Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**802.16m DL Pilot Structure**
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Re:	Call for Contributions on Project 802.16m System Description Document (SDD) (IEEE 802.16m-08/005) - Pilot Structures as relevant to DL MIMO
Abstract	This contribution describes a pilot structure to be used in the DL of 802.16m and discusses some of its advantages with respect to the current design
Purpose	Discuss as part of SDD call for contributions and consider for adoption
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802.16m DL Pilot Structure

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1 Introduction

One of the main of objectives of 802.16m, as spelled out in the SRD [1], is to achieve high spectral efficiency and peak data rates. In general, design of an effective pilot structure entails a judicious compromise between adding the necessary overhead required to provide robust channel estimation while keeping overhead to a minimum not to severely impact spectral efficiency. This issue becomes more complex as MIMO schemes are considered because the pilot structure must address the multiple antenna system envisioned and must provide for reliable operation for the combining scheme that is required. This contribution addresses a pilot structure that is sufficiently flexible to support multiple antennas while adding only the overhead required for the antennas in use (i.e., the pilot structure is tied only to those antennas in use), thus keeping overhead to a minimum while providing for robust channel estimation.

2 Downlink Pilot Structure

Figure 1 shows one slot of the downlink with the pilots inserted[1] [2]. The system supports transmission on one, two or four antennas (more antennas can be incorporated, if necessary, by a straightforward extension of the scheme shown). If only one antenna is used, it is designated as antenna 0. If two antennas are used, they are designated as antennas 0 and 1. If four antennas are used, they are designated as antennas 0, 1, 2, and 3. Each antenna has a unique placement of its pilots. Antenna 0 places pilots at subcarriers 3 and 8 on symbols 1 and 3 of a slot. Antenna 1 places pilots at subcarriers 3 and 8, but on symbols 0 and 2 of a slot. Similarly, antennas 3 and 4 use subcarriers 0 and 8, with antenna 3 placing them in symbols 1 and 3, and antenna 4 placing them in symbols 0 and 2. Note that pilots are not placed in tones that are already occupied by the preamble.

The pilot codes will be BPSK modulated by a 32767-bit *M*-sequence, generated from the polynomial $p(x) = x^{15}+x^7+x^4+x+1$. The PN generator is initialized at the start of each frame with the cell identity $N_{\text{cell}}^{\text{ID}}$ and the antenna port *p* as shown in Figure 2.

Recall that we number our slots with an ordered quadruple (*k*,*l*,*m*,*n*), where *k* is the subchannel[2], *l* is the slot time within a frame, *m* is the subcarrier within a subchannel, and *n* is the symbol within a slot. Pilot bits are assigned to slots in increasing absolute value of *k* and *l*, thus we assign them by (1,0), (-1, 0), (2,0), (-2,0), until all subchannels of slot time 0 have been assigned, and then we start over with (1,1), (-1,1), (2,1), (-2, 1), etc. until all slots in a frame have been assigned. Within a slot, pilot bits are assigned first in order of increasing *m*, and then in order of increasing *n*, until all pilots for that antenna in that slot have been assigned. An advantage of assigning pilots in this way is that we can know what the pilot codes are for the broadcast and assignment channels, regardless of the number of subchannels. This enables demodulation of broadcast channels using interference mitigation since, as pointed out previously, pilot values for interferers can be easily predicted.

[1] All parameters are in accordance with our proposal for DL Physical Resource Allocation Unit. See C80216m-08_189

[2] For algorithmic convenience, negative and positive subcarrier indexing is used, with subcarrier index 0 corresponding to DC. Conversion to indexing using positive subcarrier numbers is straightforward.

