Non-Convex Compressed Sensing based Channel State Information Feedback for Massive MIMO FDD Downlink Channels

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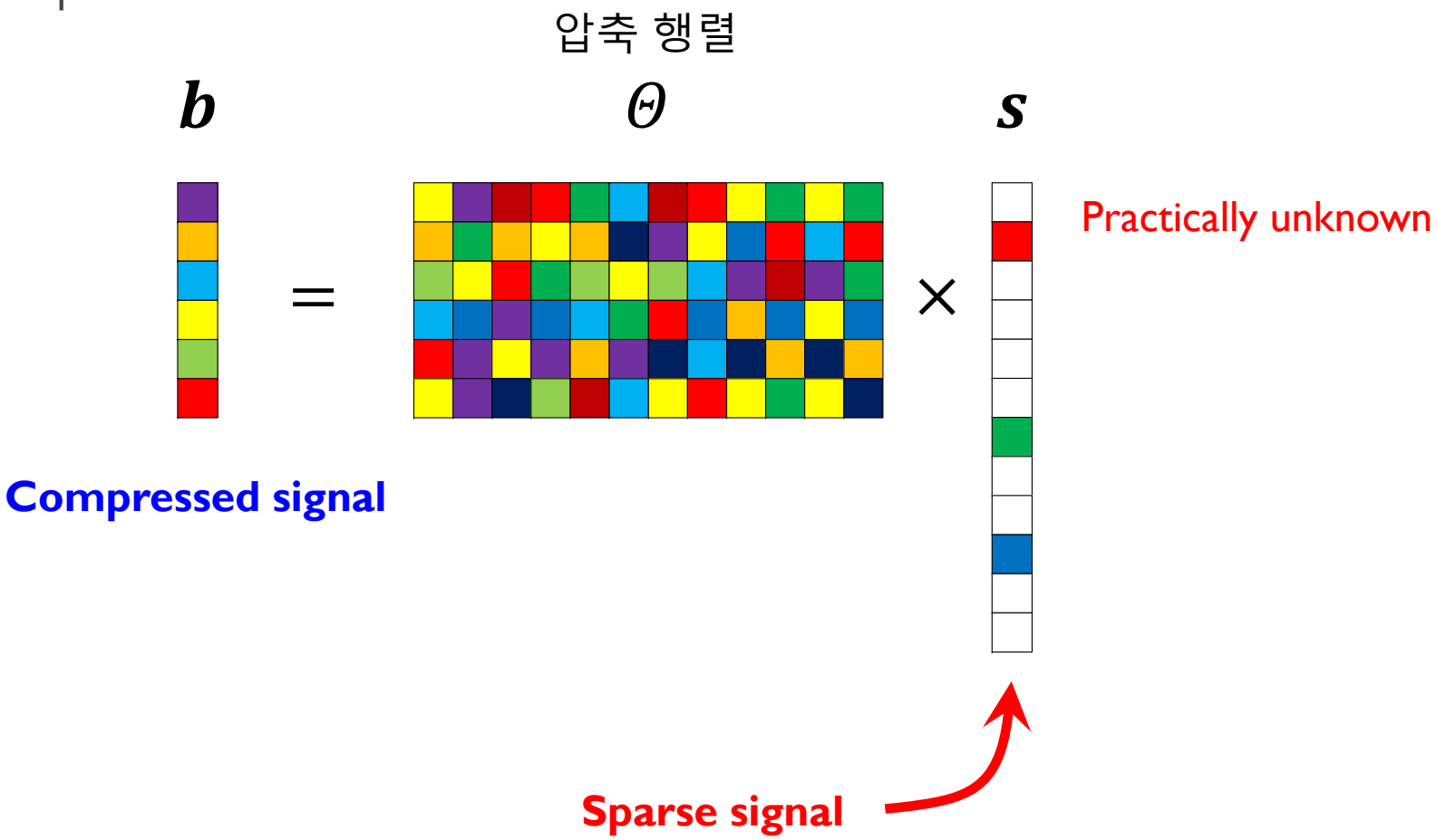
Outline

