

Introduction

Channel state information (CSI) is crucial for FDD MIMO systems.

We focus on task-oriented (semantic) compression:

- **Task:** MIMO precoding
- **Goal:** minimal CSI feedback overhead with maximal achievable rate

System Model

- MIMO system: one BS with N_t antennas, K single-antennas users
- Downlink signal with linear **precoding**: $\mathbf{x} = \sum_{k=1}^K \mathbf{v}_k s_k = \mathbf{V}\mathbf{s}$
- Received signal at k -th user: $y_k = \mathbf{h}_k^H \mathbf{v}_k s_k + \sum_{j \neq k} \mathbf{h}_k^H \mathbf{v}_j s_j + z_k$
- **Metric:** sum of achievable rates

$$R = \sum_{k=1}^K R_k = \sum_{k=1}^K \log_2 \left(1 + \frac{|\mathbf{h}_k^H \mathbf{v}_k|^2}{\sum_{j \neq k} |\mathbf{h}_k^H \mathbf{v}_j|^2 + \sigma^2} \right) \quad (1)$$

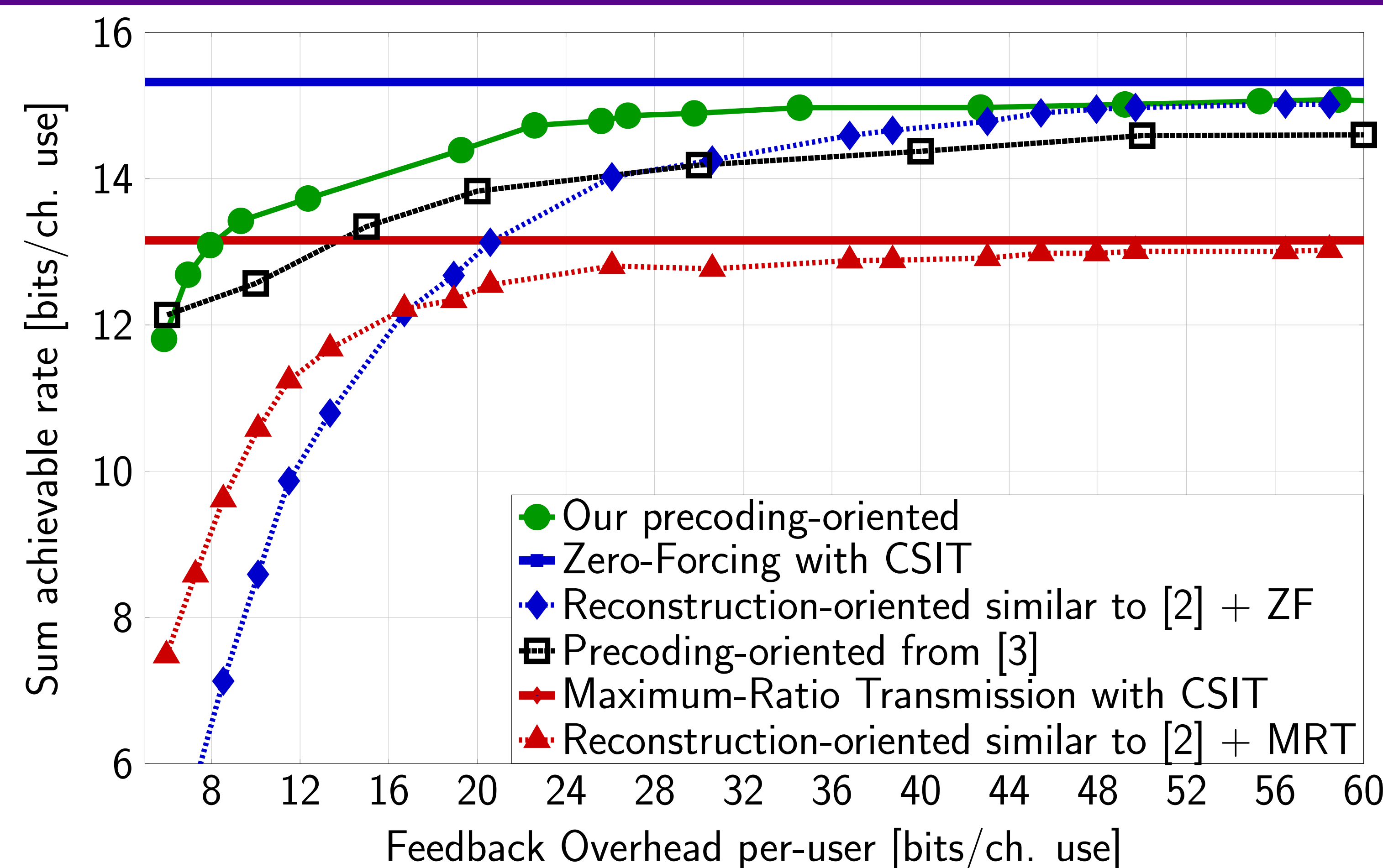
Optimization

Loss function including three possible metrics:

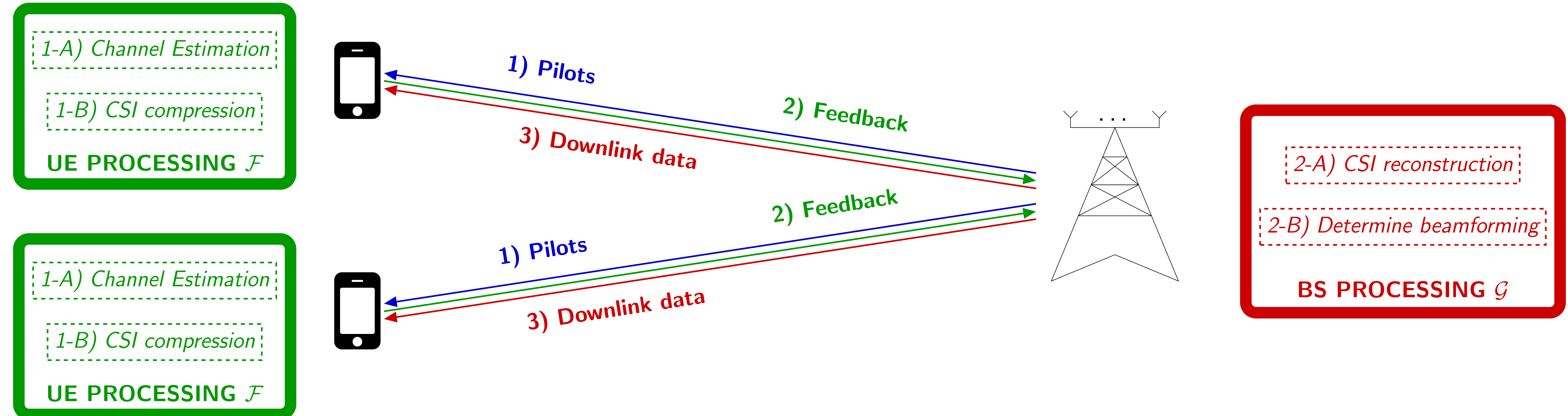
$$\mathcal{L}(\theta, \phi, \psi) = \mathcal{O} - \lambda \mathcal{R} + \gamma \mathcal{D}, \quad (2)$$

- Feedback overhead \mathcal{O} : entropy (feedback rate/overhead) of the pseudo-quantized features $\tilde{\mathbf{t}}_k = \mathbf{t}_k + \text{quantiz.noise}$ as in [1].
- Performance \mathcal{R} : achievable rates with precoding \mathbf{V} according to (1).
- Distortion \mathcal{D} : reconstruction loss when estimating channels $\hat{\mathbf{H}}$ (e.g., MSE).
- λ and γ determine the tradeoff between the three components.
- Precoding-oriented corresponds to $\{\lambda > 0, \gamma = 0\}$.

