

Revised System Model: Massive MIMO-OFDM with Rayleigh Fading

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1 System Model

We consider a single-cell massive MIMO-OFDM downlink system where the base station (BS) employs $N_t \gg 1$ transmit antennas, and the user equipment (UE) has a single receive antenna ($N_r = 1$). The system utilizes N_c orthogonal subcarriers with frequency-division duplexing (FDD), following the framework in [1].

1.1 Channel Model

The time-domain channel impulse response between the i -th transmit antenna and the UE follows a Rayleigh fading model with L multipath components [2]:

$$h_i(\tau) = \sum_{l=1}^L \alpha_{i,l} \delta(\tau - \tau_l), \quad \alpha_{i,l} \sim \mathcal{CN}(0, \sigma_l^2). \quad (1)$$

The frequency-domain channel matrix for the n -th subcarrier is:

$$\mathbf{H}_n = [H_{1,n}, H_{2,n}, \dots, H_{N_t,n}] \in \mathbb{C}^{1 \times N_t}, \quad (2)$$

where each element is derived from the DFT of the CIR, as discussed in [3]:

$$H_{i,n} = \sum_{l=1}^L \alpha_{i,l} e^{-j2\pi n \tau_l / N_c}. \quad (3)$$

1.2 Pilot Transmission and LS Estimation

The BS transmits orthogonal pilot sequences $\mathbf{X}_{p,n} \in \mathbb{C}^{N_t \times T_p}$ ($T_p \geq N_t$) for each subcarrier. The received signal at the UE is:

$$\mathbf{Y}_{p,n} = \mathbf{H}_n \mathbf{X}_{p,n} + \mathbf{Z}_n, \quad \mathbf{Z}_n \sim \mathcal{CN}(0, \sigma^2 \mathbf{I}). \quad (4)$$

The least-squares (LS) channel estimate is:

$$\hat{\mathbf{H}}_n = \mathbf{Y}_{p,n} \mathbf{X}_{p,n}^\dagger, \quad \text{where } \mathbf{X}_{p,n}^\dagger = \mathbf{X}_{p,n}^H (\mathbf{X}_{p,n} \mathbf{X}_{p,n}^H)^{-1}. \quad (5)$$

1.3 CSI Feedback Compression

The full CSI matrix $\mathbf{H}_{\text{freq}} \in \mathbb{C}^{N_c \times N_t}$ is constructed as:

$$\mathbf{H}_{\text{freq}} = \left[\hat{\mathbf{H}}_1^T, \hat{\mathbf{H}}_2^T, \dots, \hat{\mathbf{H}}_{N_c}^T \right]^T. \quad (6)$$

To exploit sparsity, we transform \mathbf{H}_{freq} to the angle-delay domain via 2D-DFT, similar to the approach in [1]:

$$\tilde{\mathbf{H}} = \mathbf{F}_d \mathbf{H}_{\text{freq}} \mathbf{F}_a^H. \quad (7)$$

2 References

References

- [1] L. Lu, G. Y. Li, A. L. Swindlehurst, A. Ashikhmin, and R. Zhang, “An Overview of Massive MIMO: Benefits and Challenges,” *IEEE Journal of Selected Topics in Signal Processing*, vol. 8, no. 5, pp. 742–758, 2014.
- [2] D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*. Cambridge Univ. Press, 2005.
- [3] R. W. Heath Jr. and A. Lozano, *Foundations of MIMO Communication*. Cambridge Univ. Press, 2018.