- Background
  - Compressed Sensing (CS)
- System Model
  - Finite-rate feedback Massive MIMO system
- Proposed Scheme
  - Non-Convex CS-based feedback
- Theoretical Analysis
- Simulation Results
- Conclusions

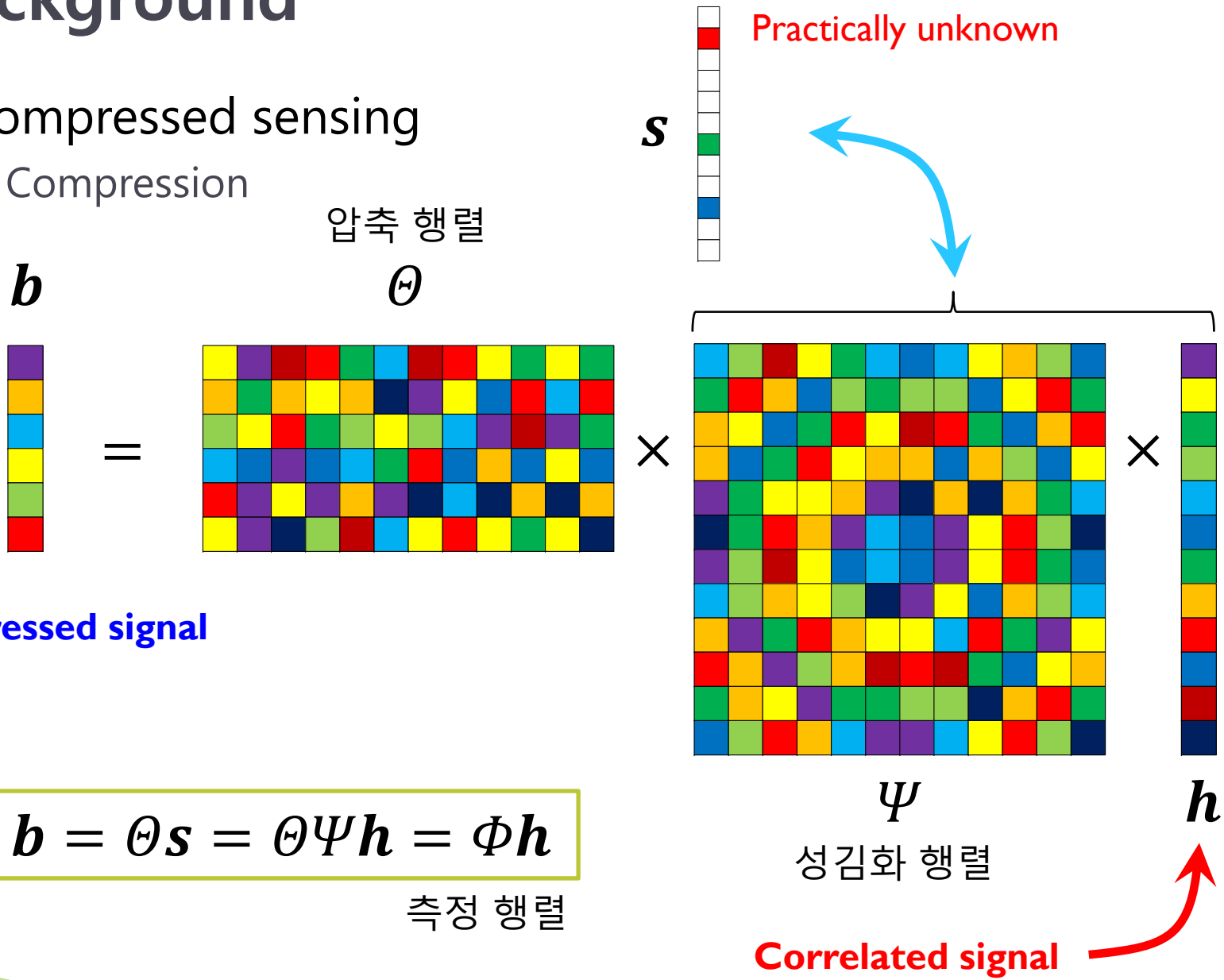
