



Receiver Based PAPR Reduction in OFDMA

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High PAPR in OFDM Signals

- ▶ Though OFDM signals are used in many wireless communication standards, they suffer from high PAPR.
- ▶ The high PAPR causes either of the following
 - ▷ Nonlinear distortions from the high power amplifier (HPA).
 - ▷ Inefficient use of HPA due to power backoff in order to avoid distortions.

Existing Schemes

- ▶ There are numerous existing transmitter based schemes including
 - ▷ Selected mapping (SLM)
 - ▷ Partial transmit sequence (PTS)
 - ▷ Tone reservation (TR)
- ▶ These schemes are computationally expensive
- ▶ Cause reduction in battery lifetime

Publications

- ▶ A. Ali, A. Al-Zahrani, T. Y. Al-Naffouri and A. Naguib, "Receiver Based PAPR Reduction in OFDMA", in *IEEE Int. Conf. Acoust., Speech, Signal Process.*, 2014.
- ▶ A. Ali, A. Al-Rabah, M. Masood and T. Y. Al-Naffouri, "Receiver-based Recovery of Clipped OFDM Signals for PAPR Reduction: A Bayesian Approach", submitted to *IEEE Trans. Signal. Process.*

Clipping at the Transmitter

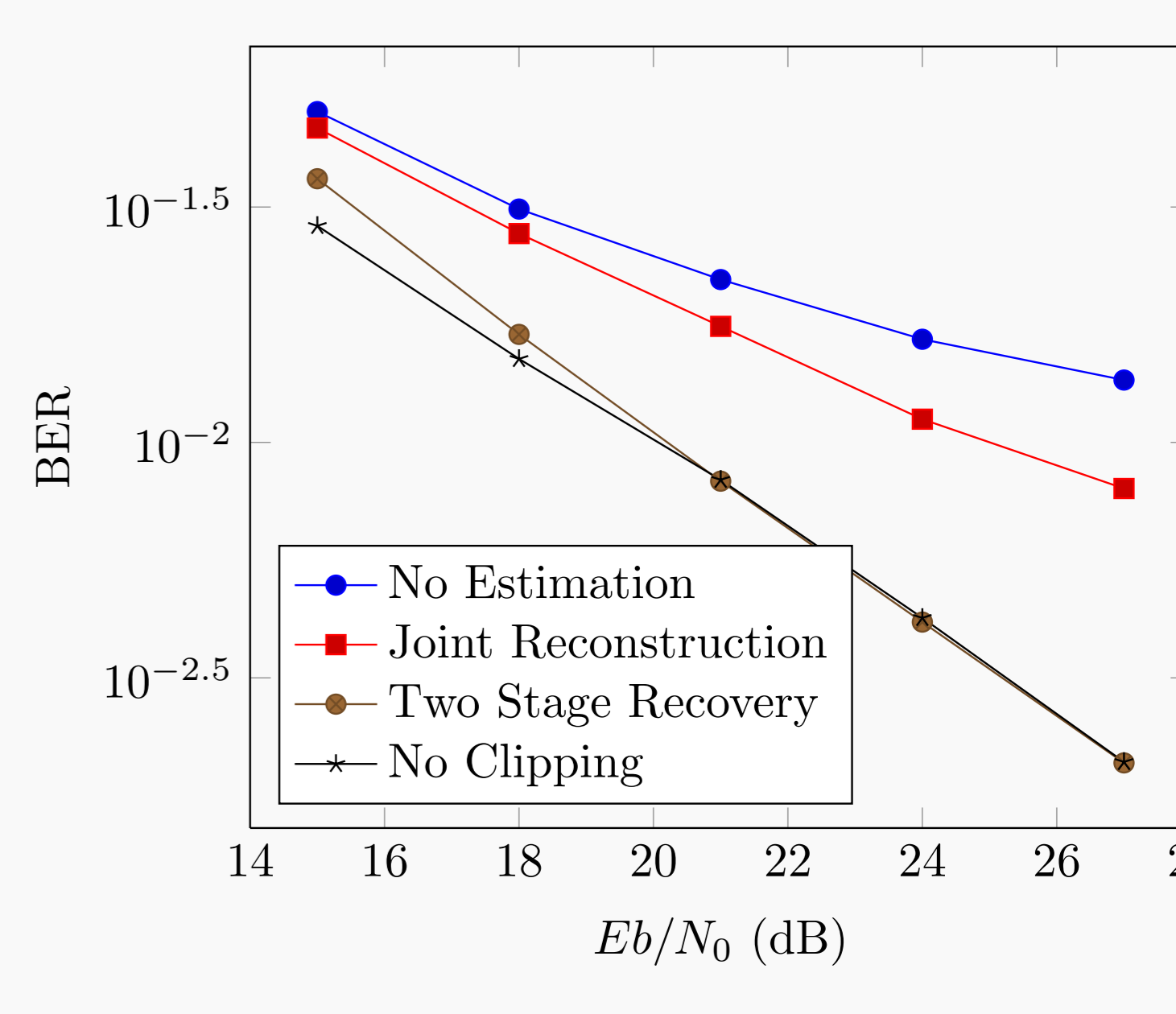
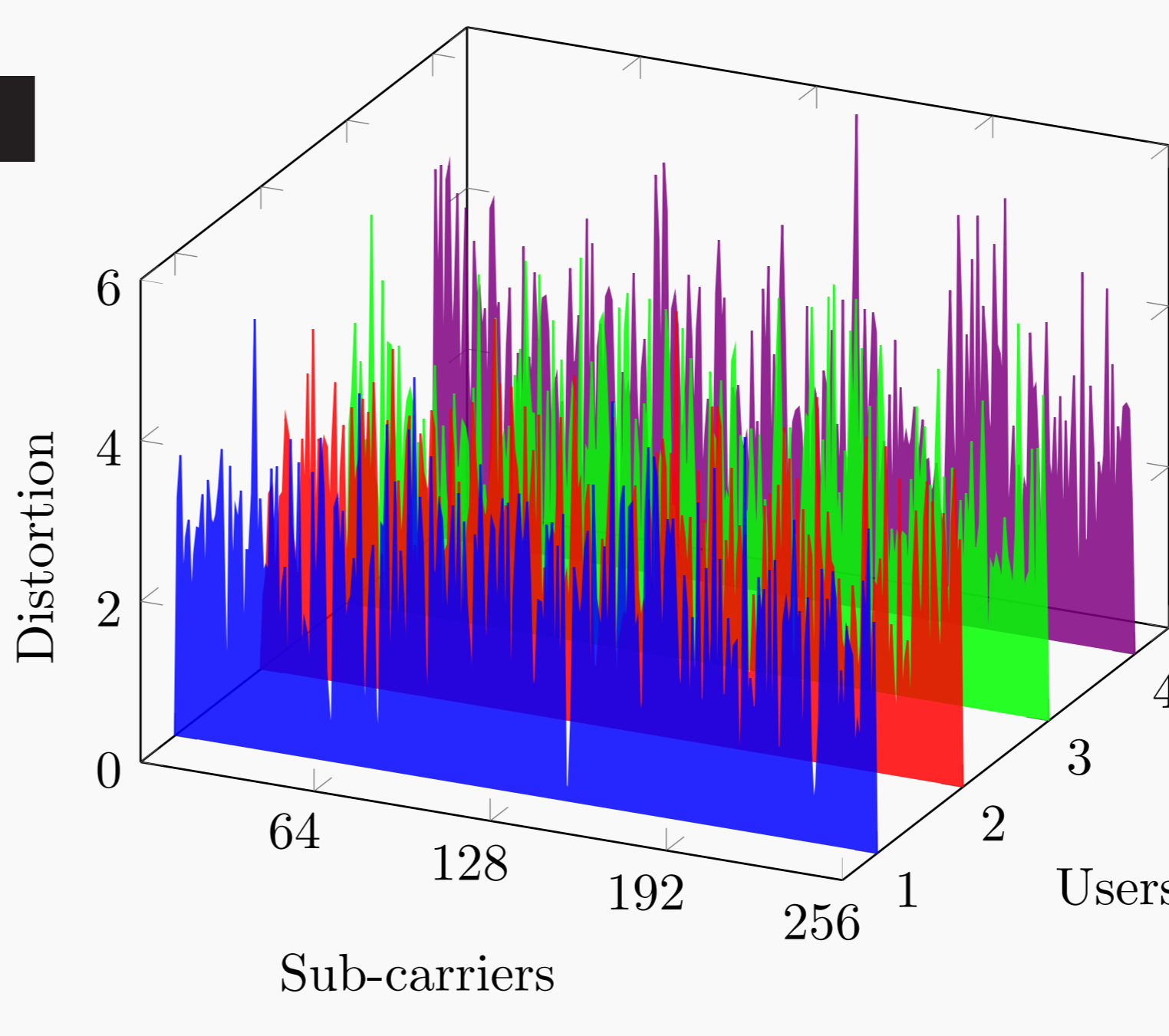
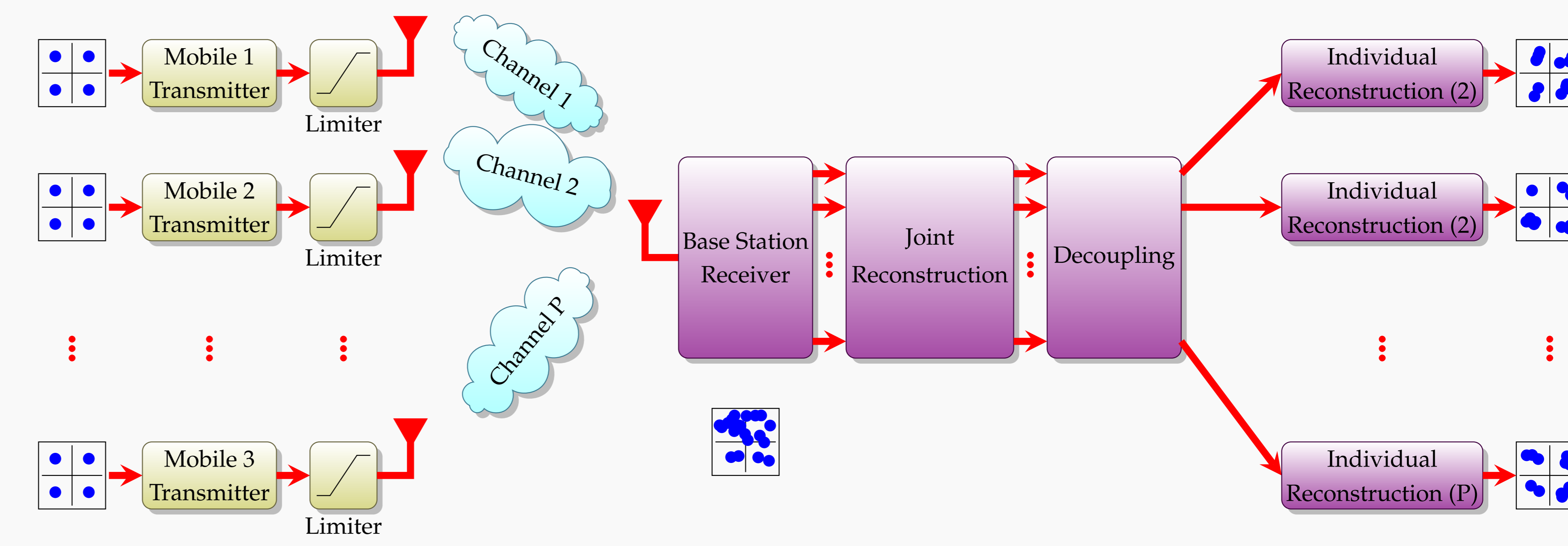
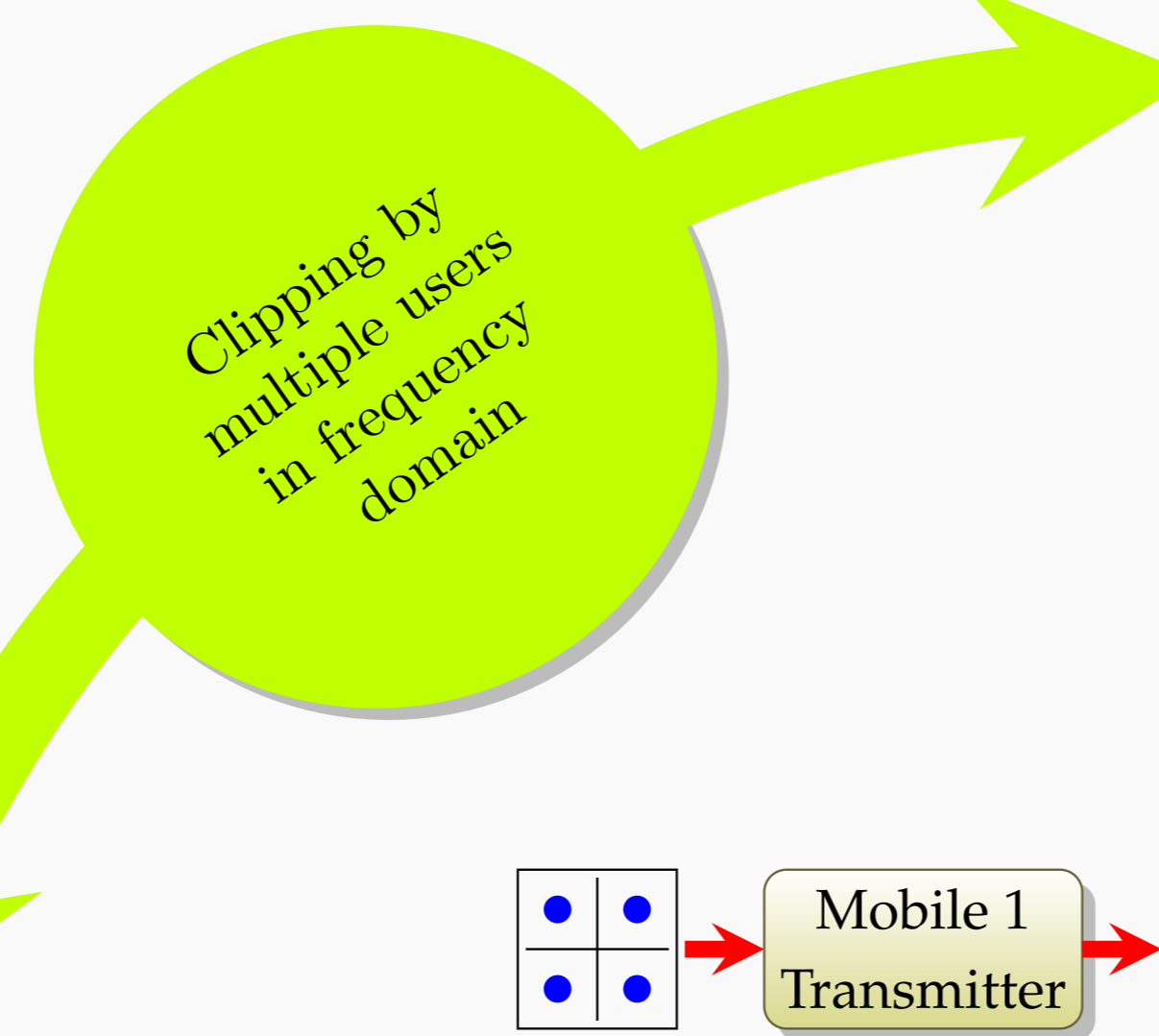