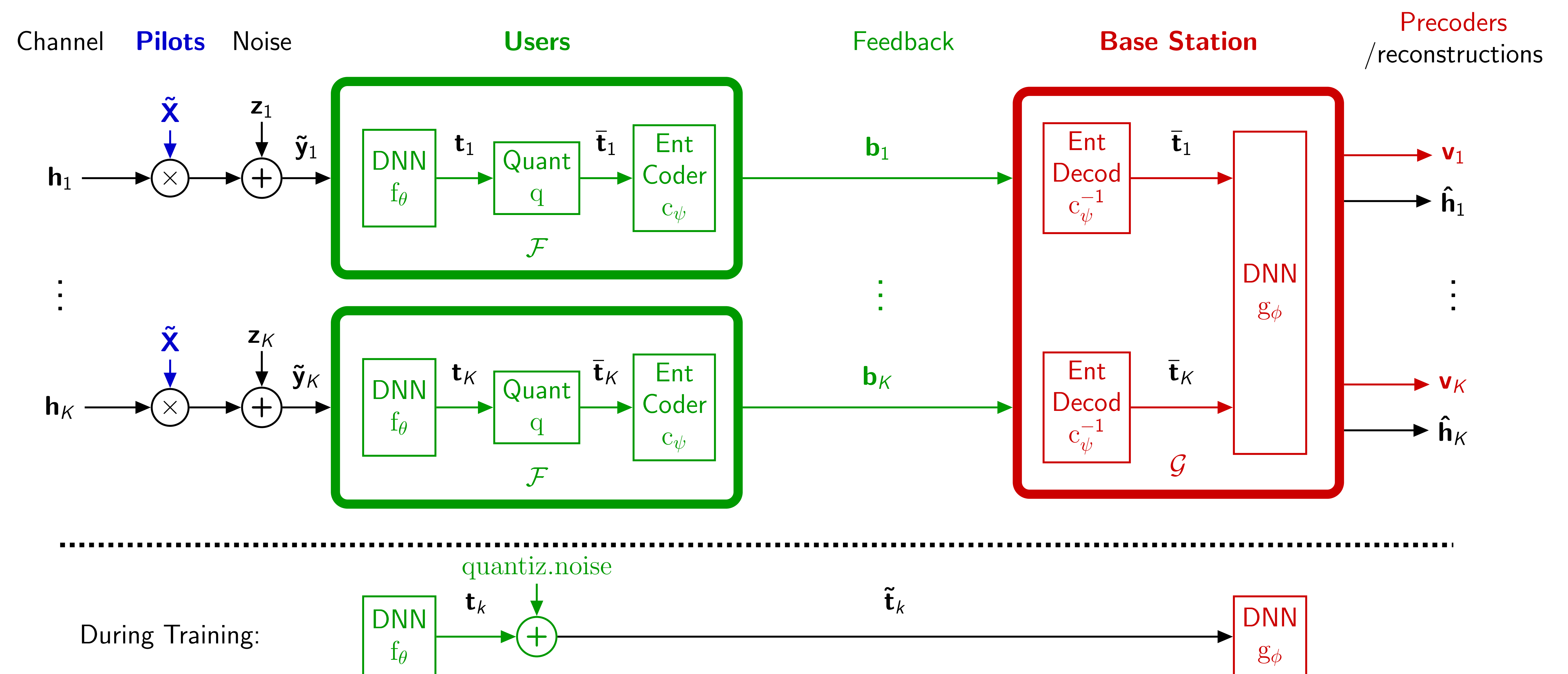
Results: Feedback Overhead vs Users' Performance



Conventional vs Semantic CSI



Proposed CSI Feedback Architecture



References

- [1] J. Ballé, D. Minnen, S. Singh, S. J. Hwang, and N. Johnston, "Variational image compression with a scale hyperprior," in *International Conference on Learning Representations (ICLR)*, 2018.
- [2] M. B. Mashhadi, Q. Yang, and D. Gündüz, "Distributed deep convolutional compression for massive MIMO CSI feedback," *IEEE Transactions on Wireless Communications*, vol. 20, no. 4, pp. 2621–2633, 2021.
- [3] F. Sohrabi, K. M. Attiah, and W. Yu, "Deep learning for distributed channel feedback and multiuser precoding in FDD massive MIMO," *IEEE Transactions on Wireless Communications*, vol. 20, no. 7, pp. 4044–4057, 2021.
- [4] F. Carpi, S. Venkatesan, J. Du, H. Viswanathan, S. Garg, and E. Erkip, "Precoding-oriented massive MIMO CSI feedback design," in *IEEE International Conference on Communications (ICC)*, May 2023.

Acknowledgments

This work was done in part while F. Carpi was with Nokia Bell Labs. The work of F. Carpi, S. Garg, and E. Erkip was supported in part by the NYU WIRELESS Industrial Affiliates Program, by the NSF–Intel grant 2003182, and by the NSF grant 1925079.