Background

- Compressed sensing
  - Compression



Background

- Compressed sensing
  - Compression



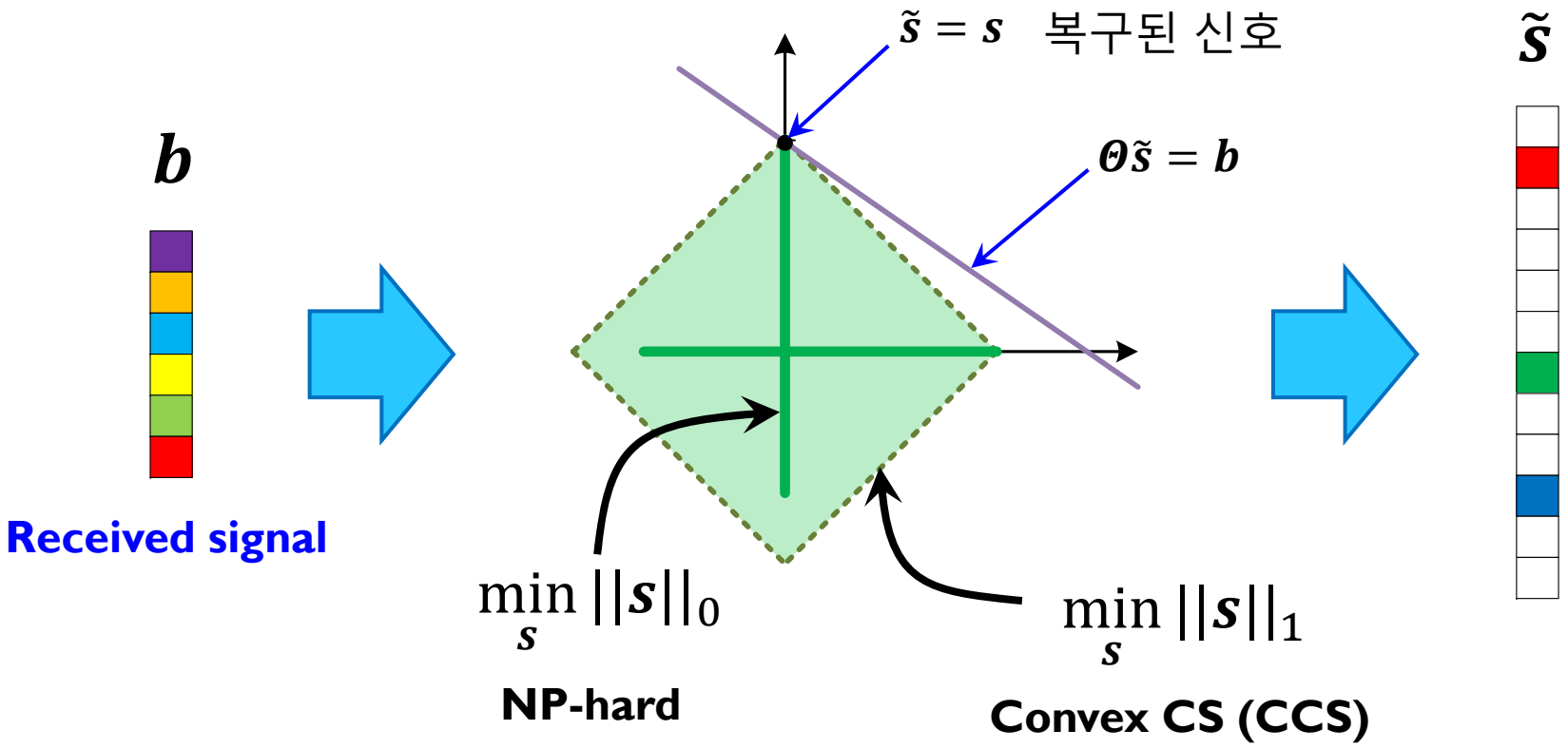
$$\boldsymbol{b} = \Theta \boldsymbol{s} = \Theta \Psi \boldsymbol{h} = \Phi \boldsymbol{h}$$

