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Title	**Analysis of end-of-burst degradation in the OFDM UL PHY under mobile conditions**
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Abstract	This document addresses the performance degradation due to lack of a terminating midamble in the UL burst. A significant loss in performance is shown to be present under mobile conditions. It is proposed to mitigate this loss by the addition of a 'postamble' to UL bursts that already include midambles.
Purpose	The document is submitted for consideration in the 802.16d WG.
Notice	
Release	
Patent Policy and Procedures	

Analysis of end-of-burst degradation in the OFDM UL PHY under mobile conditions

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Introduction

This document addresses the performance degradation due to lack of a terminating midambles in the UL burst. It is shown that there is a significant loss in performance under mobile conditions. It is proposed that UL bursts which include midambles will end with a 'postamble' that has the same structure as the short preamble / midamble.

Notations

E_s	Average signal power / subcarrier
E_d	Average signal power / data subcarrier
N_0	Thermal noise power / subcarrier
N_{est}	Estimation noise power / subcarrier

Performance Analysis

We analyze the channel estimation error for the data symbols remaining after the last midambles, as well as the potential improvement when a terminating midamble (or 'postamble') is present. Channel estimation is performed using linear MMSE interpolation [1], a method summarized briefly in [3].

As a test case, we consider an UL burst with a midamble spacing of L data symbols. The following scenarios are addressed:

1. A block of *at most* L data symbols is preceded by midamble S_0 and has no terminating postamble. The channel estimator makes use of midamble S_0 alone.

2. As above, however the estimator makes use of two past midambles, S_0 and S_{-L-1}.

3. Baseline: a block of L data symbols S_1, … S_L is preceded by midamble S_0 and ends with midamble S_{L+1}. The estimator makes use of these two adjacent midambles. This scenario represents the regular section of the burst and its performance is a lower-bound on the performance at the end of the burst in the presence of a terminating postamble.

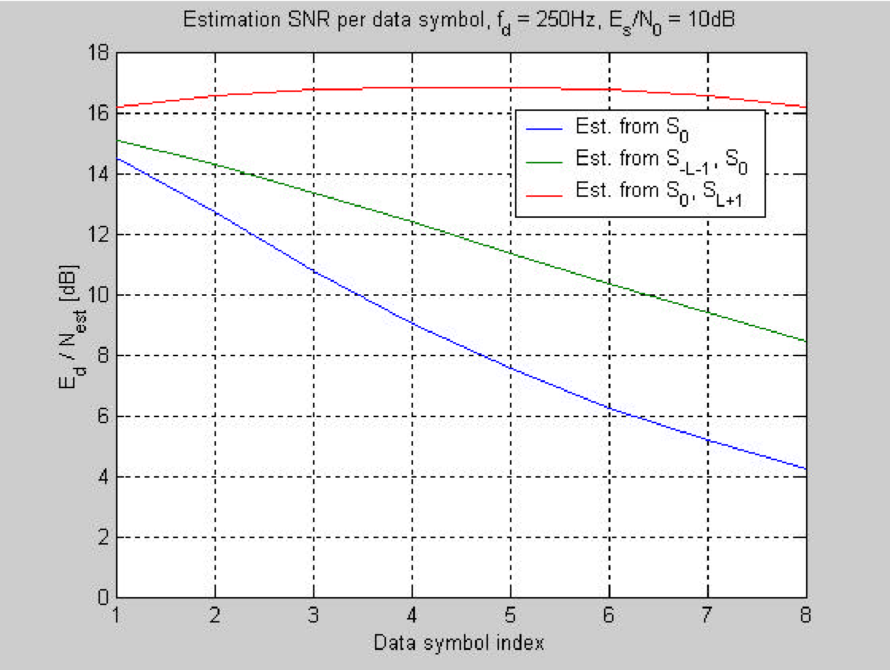
The evaluation was carried out under the following additional assumptions:

- 1/16 subchannelized transmission.
- Midamble spacing (L) = 8 data symbols.
- 4 Msamples/sec sampling rate.
- Carrier frequency: 3.5 GHz.
- MMSE estimator is matched to a maximum delay spread of 4µsec and to true Doppler frequency.
- Velocities: 75km/h ($f_{d,max}$ = 250Hz), 125km/h ($f_{d,max}$ = 400Hz).
- Channel profile: Vehicular Test A [2].

