Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	Modified Pilot Allocation for AMC and Optional PUSC Uplink Subchannels for STC Mode
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Re:	802.16e/D3-2004
Abstract	We propose a modification of the pilot allocation scheme in the AMC and Optional PUSC subchannels to support up to two antennas on the uplink. This pilot allocation enhances the channel estimation performance for highly frequency selective channels, without affecting the existing subcarrier permutations.
Purpose	To propose enhancements to the pilot allocation for uplink STC modes in 802.16e/D3.
Notice	
Release	
Patent Policy and Procedures	

Modified Pilot Allocation for Uplink STC using AMC Modes

Beceem Communications, Inc.

1. Introduction

The 802.16e standard plans to support high data rates over large cells, which would invariably result in frequency selective fading. To ensure bandwidth efficiency, the standard proposes a pilot overhead of (typically) only 1/9 in most modes. In the band AMC sub-channel allocations, which are based on bins consisting of 9 adjacent sub-carriers over one OFDMA symbol interval, only a single pilot is provided in the middle of the bin. In highly frequency selective channels, this single pilot tone may not give a good estimate of the channel frequency response over the entire bin. For example, assuming 1024-pt FFT and 10MHz bandwidth, a bin spans 9x10MHz/1024 = 90KHz (approximately). In a channel with delay spread of 10μs, implying a coherence bandwidth of only 100KHz, the channel frequency response would significantly change over the bin bandwidth.

We propose a modified pilot placement across the time and frequency domains for the band AMC modes in order to improve the channel frequency response estimation. This is done without affecting the temporal channel tracking property of the pilots. The proposed allocation also improves the performance for the single antenna mode. This contribution also proposes the pilot allocation when two transmit antennas are used on the uplink.

For the optional PUSC mode, we propose a revised pilot allocation for the 3x3 tile (3 sub-carriers over 3 OFDMA symbol intervals) for two transmit antennas. While the 802.16e currently has frequency shifting pilots on the downlink in the optional FUSC and the optional AMC zones (section 8.4.8.3.2), no such technique appear to be available on the uplink, especially for the STC mode. This proposal aims at fulfilling this requirement, in order to support robust channel estimation even in highly frequency selective fading channels.

2. Proposed Pilot Allocation Schemes

2.1 Modified Pilot Allocation for 1x6 Band AMC Sub-channel

We propose to replace the existing 1x6 tiled band AMC sub-channel

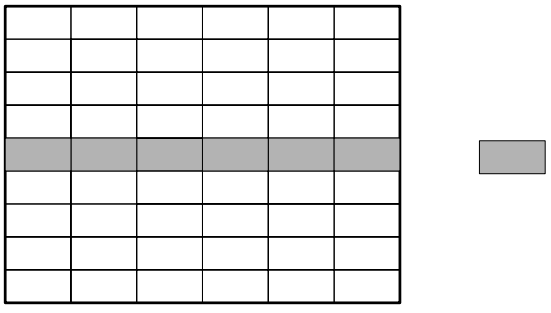

Figure 1(a) : Existing pilot allocation for 1x6 Band AMC tile for single antenna uplink

with a new 1x6 sub-channel pilot mapping which can estimate the frequency response over the entire bin in a better manner. This is achieved by allowing the pilots to sweep across the frequency band, over the 6 symbol times, as shown below:

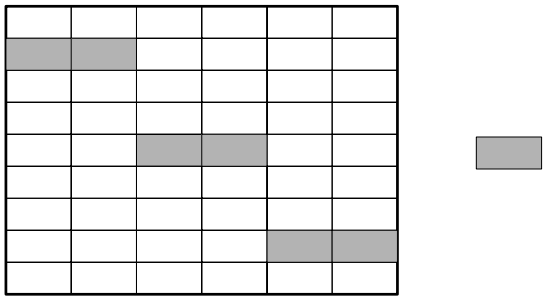

Figure 1(b) : Modified pilot allocation for 1x6 Band AMC tile for single antenna uplink

The allocation above also enables temporal smoothing of the frequency response over adjacent OFDMA symbols, thereby preserving the robustness of the pilot based tracking loop to Doppler induced temporal fading. In the case of STC where the SS employs two transmit antennas, the pilot allocations for antenna-0 and antenna-1 for the 1x6 tile defined by band AMC are as follows:

