Performance of Relay Based Interference Alignment with Imperfect Channel State Estimation

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In this paper, we consider a multiusers' (MUs) interference network, where exist K relay-destination (R-D) pairs, and each user has a single transmit antenna and each relay has K receive antennas. To estimate the CSI of K destination-relay/relay-destination pairs, the maximum likelihood based channel estimator is proposed in K distributed relay stations. Meanwhile, by considering the estimation error in the uplink, the upper bond of sum rate loss for relay based space-time interference alignment scheme is derived in K pairs relay-destination interference network. The simulation results of sum rate performance are analyzed under different outdated CSIT scenarios.

By using the maximum likelihood Bayesian based Estimator in relays, the estimated channel matrix $\hat{h}_{dr}$ is derived to $\hat{h}_{dr} = \frac{Rr_f s_p^H}{\left(\sigma_n^2 + Rs_p s_p^H\right)}$, where s_p and r_f is the transmitted and received pilot signal, $R = E\left\{h_{dr} h_{dr}^H\right\}$ is the channel co-variance. The estimated channel matrix will bring the leaked interference I_K from interference alignment schemes. Parameter β_{rd} is ratio of R-D pairs with outdated CSI to K R-D pairs, if $\beta_{rd} < 1$, the sum rate loss ΔRt is derived to:

$$\Delta Rt < \frac{(1-\beta_{rd})K^2}{1+K} \cdot \sum_{k=1}^{(1-\beta_{rd})K} \log_2\left(1+\frac{E(I_k^{(1)})}{\sigma^2}\right) + \frac{\beta_{rd}K^2}{\lceil 1/\beta_{rd} \rceil \beta_{rd} K \sum_{k=1}^{\beta_{rd}}(k^{-1})} \cdot \sum_{k=1}^{\beta_{rd}K} \log_2\left(1+\frac{E(I_k^{(2)})}{\sigma^2}\right)$$

Two types of MUs' pilots are considered: in simulation results: the frequency orthogonal pilots(the left Figure) and co-channel frequency-reuse pilots(the right figure). For the orthogonal MUs' pilots, the Least Squares estimator is adopted at received relays (perfect pilot estimation); for the co-channel MUs' pilots, the Bayesian estimator (imperfect pilot estimation) is adopted. In two figures, the ideal case means all the CSIT are regarded as the current CSIT; the non-ideal case-1 means the outdated source to relay at base station CSIT is considered;the non-ideal case-2 means the outdated relay to destination CSIT at relays are considered. The sub cases (a) and (b) are separately indicate that all the receivers feedback outdated CSI to transmitter at partly time slots or partly receivers feedback outdated CSI to transmitters at all time slots.