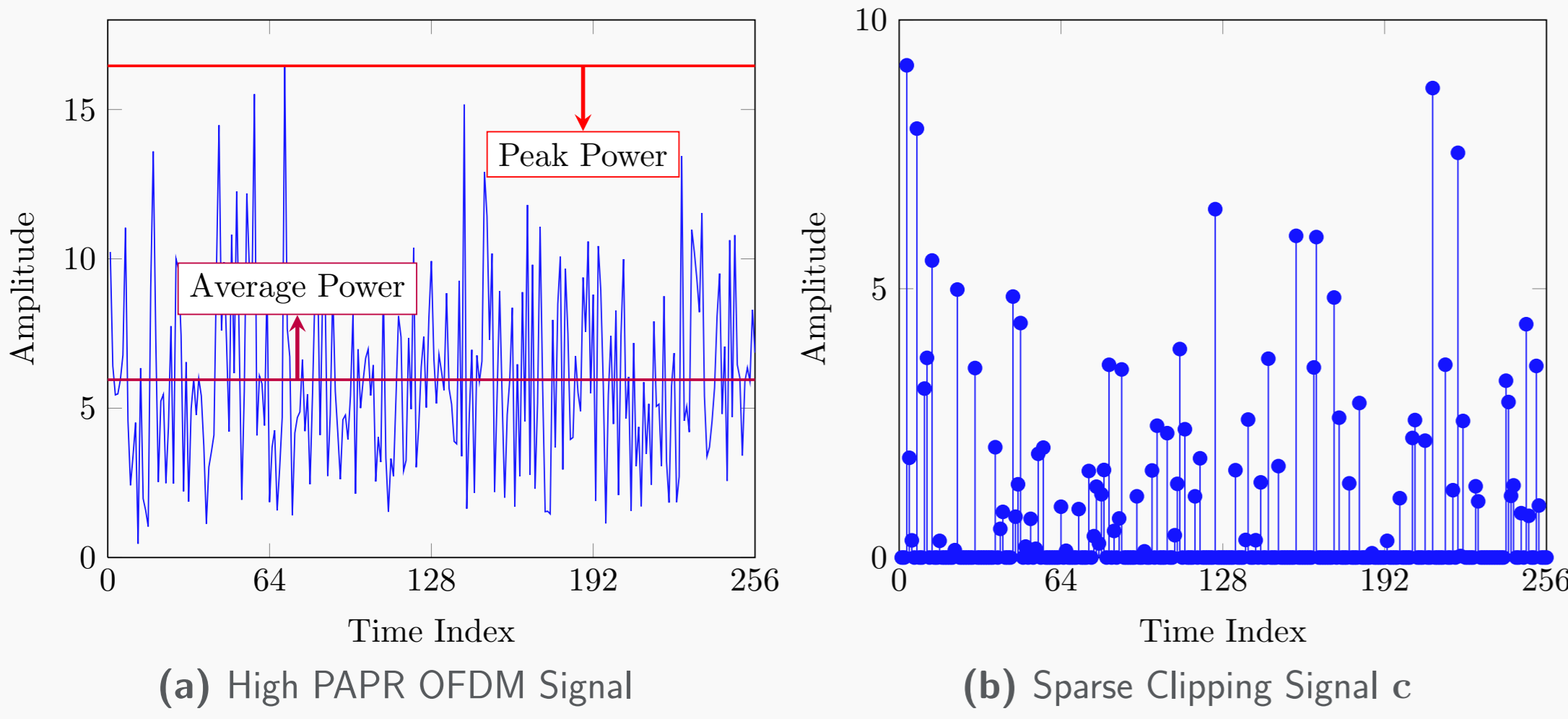
- ▶ A clipping signal c is added to the the time domain high PAPR signal x to get the clipped signal x_c
- $$x_c(i) = \begin{cases} \gamma e^{j\theta_{x(i)}} & \text{if } |x(i)| > \gamma \\ x(i) & \text{otherwise} \end{cases}$$
- ▶ The amplitude of the clipped signal x_c is limited to clipping threshold γ .
 - ▶ The clipping signal c is sparse in time domain.

