

Project	<b>IEEE 802.16 Broadband Wireless Access Working Group</b> < <a href="http://ieee802.org/16">http://ieee802.org/16</a> >	
Title	<b>Pilot Arrangement in FUSC to Average Interference between Neighbor Cells</b>	
Date Submitted	<b>2004-11-04</b>	
Source(s)	Bingyu Qu Huawei Huawei Bld., No.3 Xinxu Rd., Shang-Di Information Industry Base,Hai-Dian District, Beijing, China	Voice: +86-10-82882755 Fax: +86-10-82882940 <a href="mailto:qubingyu@huawei.com">qubingyu@huawei.com</a>
Re:	Contribution on comments to IEEE P802.16e/D5	
Abstract	A pilot allocation method for FUSC to average interference between neighbor cells	
Purpose	Discussion, Decision and Adoption	
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.	
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures < <a href="http://ieee802.org/16/ipr/patents/policy.html">http://ieee802.org/16/ipr/patents/policy.html</a> >, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair < <a href="mailto:chair@wirelessman.org">mailto:chair@wirelessman.org</a> > as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site < <a href="http://ieee802.org/16/ipr/patents/notices">http://ieee802.org/16/ipr/patents/notices</a> >.	

# Pilot Arrangement in FUSC to Average Interference Between Neighbor Cells

Bingyu Qu  
Huawei

## 1. Introduction

In 802.16e-D5, the defined pilot positions are identical for all base stations, and different scrambling sequences modulated on the pilots used for channel estimation are used for different base stations. So the interference between pilots of neighbor cells is significant because the pilot positions of different neighbor base stations overlap almost completely with a very high probability, which will degrade the channel estimation performance greatly, especially in the case of frequency reuse factor one.

In [1], pilot arrangement related to a cell-specified parameter is used to separate the pilots of different cells in frequency to reduce the interference between pilots to some degree. But since there are very few different pilot arrangement patterns, the collision probability of pilots from different cells is still very high.

In this contribution, first we construct many more pilot arrangement patterns with very few intercell collisions, then we give a randomized allocation method of the constructed pilot arrangement patterns. This random method will average the interference on the current cell which are from the pilots transmitted in neighboring cells. So the interference between pilots of neighboring cells is reduced by the proposed pilot arrangement.

## 2. Proposed Solution

First, given a base permutation sequence  $p = (6,9,4,8,10,11,5,2,7,3,1,0)$ , construct the set of sequences with good correlation property by shifts in two dimensions. Let  $p_s[i]$  be the series obtained by rotating cyclically  $p$  to the left  $s$  times, then the set of sequences we need with length 12 is

$$P_k[i] = (p_{\lfloor k/12 \rfloor}[i] + k \bmod 12) \bmod 12, i = 0,1,\dots,11, k = 0,1,\dots,143.$$

So in FUSC, the downlink pilot arrangement patterns are defined by the following formula

$$PilotLocation = VariableSet\#x + P_k[FUSC\_SymbolNumber \bmod 12]$$

Where *VariableSet #x* is defined in 802.16-REVd-D5 8.4.6.1.2.2 [2]. *FUSC\_SymbolNumber* counts the FUSC symbols used in the transmission starting from 0.

Now we have many more pilot arrangement patterns. In principle, a simple allocation method which is that different cells can be allocated different pilot arrangement pattern can be used to reduce the collision probability. But since the pilot arrangement patterns are derived by time and frequency shifts of a base pilot arrangement pattern, the complete overlapping of pilots can occur with the simple pilot pattern allocation method, due to the time and frequency non-synchronization of different base stations. So we consider the randomization method to average the interference of pilots. If the pilot arrangement patterns between two base stations overlap completely in one time interval (now the time interval is 12 OFDM symbols), they will again overlap completely in the next interval with only a very small probability due to the proposed randomization.

The index  $k$  to indicate the pilot arrangement patterns are determined by the following formula,

$$k = z(CellID, Segment, \lfloor FUSC\_SymbolNumber / 12 \rfloor)$$

Where *CellID* is from 0 ~ 31, *Segment* is 0,1,2. *CellID* and *Segment* can be determined by preambles.

So  $12 \times 12 = 144$  number of pilot patterns are given for a 12 number of symbol time interval. In each 12 number of symbol time interval pilot positions are allocated by one pilot pattern determined by an index  $k$ , which is a pseudo-random variable  $z$  determined by *CellID*, *Segment*, *FUSC\_SymbolNumber*.

The function  $z(l, m, n)$  should be obtained by an pseudo-random sequence. Suppose  $x(i)$  is the m-sequence generated by  $1 + X^3 + X^{10}$  and  $y(i)$  is the m-sequence generated by  $1 + X^2 + X^3 + X^6 + X^8 + X^9 + X^{10}$ , with initial register state all "1".  $z(l, m, n)$  can then be represented in a binary format as follows

$$z(l, m, n) = (b_7 b_6 b_5 b_4 b_3 b_2 b_1 b_0) \bmod 144, b_i = [x(n \cdot 8 + l \cdot 3 + m + i) + y(n \cdot 8 + 2^9 + i)] \bmod 2.$$

### 3. Proposed Text Changes

Insert the following text in

8.4.6.1.2.2 page 217, line 43

$$PilotLocation = VariableSet\#x + P_k(FUSC\_SymbolNumber \bmod 12)$$

$$P_k[i] = (p_{\lfloor k/12 \rfloor}[i] + k \bmod 12) \bmod 12, i = 0, 1, \dots, 11,$$

$p_s[i]$  is the series obtained by rotating cyclically  $p$  to the left  $s$  times,  $p = (6, 9, 4, 8, 10, 11, 5, 2, 7, 3, 1, 0)$ .

$$k = z(CellID, Segment, \lfloor FUSC\_SymbolNumber / 12 \rfloor)$$

*FUSC\_SymbolNumber* counts the FUSC symbols used in the transmission starting from 0. *CellID* is from 0 ~ 31, *Segment* is 0, 1, 2.

$x(i)$  is the m-sequence generated by  $1 + X^3 + X^{10}$  and  $y(i)$  is the m-sequence generated by  $1 + X^2 + X^3 + X^6 + X^8 + X^9 + X^{10}$ , both with initial register state all "1".

$$z(l, m, n) = (b_7 b_6 b_5 b_4 b_3 b_2 b_1 b_0) \bmod 144, b_i = [x(n \cdot 8 + l \cdot 3 + m + i) + y(n \cdot 8 + 2^9 + i)] \bmod 2.$$

### 4. Reference:

- [1] Ran Yaniv, Tal Kaitz, Naftali Chayat, Vladimir Yanover, Mariama Goldhammer, Pilot Arrangement in FUSC-Reply to Comment #433, IEEE 802.16e/238
- [2] IEEE 802.16-REVd\_D5
- [3] IEEE 802.16e\_D5