Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Uplink Pilot Patterns for IEEE 802.16m**
Date Submitted	**2008-5-15**
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Re:	IEEE 802.16m-08/016 Call for Contributions on project 802.16m System Description Document (SDD) – Uplink Pilot Structures
Abstract	Proposal of an UL pilot pattern for frequency diverse allocation like UL PUSC in 802.16e. Compared to UL PUSC, the proposed schemes provide more pilots in multi-layer configurations due to bigger physical resource units (PRUs) and less pilot overhead in single-layer transmission.
Purpose	For 802.16m discussion and adoption into the SDD.
Notice	
Release	
Patent Policy	

Uplink Pilot Patterns for IEEE 802.16m

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1. Introduction

UL PUSC, the mandatory allocation scheme in 802.16e distributes tiles (the smallest contiguous physical allocation unit) over the frequency-time domain to obtain a frequency diverse allocation of the data in the frame. Big drawbacks of this allocation are the low number of pilots per tile in multi-layer setups and the big pilot overhead of 33.3% in single-layer operation.

The proposed physical resource units (PRUs) are enhanced versions of UL PUSC in 802.16e. Especially the low number of pilots per tile in the multi-layer pattern of conventional UL PUSC is addressed and increased in the here proposed allocations. Like that, the proposed PRUs provide more robustness in multi-layer transmission (e.g. MIMO) without additional pilot overhead. This is obtained with increased size of the tile (doubled width in frequency) and new, more uniform pilot patterns.

Within the scope of this document layers are physical channels that allow the transmission of independent data streams between a base station and one ore more users using simultaneously the same frequency band (and CDMA code if applicable). An example for multi-layer transmission is MIMO spatial multiplexing.

2. Proposed physical resource unit

All the proposed structures are 3 OFDM symbols long in time like UL PUSC tiles [1]. As shown in Figure 1, the multi-layer PRUs (S2/S4) are extended in width (frequency) from 4 to 8 subcarriers. The new PRUs are called 8x3 PRUs (subcarriers x symbols). The pilot overhead is identical to the conventional UL PUSC scheme (33%) but the number of pilots of an 8x3 tile is doubled compared to a 4x3 tile (802.16e). This, and the more uniform and equal distribution of the pilots allows more robust channel estimation and detection of the data block. One slot consists of three 8x3 PRU in a row (in frequency) occupying the same frequency-time area than the six 4x3 tiles in UL PUSC permutation of 802.16e.

For the definition of single-layer structures three parameters exist and cannot be varied independently. These are the size of one slot, the number of data subcarriers in one slot and the pilot density. In 16e UL zones, SISO and MIMO operation is performed in the same zone and therefore the slot size of single- and multi-layer PRUs must be the same (due to line-by-line allocation). If the pilot density is reduced under this constraint (same slot size), the number of data subcarriers per slot grows. This happens in single-layer PRU proposal S1C. Structures S1A and S1B are based on the same number of data subcarriers per tile like their multi-layer counterpart. These three single-layer structures are described in the following.

Structure S1A represents a 16e UL PUSC allocation where two tiles are taken together to form a new 8x3 tile. After tile permutation of the new 8x3 tiles, the 8x3 tiles can be split into two 4x3 sub-tiles (equal to an UL PUSC tile) and additional permutation between all the users transmitting with a single layer (structure S1A) is possible. In this case single-layer communication performance is similar to conventional PUSC whereas multi-layer communication with structures S2/S4 shows the above mentioned advantages over the existing scheme and all are having the same number of data subcarriers per slot.

A second option for single-layer communication is structure S1B. A more uniform pilot pattern allows better

[1] Parts of this contribution are based on work supported by the FP7 project WiMAGIC

channel estimation and data detection than S1A without the additional frequency permutation of 4x3 tiles. The increased size leads to smaller number of tiles per slot and therefore to smaller diversity gains for small burst sizes.

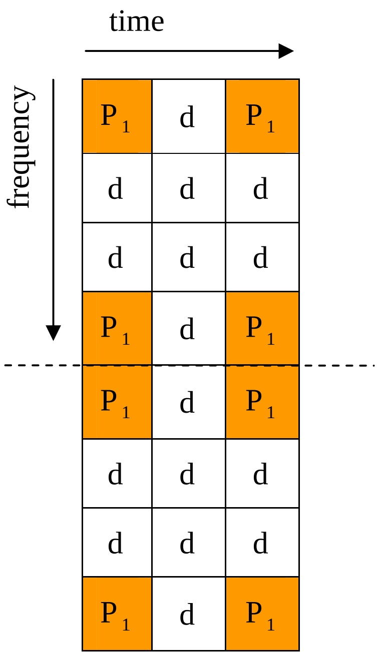
Structure S1C has a uniform pilot pattern which benefits from half the pilot overhead (16.7%) compared to the previous structures and 16e UL PUSC (33.3%). This PRU has 60 data subcarriers per slot and not the conventional number of 48.