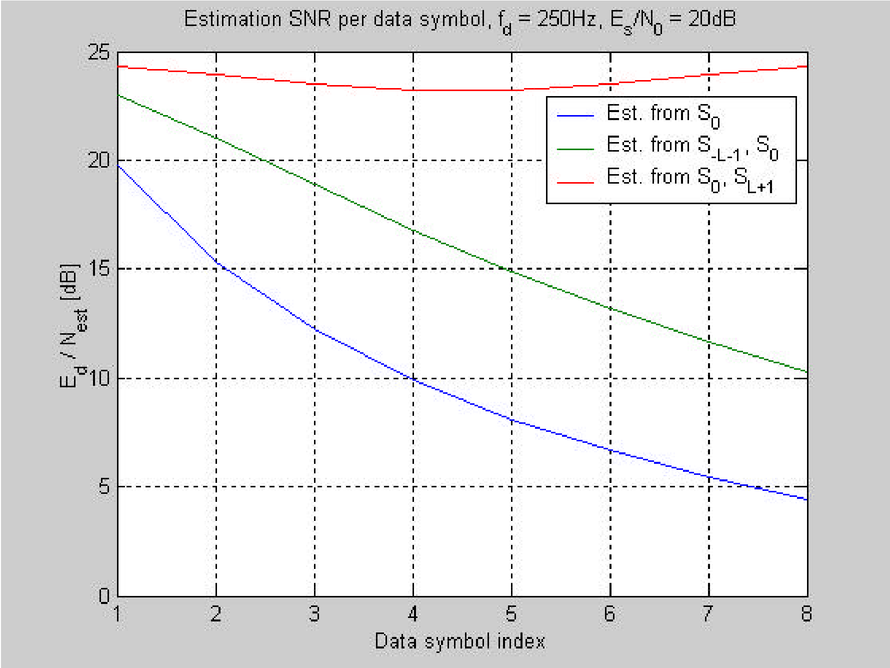
I: 75km/h velocity

The figures below depict the estimation SNR E_d / N_{est} for the different scenarios as a function of data symbol index. Note that the total signal-to-noise-ratio is a combination of thermal noise, estimation noise, ICI due to Doppler spreading, and other degradation factors.

