모바일 와이맥스 시스템에서 인접 셀 간섭 완화를 위한 채널 추정

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Channel Estimation for OCI Mitigation in Mobile WiMAX Systems

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Abstract

In orthogonal frequency division multiplexing based wireless system, a pilot signal is often employed to estimate channel state information (CSI). However, the received pilot signal is interfered by other cell interference in multi-cell environments. We consider the estimation of CSI by utilizing orthogonal preambles and channel correlation.

I. Introduction

Orthogonal frequency division multiplexing (OFDM) can provide high spectral efficiency and mitigate inter-symbol interference in frequency selective channel. However, this requires the use of accurate channel state information (CSI), which is not easily obtainable. In OFDM based wireless systems such as the mobile-WiMAX, a pilot signal is employed to estimate the CSI. The received pilot signal is interfered by other cell interference, making it difficult to the CSI estimation. In this paper, we consider the use of orthogonal preamble and channel correlation to improve the CSI estimation performance.

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II. System modeling

We consider a three-cell three-sector OFDM based wireless system. Define the target channel and the i-th interference channel between the target base station (TBS) and the mobile station (MS), and the i-th interfering base station (IBS) and the MS, respectively. Received pilot signal corresponding to the t_p-th OFDM symbol and the f_p-th subcarrier can be represented as

$$Y(t_p,f_p)=H_t(t_p,f_p)P_t(t_p,f_p)+\sum_{i=1}^{2}H_i(t_p,f_p)P_i(t_p,f_p) + W(t_p,f_p) \quad (1)$$

where $H_t(t_p,f_p)$ and $P_t(t_p,f_p)$ are respectively the target channel and pilot signal transmitted from the TBS, $H_i(t_p,f_p)$ and $P_i(t_p,f_p)$ are respectively the i-th interference channel and the pilot signal transmitted from the i-th IBS, and $W(t_p,f_p)$ is a zero-mean complex Gaussian noise with variance σ_w^2.

Preambles are transmitted through different frequency bands according to the sectors at time t_s. Received preambles transmitted from the TBS and the i-th IBS can be represented as

$$Y(t_s,f_p)=H_t(t_s,f_p)S_t(t_s,f_p)+W(t_s,f_p) \quad (2)$$

$$Y(t_s,f_p+(-1)^i)=H_i(t_s,f_p+(-1)^i)S_t(t_s,f_p+(-1)^i) + W(t_s,f_p+(-1)^i) \quad (3)$$

where $S_t(t_s,f_p)$ and $S_i(t_s,f_p+(-1)^i)$ denote the preambles transmitted from the TBS and the i-th IBS, respectively. Let ρ_t and ρ_i be the correlation between the channel of the pilot signal and the preamble transmitted from the TBS and the i-th IBS, respectively.

Ⅲ. Proposed channel estimation

The target CSI can be estimated as

$$\widetilde{H}_t(t_p,f_p)=\left[\widehat{H}_t(t_p,f_p)\ \widehat{H}_p(t_s,f_p)\right]W_t = V_t W_t \qquad (4)$$

where $\widehat{H}_t(t_p,f_p)$ and $\widehat{H}_t(t_s,f_p)$ are estimated target CSI at pilot signal and preamble by using LS method, respectively. Also, W_t is a weight vector to be determined. Let R_t and P_t be the auto-covariance matrix and cross-covariance vector of the target channel respectively defined by [1]

$$R_t = E\{V_t^T V_t^*\} = \begin{bmatrix} \sigma_t^2+(\sigma_w^2/\sigma_p^2)+\sum_{i=1}^{2}\sigma_i^2 & \sigma_t^2\rho_t \\ \sigma_t^2\rho_t^* & \sigma_t^2+(\sigma_w^2/\sigma_s^2) \end{bmatrix} \qquad (5)$$

$$P_t = E\{V_t^T\widetilde{H}_t^*(t_p,f_p)\} = \begin{bmatrix} \sigma_t^2 \\ \sigma_t^2\rho_t^* \end{bmatrix} \qquad (6)$$

where σ_t^2 and σ_i^2 are the gains of the target and the i-th interference channel, respectively. σ_s^2 and are σ_p^2 the average transmit power of preamble and pilot signal, respectively. The optimum weight vector W_t can be determined by [1]

$$W_t = R_t^{-1}P_t \qquad (7)$$

Since the target channel behaves as noise to the estimation of the interference CSI, the interference CSI can be estimated by using the estimated target CSI as

$$\widehat{H}_i' = \frac{Y(t_p,f_p)-\widetilde{H}_t(t_p,f_p)P_t(t_p,f_p)}{P_i(t_p,f_p)} \qquad (8)$$

The interference channel can further be re-estimated as

$$\widetilde{H}_i(t_p,f_p)=\left[\widehat{H}_i'(t_p,f_p)\ \widehat{H}_i(t_s,f_p+(-1)^i)\right]W_i = V_i W_i \qquad (9)$$

where $\widehat{H}_i(t_s,f_p+(-1)^i)$ and W_i are the estimated the i-th interfering CSI by using LS method and a weight vector for the i-th interfering CSI, respectively. The auto-covariance R_i matrix and cross-covariance vector P_i of the i-th interference channel can respectively be represented as [1]

$$R_i = E\{V_i^T V_i^*\} = \begin{bmatrix} \epsilon_t^2+(1-2Re\{W_t(1)\})\left(\sigma_w^2/\sigma_p^2+\sum_{i=1}^{2}\sigma_i^2\right) & \sigma_i^2\rho_i(1-W_t(1)) \\ \sigma_i^2\rho_i^*(1-W_t(1))^* & \sigma_w^2/\sigma_p^2+\sigma_i^2 \end{bmatrix} \qquad (10)$$

$$P_i = E\{V_i^T\widetilde{H}_i^*(t_p,f_p)\} = \begin{bmatrix} \sigma_i^2(1-W_t(1)) \\ \sigma_i^2\rho_i^* \end{bmatrix} \qquad (11)$$

where ϵ_t^2 is mean square error of the target CSI estimation. Similarly, the optimum weight vector W_i for the i-th interfering CSI is determined by [1]

$$W_i = R_i^{-1}P_i \qquad (12)$$

Ⅳ. Performance evaluation

The performance of the proposed scheme is verified by computer simulation. Fig. 1 depicts the packet error rate (PER) of the proposed scheme. It can be seen that the performance of the LS scheme is significantly degraded. It can also be seen that the proposed scheme outperforms the LS scheme.

Ⅴ. Conclusion

In this paper, we have proposed a channel estimation scheme that utilizes the preamble and channel correlation. Simulation result shows that the the proposed scheme is quite effective.

Reference

[1] S. Haykin, *Adaptive Filter Theory*, Prentice Hall, fourth edition, 2002.

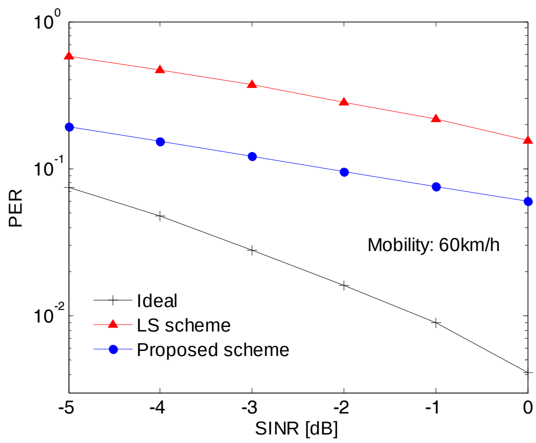

Fig. 1. PER according to the SINR