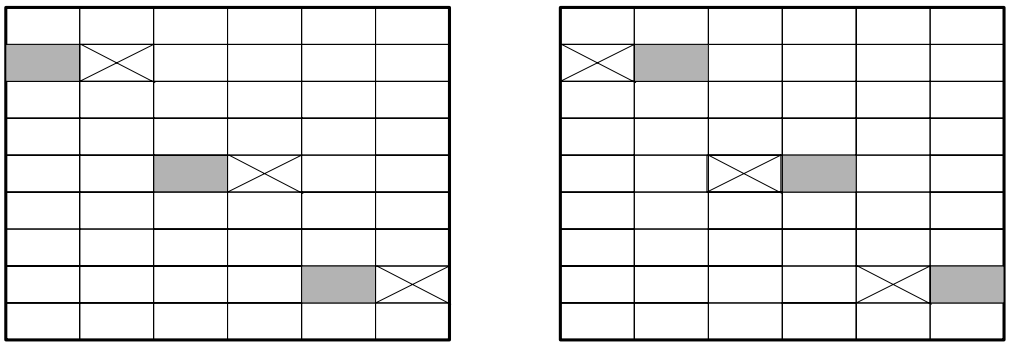

Figure 1(c) : Modified pilot allocations for antenna-0 and antenna-1

In this case, the pilots are equally split in time† between the 2 antennas, even while ensuring that the frequency response of the channel can be adequately estimated on a per-antenna basis. Since only pilots are punctured and the data subcarriers remain unaltered, there is no change on the subcarrier permutation structures. No symbol or pilot is transmitted on subcarriers identified with an X.

† In Figure 1(c) only one of the antennas transmits the pilot symbol (in the designated subcarrier marked in grey); the other antenna does not transmit any symbol in that subcarrier. All the remaining entries correspond to data subcarriers.

The motivation for the following modifications to the pilot allocation for the 2x3 and 3x2 subchannels are very similar.

2.2 Modified Pilot Allocation for 2x3 Band AMC Subchannel

We propose to replace the existing 2x3 band AMC subchannel giving on the left, with the proposed new pilot allocation shown on the right, for the single antenna uplink

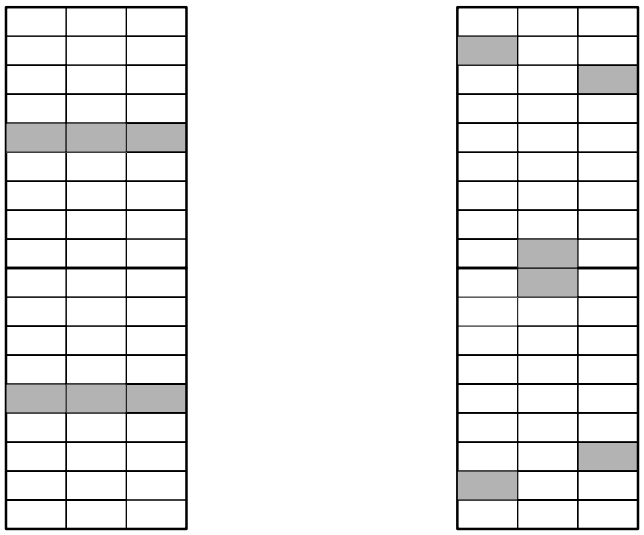

Figure 2(a) : Existing and Proposed pilot allocation for 2x3 Band AMC tile for single antenna uplink.

For two transmit antennas, the modified pilot allocation for the uplink 2x3 band AMC mode is as follows:

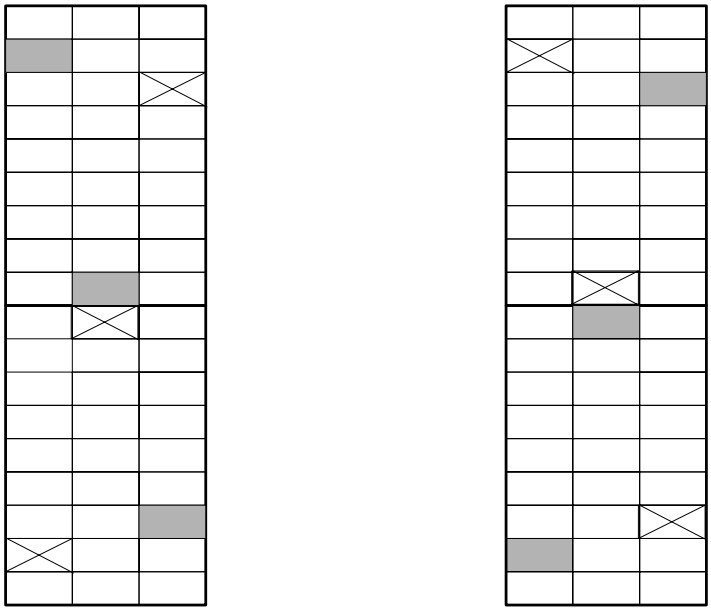

Figure 2(b) : Modified pilot allocations for antenna-0 and antenna-1 for 2x3 band AMC. *No symbol or carrier is transmitted on subcarriers marked with an X.*

2.3 Modified Pilot Allocation for 3x2 Band AMC Sub-channel

We propose to replace the existing 3x2 band AMC sub-channel shown on the left, by the allocation shown on the right, in the figure below.

