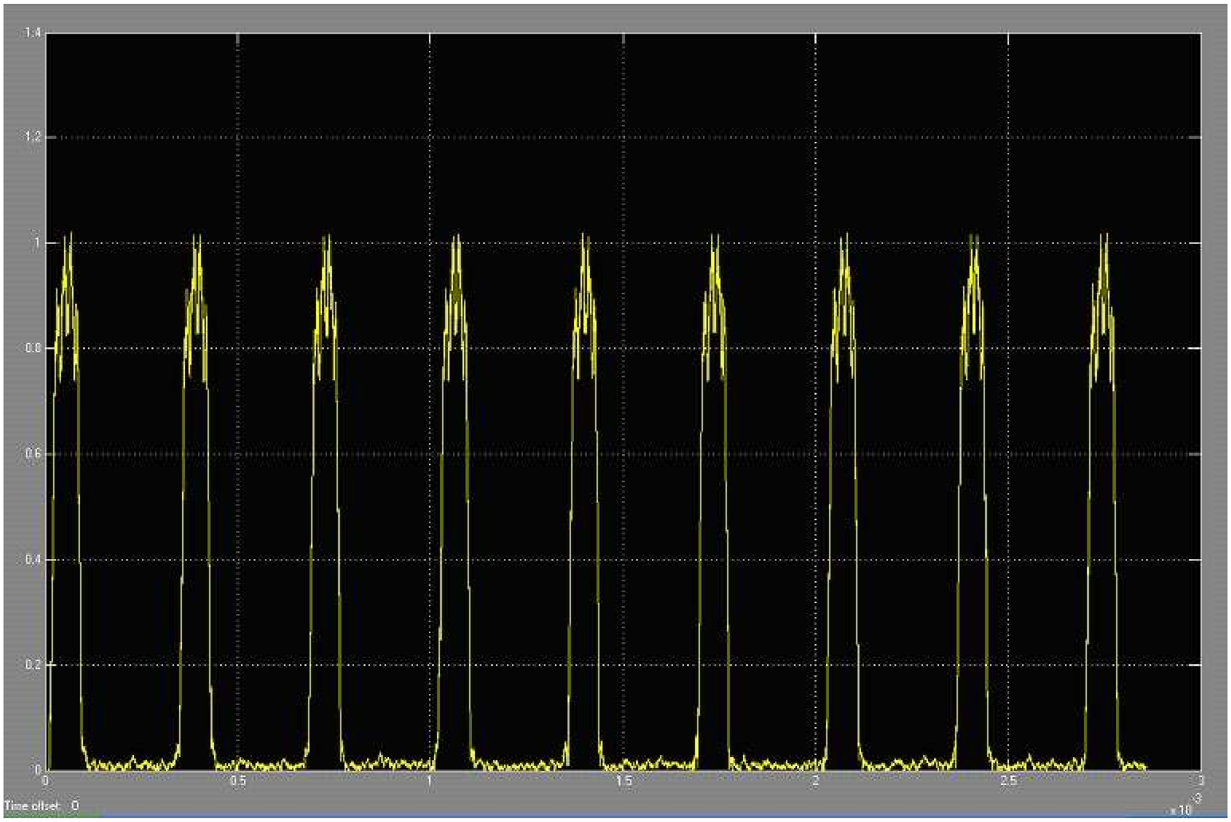


Fig. 8 Autocorrelation of 3 overlapped preamble.

The merits of this fix can be summarized as follows. First, it does not change the original preamble PN sequence but change the mapping rule between the subcarriers and PN sequence. Second, the puncture pattern of mapping preamble PN to subcarriers will retain repetition pattern with more repetition times, which will make autocorrelation detection more robust comparing to the original scheme. Third, the preamble searching calculation load is reduce and Further more the modification of the preamble design is simple, which makes very little impact to the receiver design of SS. Since the original preamble PN is carefully search that the PAPR is low.

4. Suggested Text changes

In Cor1/D3, page 139, line 18 insert the following:
Add a notes below the Equation (109)

$$PreambleCarrierSet_n = n + 3k, \qquad (109)$$

Punctured (forced to zero) when k = 1, 3, …