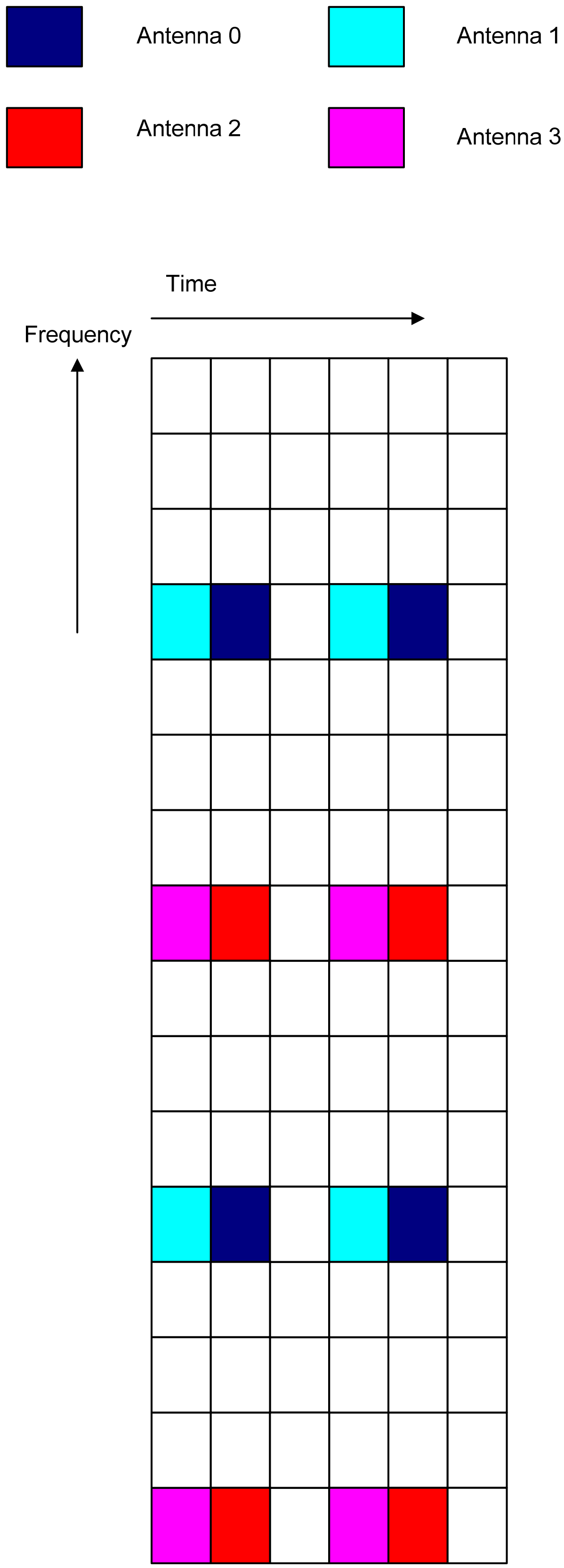

Figure 1 Pilot patterns per slot.

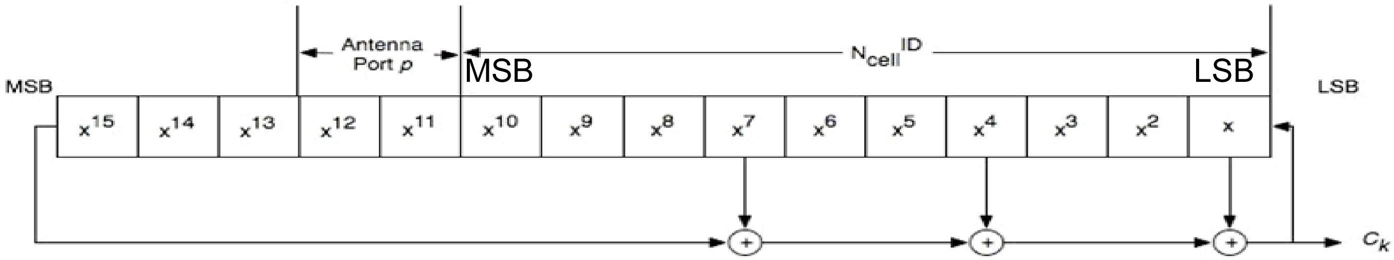

Figure 2 Initialization and generation of Pilot PN sequences.

Note that using this scheme pilots are always on the same tones and frequencies, regardless of what base station is transmitting them. We assume there will be broadcast channel(s) in the first mini-frame of a frame, which occupy only the central tones of a frame, i.e., around DC. The PN bits are assigned to pilots in a pattern which enables prediction without knowing the channel bandwidth. The PN sequence is tied in directly to the base station ID, so that we can predict the pilot values of interferers by identifying them using the searcher, thus improving channel estimation.

3 Summary of the contribution

A simple, yet effective DL pilot scheme for 802.16m has been presented. This scheme has the following attractive features

a) Pilot overhead is tailored for the number of antennas being used and it can be easily generalized if a larger number of antennas is required.

b) Due to the pilot placement (pilots are always on the same tones and frequencies, regardless of what base station is transmitting them and the PN sequences are directly tied to the BS ID), the scheme enables interference mitigation to improve performance

c) The PN bits are assigned to pilots in a pattern which enables prediction of the pilot modulation using preamble search results [3]. This scheme enables interference mitigation to improve performance

d) Assuming there will be broadcast channel(s) in the first mini-frame of a frame, which occupy only the central tones of a frame, i.e., around DC, pilot placement and pilot modulation have been selected to enable interference mitigation and channel estimation without knowledge of the channel bandwidth

4 References

[1] IEEE 802.16m-07/002r4. See Section 6.1, Table 1.

[2] G. Marsh et al. (NextWave), “Proposal for Downlink Physical Resource Allocation Unit,” C80216m-08_189

[3] G. Marsh et al. (NextWave), “802.16m DL Control Structure: Preamble Design,” C80216m-08_192