측정 행렬

Background

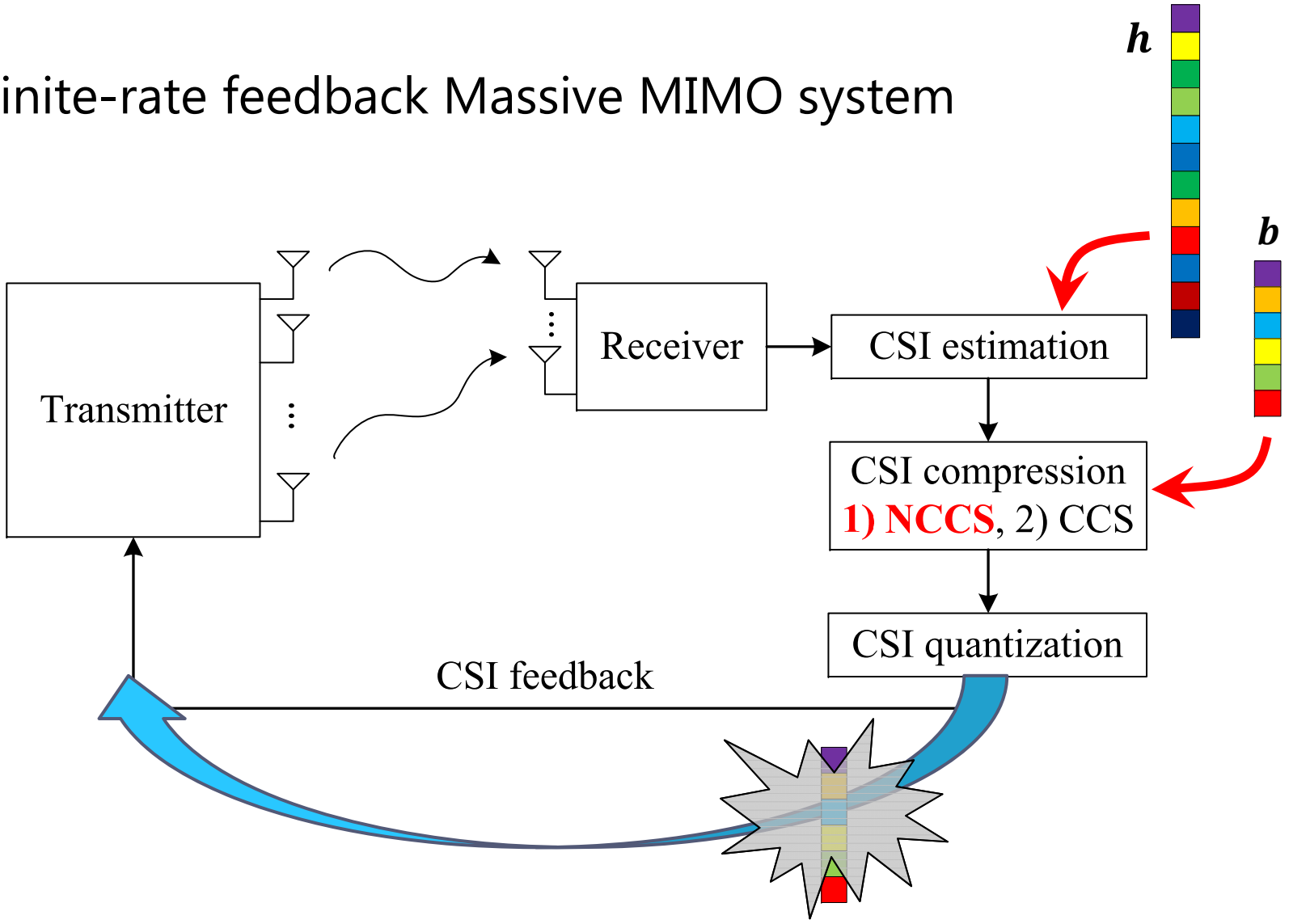
- Compressed sensing
  - Recovery (without noise and error)