The Proposed Solution

- ▶ A two stage recovery procedure.
- ▶ The first stage of joint reconstruction and decoupling.
- ▶ Individual reconstruction on each subsystem.

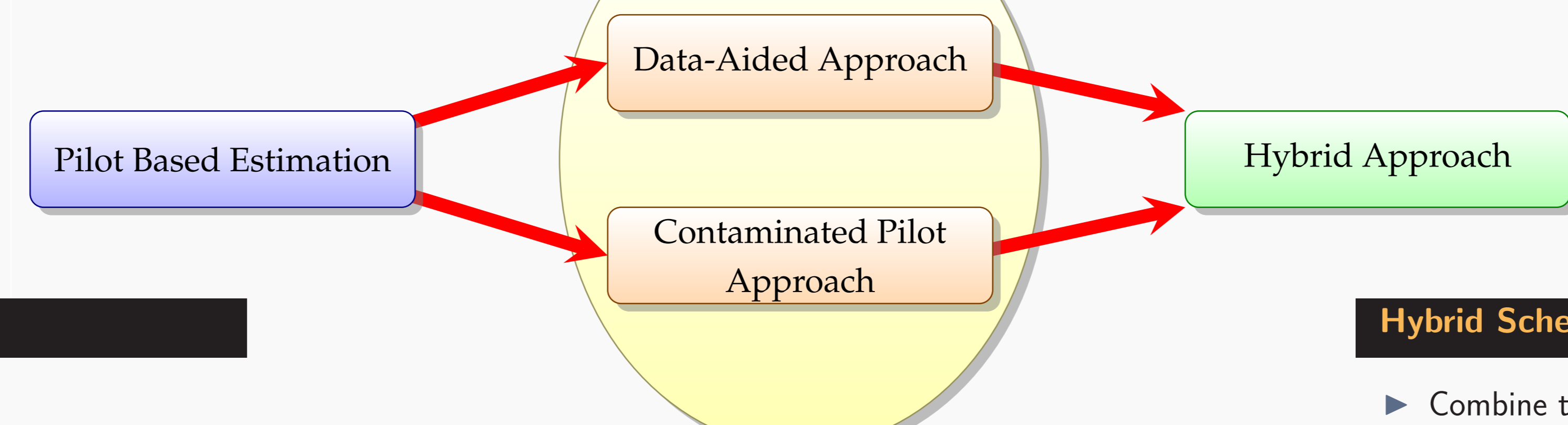
The Problem

- ▶ All users clip simultaneously.
- ▶ The clipping signal is sparse in time domain and spread in frequency domain.
- ▶ The clipping signals from all users overlap in frequency domain.
- ▶ Compressed sensing based reconstruction is not possible as measurements are corrupted.