Table 1 lists the number of available pilots per tile, the resulting density and the overhead for the 16e UL PUSC configurations (rows 1-3) followed by the here proposed tile structures. (Every layer of a specific multi-layer structure has the same number of pilots. Therefore the numbers in Table 1 are valid for any of the 2/4 layers in each multi-layer configuration.)

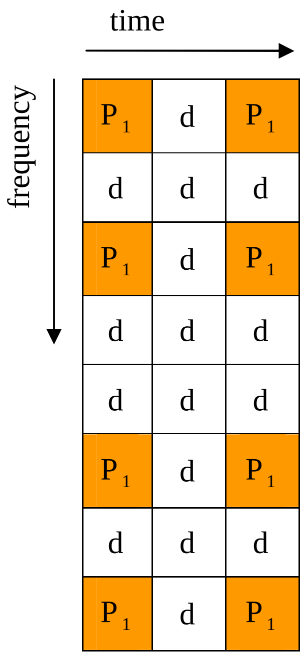
Allocation structure	Pilot overhead per layer	Number of pilots per layer per tile/PRU	Useful pilot density per layer
UL PUSC 16e (1 layer)	33.3 %	4	33.3 %
UL PUSC 16e (2 layers)	33.3 %	2	16.7 %
UL PUSC 16e (4 layers)	33.3 %	1 (average)	8.3 %
S1A (1 layer)	33.3 %	4	33.3 %
S1B (1 layer)	33.3 %	8	33.3 %
S1C (1 layer)	16.7 %	4	16.7 %
S2 (2 layers)	33.3 %	4	16.7 %
S4 (4 layers)	33.3 %	2	8.3%

Table 1: Comparison of pilot overhead and useful pilot density per layer for different tile/PRU structures

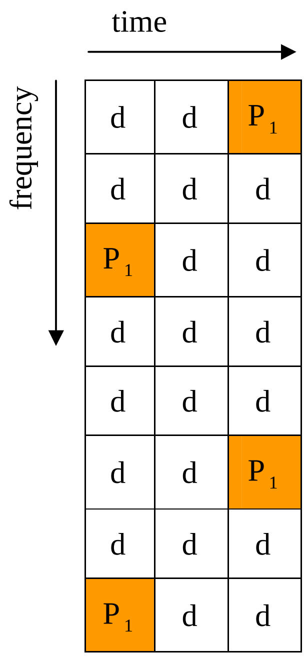
The selection of one of the three options S1A, S1B and S1C is FFS.



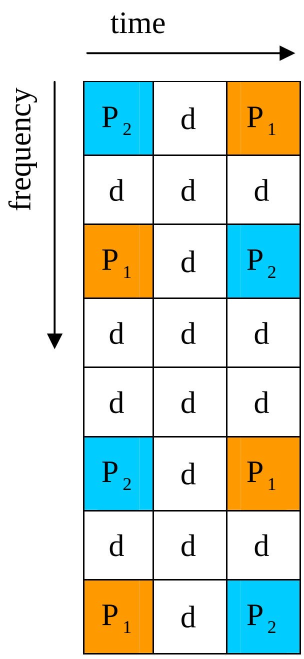
Tile structure **S1A** for **1 layer** (2 tiles of 16e UL PUSC)



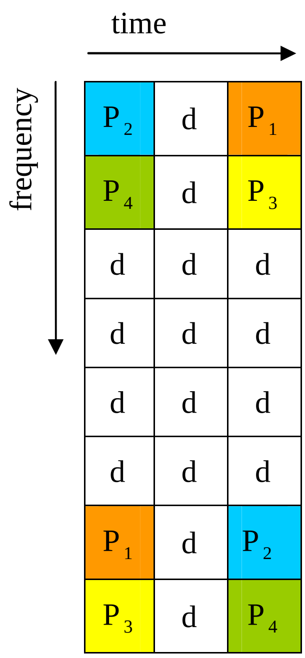
Tile structure **S1B** for **1 layer** (same as structure S2 using also P_2 pilot positions)



Tile structure **S1C** for **1 layer** (same as structure S2 with data on P_2)



Tile structure **S2** for **2 layers**



Tile structure **S4** for **4 layers**

Figure 1: Proposed pilot structures

3. Pilot boosting

For allocations using structure S2 the per pilot tone power is per default 3 dB above the per data tone power for each layer.

For allocations using structure S4 the per pilot tone power is per default 6 dB above the per data tone power for each layer.

The pilot tone power of 0, 3 or 6 dB above the per data tone power according to the number of orthogonal pilot patterns shall be further modified by a flexible value from the set {-2.5 dB; 0 dB; 2.5 dB; 5 dB} added on top. Different boosting values can be chosen for different layers. This variable boosting can e.g. be used to mitigate the pilot interference coming from the different layers and depends on the scenario.

4. References

[1] IEEE 802 Part 16: Air Interface for Broadband Wireless Access Systems, P802.16Rev2/D4