Thermal SNR = 10dB



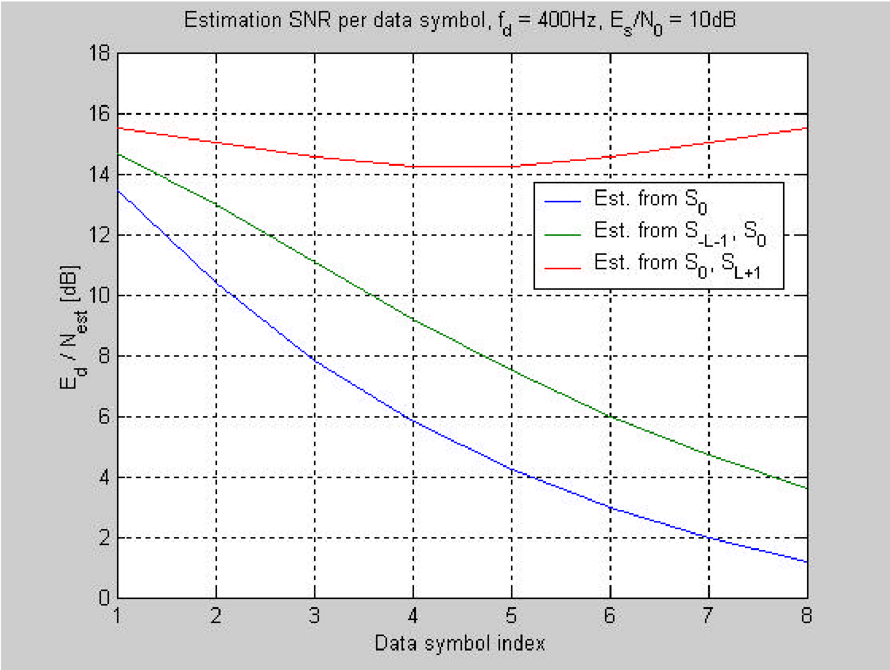
Thermal SNR = 20dB



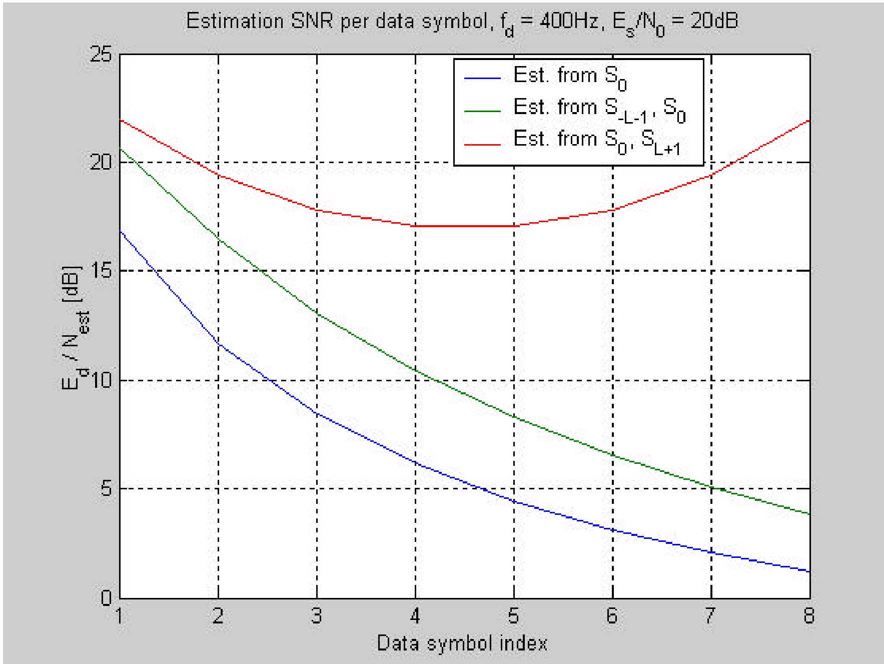
II: 125km/h velocity

The same is shown for mobile velocity of 125km/h.

Thermal SNR = 10dB


Estimation SNR per data symbol, f_d = 400Hz, E_s/N_0 = 10dB
Est. from S_0
Est. from S_-L-1, S_0
Est. from S_0, S_L+1
E_d / N_est [dB]
Data symbol index
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8

Thermal SNR = 20dB



Conclusions and Recommendation

At vehicular velocities, the lack of terminating postamble causes the channel estimation error to be the dominant limiting noise source in the decoding of symbols past the last midamble. This of course becomes more severe as the number of residual symbols grows.

In light of the above, it is proposed to add a postamble to all UL bursts that have at least $L/2$ remaining data symbols, where L is the number of data symbols between the regularly spaced midambles.

References

[1] P. Hoeher, S. Kaiser, and P. Robertson. “Two-Dimensional Pilot-Symbol-Aided Channel Estimation by Wiener Filtering”. Proc. IEEE ICASSP '97, Munich, Germany, pp. 1845-1848, Apr. 1997.

[2] ITU Recommendation ITU-R M.1225 – Guidelines for evaluation of radio transmission technologies for IMT-2000 (Question ITU-R 39/8).

[3] R. Yaniv, T. Kaitz. “Comparison between the midamble and the hopping-pilots schemes for estimation of the downlink mobile channel”. Submitted to the IEEE 802.16e task group (IEEE C802.16e-03/18).