The Channel Estimation Problem

- ▶ In OFDM systems, a known pilot sequence is used to perform channel estimation.
- ▶ Clipping not only affects data but also the pilot sequence.
- ▶ Increasing the number of pilots is helpful, but we are bottlenecked by clipping distortion.



The Proposed Solution

- ▶ Reliable data carriers are used as additional pilot tones to improve estimation accuracy.
- ▶ The contaminated pilot approach is used to estimate the clipped pilot signals.
- ▶ A hybrid approach is proposed that uses both the data-aided approach and the contaminated pilot approach.

Pilot Tones and Reliable Carriers

- ▶ Given the OFDM system

$$y = Xh + z'$$

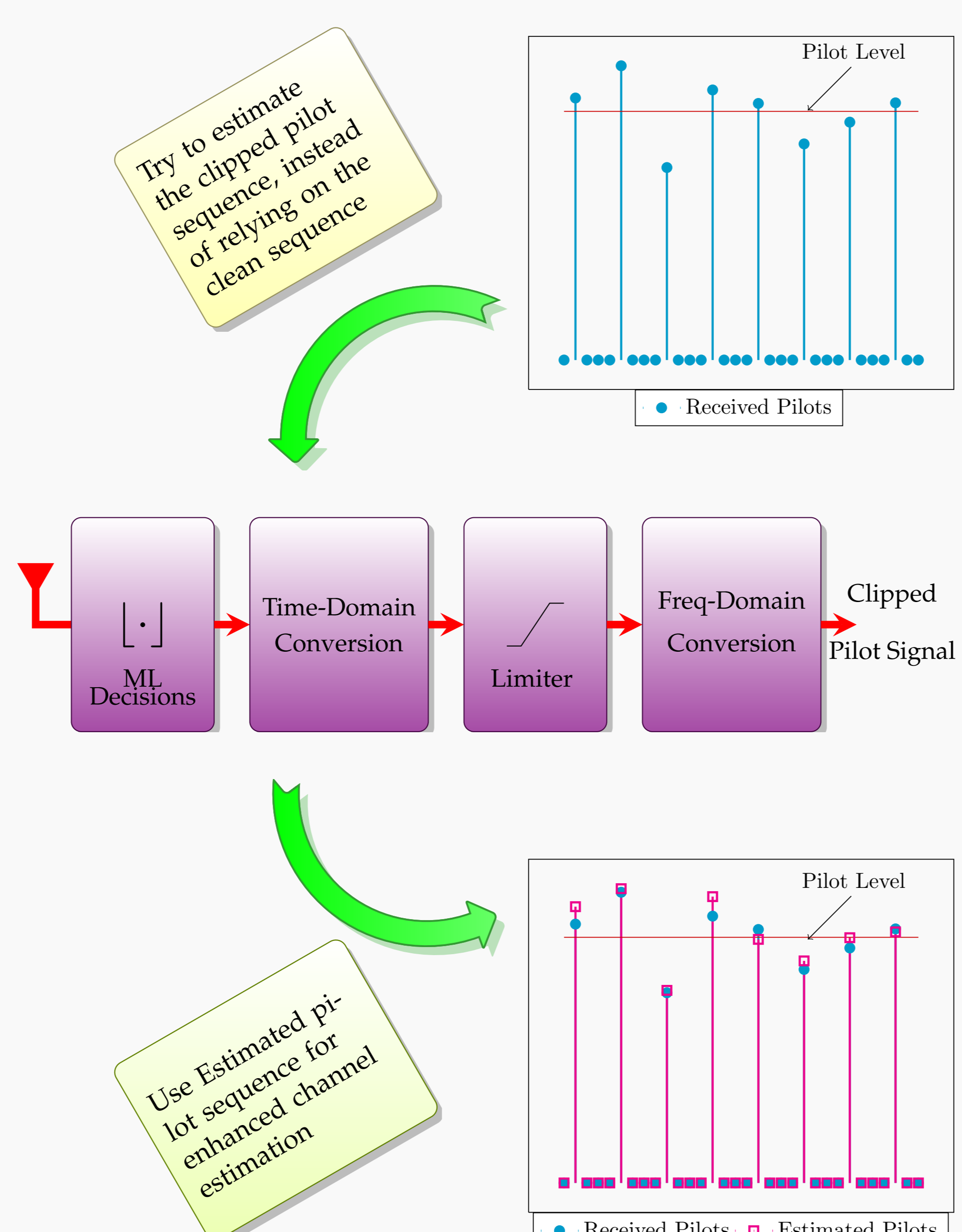
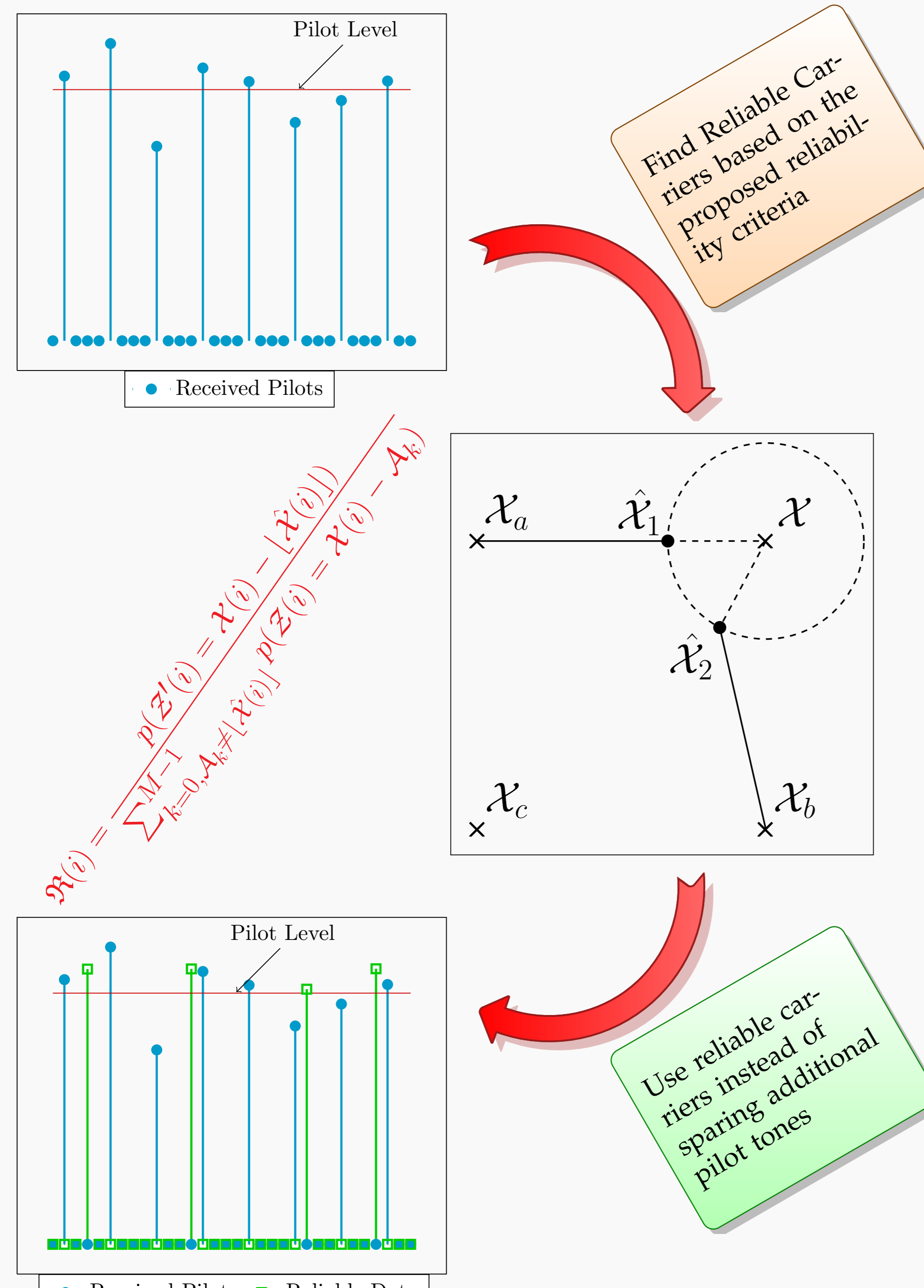
we solve the following regularized least squares problem, using pilot tones

$$\hat{h} = \arg \max_h \{ \|\mathcal{Y}_{\mathcal{I}_p} - X_{\mathcal{I}_p} h\|_{R_{z'}}^2 + \|h\|_{R_h}^2 \}$$

- ▶ BUT all tones are corrupted.