Antenna-0

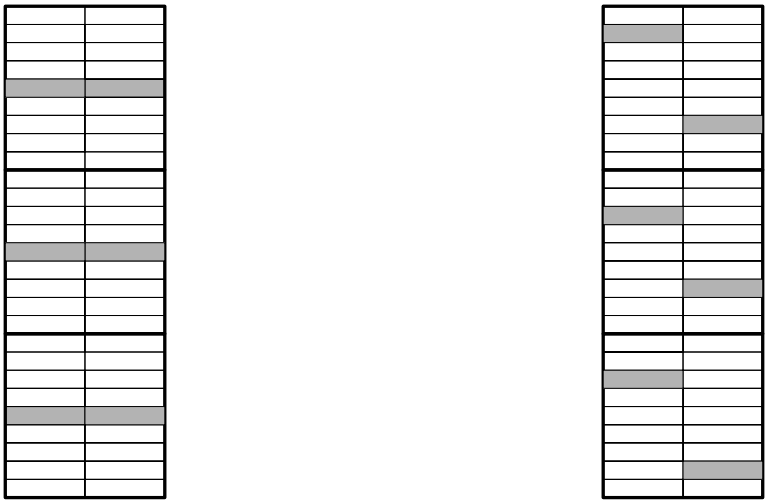

Figure 3(a) : Existing pilot allocation on the left, and the proposed pilot allocation on the right, for the 3x2 uplink

For two transmit antennas, the modified pilot allocation for the uplink 3x2 band AMC subchannel is as shown below for both the antennas.

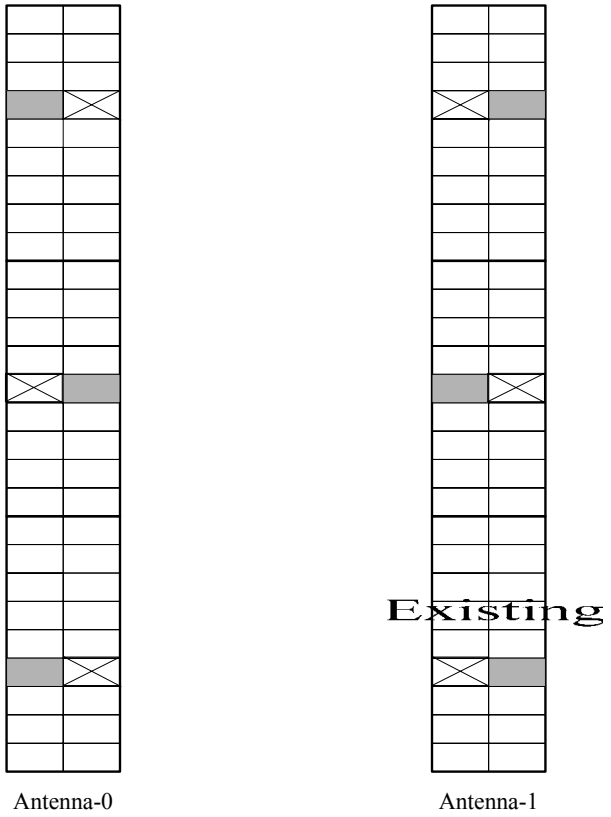

Figure 3(b) : Proposed pilot allocation for 3x2 Band AMC. No symbolor pilot is transmitted on subcarriers marked with an X.

2.4 Pilot Allocation for two Antennas for Additional Optional PUSC Uplink

For the 3x3 tile in the optional PUSC uplink where two antennas are used, the pilot allocation for the individual antennas may be specified in the following manner:

Any STC uplink in PUSC mode should have a minimum of 2 slot intervals (implying a minimum assignment of 48x2=96 symbols per user burst). The assignment of pilot tones would then alternate between antenna-0 and antenna-1 across temporally adjacent 3x3 tiles until the end of the burst.

This ensures that the base station can independently train to both the SS antennas

3. Specific text changes to 802.16e/D3

In Section 8.4.8.3.1 dealing with allocation of , the proposed pilot allocation schemes may be include as new subsections, in the following manner:

"8.4.8.3.1.1 Optional FUSC uplink with STC:
The optional PUSC uplink with 3x3 tiles can support up to 2 transmit antennas by employing pilot puncturing. Any STC uplink in PUSC mode should have a minimum of 2 slot intervals (implying a minimum assignment of 48x2=96 symbols per user burst). The assignment of pilot tones would then alternate between antenna-0 and antenna-1 across temporally adjacent 3x3 tiles until the end of the burst."

"8.4.8.3.1.2 Supporting STC uplink for Band AMC subchannels" **TBD**