Impact of Channel Estimation Error for Frequency Domain Adaptive Antenna Array

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1. Introduction

In our previous study [1], we proposed a frequency domain adaptive antenna array (FD-AAA) algorithm for the uplink detection in the broadband single-carrier multiple access system. In this paper, we will consider imperfect channel estimation and study the performance of the proposed algorithm with the presence of channel estimation error.

2. System Model

The multi-user single-carrier uplink transmission model is shown in Fig. 1.

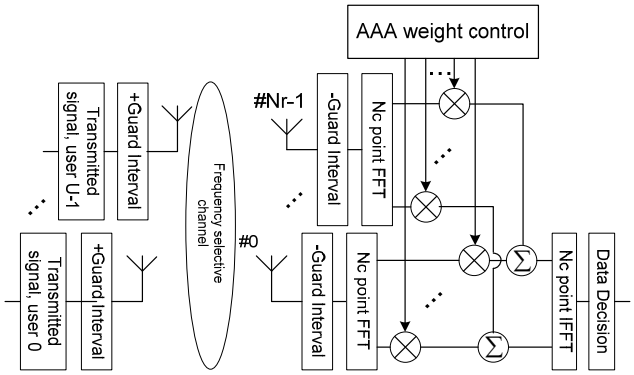

Fig. 1 The FD-AAA single-carrier uplink transmission.

The frequency domain representation of the received signal from the m^{th} antenna on the k^{th} frequency is given by

$$R_m(k) = H_m(k)S(k) + N_m(k). \quad (1)$$

where $H_m(k)$, $S(k)$ and $N_m(k)$ are the frequency domain channel gain, transmitted signal and noise, respectively. The AAA weight control is performed on each frequency as

$$\tilde{R}(k) = \mathbf{W}_{FD-AAA}^T(k)\mathbf{R}(k) \quad (2)$$

with $\mathbf{W}_{FD-AAA}(k) = \left[W_{FD-AAA,0}(k), \cdots, W_{FD-AAA,N_r-1}(k)\right]^T$ and $\mathbf{R}(k) = \left[R_0(k), \cdots, R_{N_r-1}(k)\right]^T$.

The frequency domain representation of the estimated channel gain can be modeled as

$$H_m(k) = H_m(k) + \Delta H_m(k), \quad (3)$$

where $\Delta H_m(k)$ is a complex Gaussian distributed variable with its variance $\sigma_{\Delta H}^2 = \beta\sigma_H^2$. σ_H^2 is the variance of the channel gain. It is obvious that the larger β is, the channel estimation becomes less accurate.

3. Simulation Result

Below, the effect of channel estimation error on the performance of the proposed FD-AAA algorithm is studied. The parameters used in the simulation are listed in Tab. 1.

Table I Simulation Parameters

Modulation		QPSK
Number of antennas N_r		4
Channel	Channel model	Frequency selective block Rayleigh fading
	Number of paths L	16
	Power delay profile	Uniform
Signal to noise ratio (SNR)		0dB, 5dB, 10dB
N_c		256
β		0~0.1

The parameter β is chosen from 0~0.1 and the signal to noise ratio (SNR) varies from 0dB to 10dB. The simulation results on the bit error rate (BER) performance versus the parameter β are shown in Fig. 2. It can be observed that when the SNR is low (0dB), the BER performance of the FD-AAA algorithm is slightly affected by the channel estimation error. This is because the major reason for the performance degradation when SNR is low is the noise; therefore, the channel estimation error will only slightly affect the performance. On the other hand, as the SNR increases, the performance of the FD-AAA algorithm becomes more sensitive to the channel estimation error and the channel estimation error more significantly degrades the performance. Therefore, to ensure a good performance of the FD-AAA algorithm, high accuracy channel estimation is necessary.

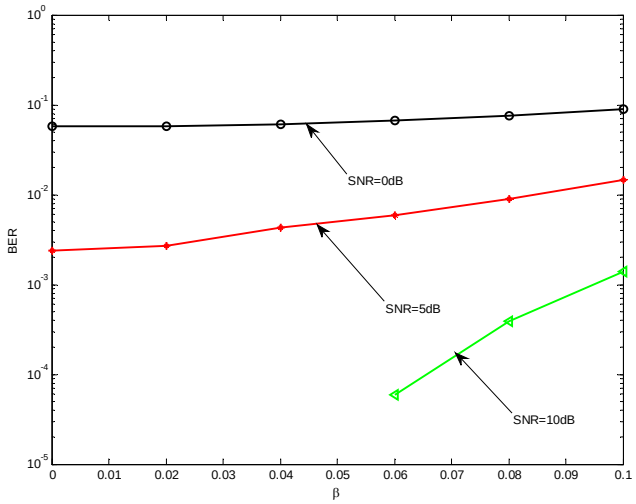

Fig. 2 The effect of imperfect channel estimation on FD-AAA algorithm.

[1] W. Peng and F. Adachi, "Frequency Domain Adaptive Antenna Array Algorithm for Single-carrier Uplink Transmission," IEEE conference PIMRC 2009, pp. 1-5, Sept. 2009.