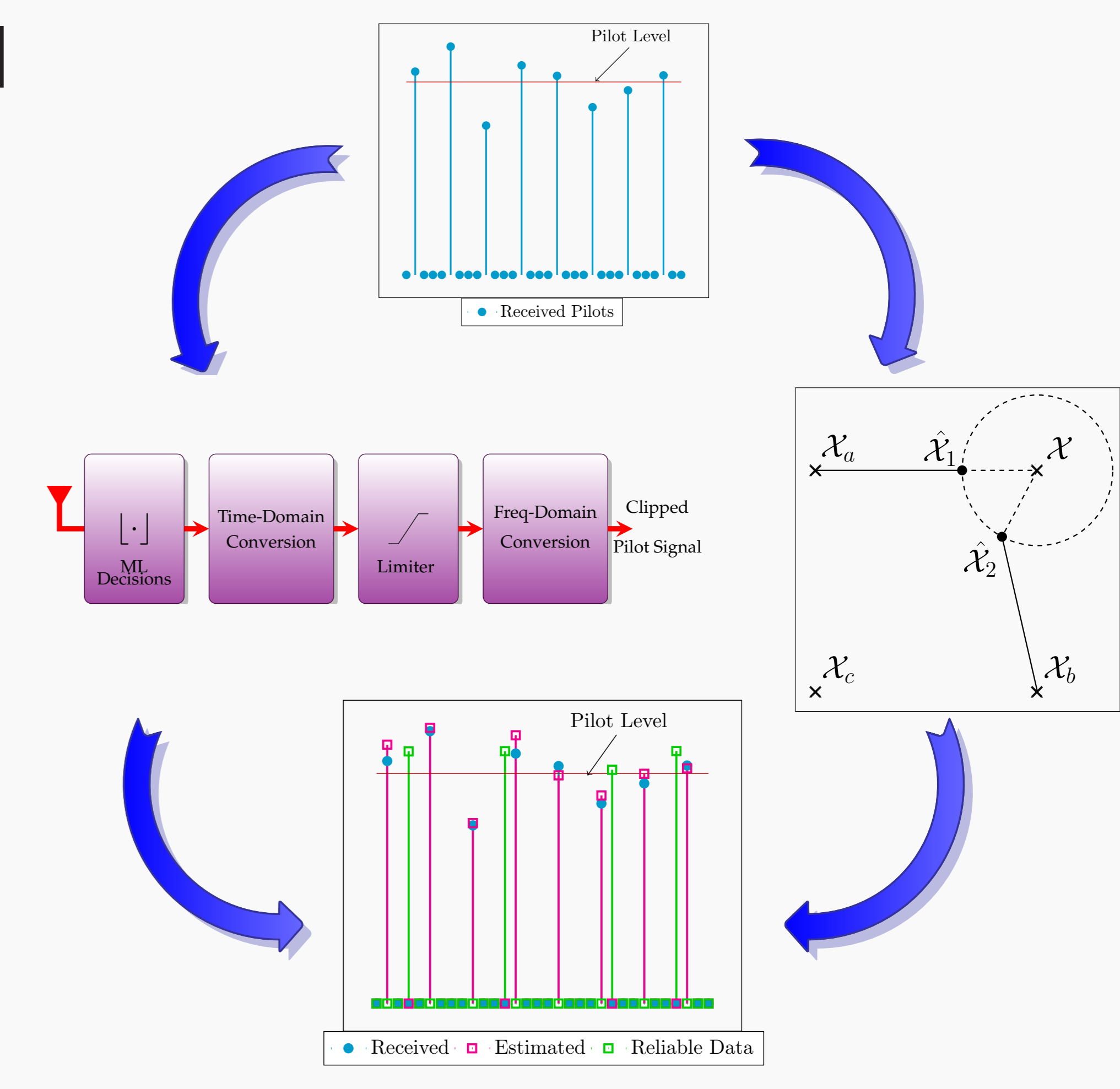
The Contaminated Pilot Approach

- ▶ This approach acknowledges that the received pilot signal is corrupted.
- ▶ Instead of increasing the number of measurements, estimate the distorted pilot sequence.



Hybrid Scheme

- ▶ Combine the data-aided and contaminated pilot approach together.



Channel Estimation Results