$$s = \Psi h \rightarrow \tilde{h} = \Psi^T \tilde{s}$$



System Model

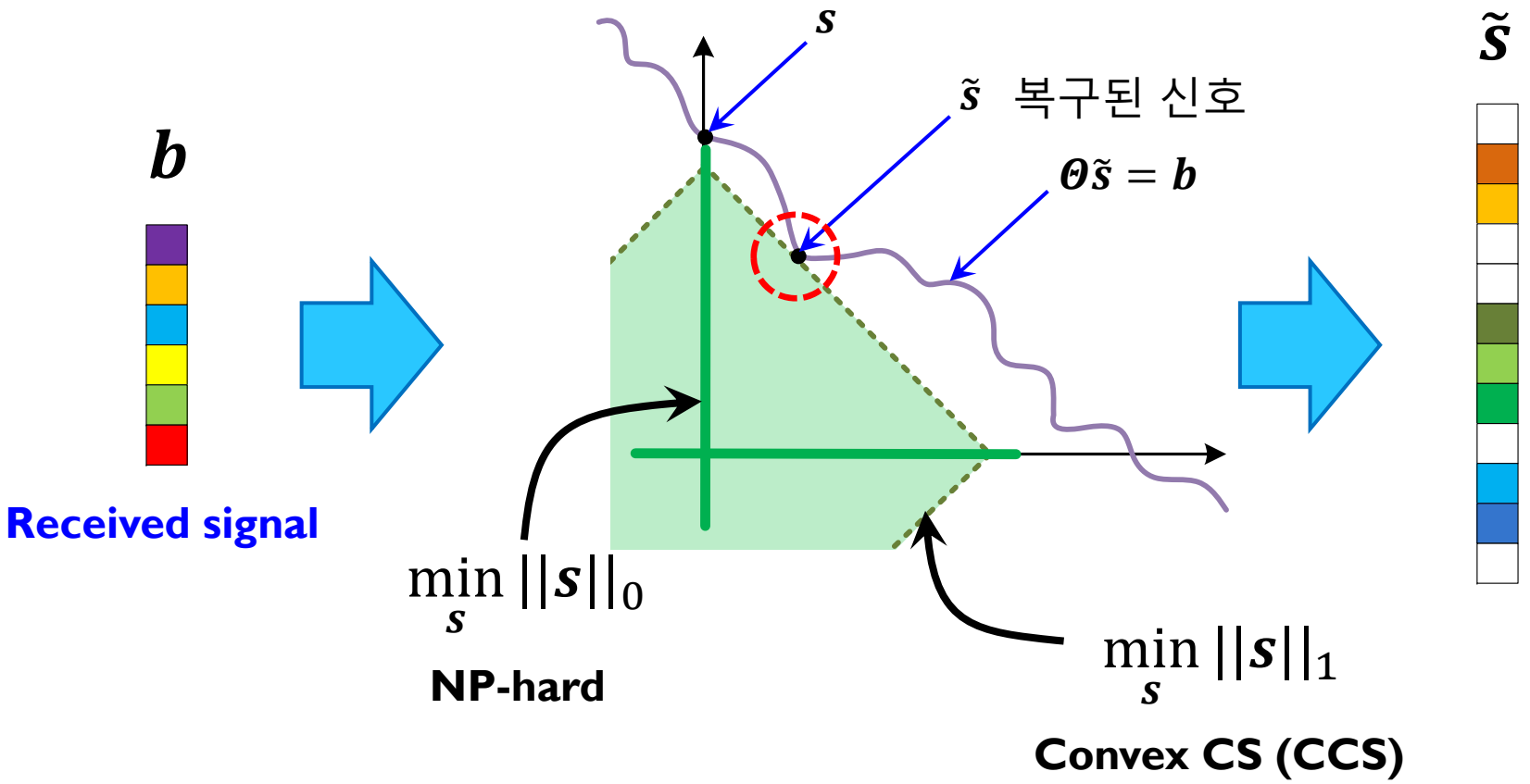
- Finite-rate feedback Massive MIMO system



CCS-based Feedback

- CSI recovery
  - With noise and error

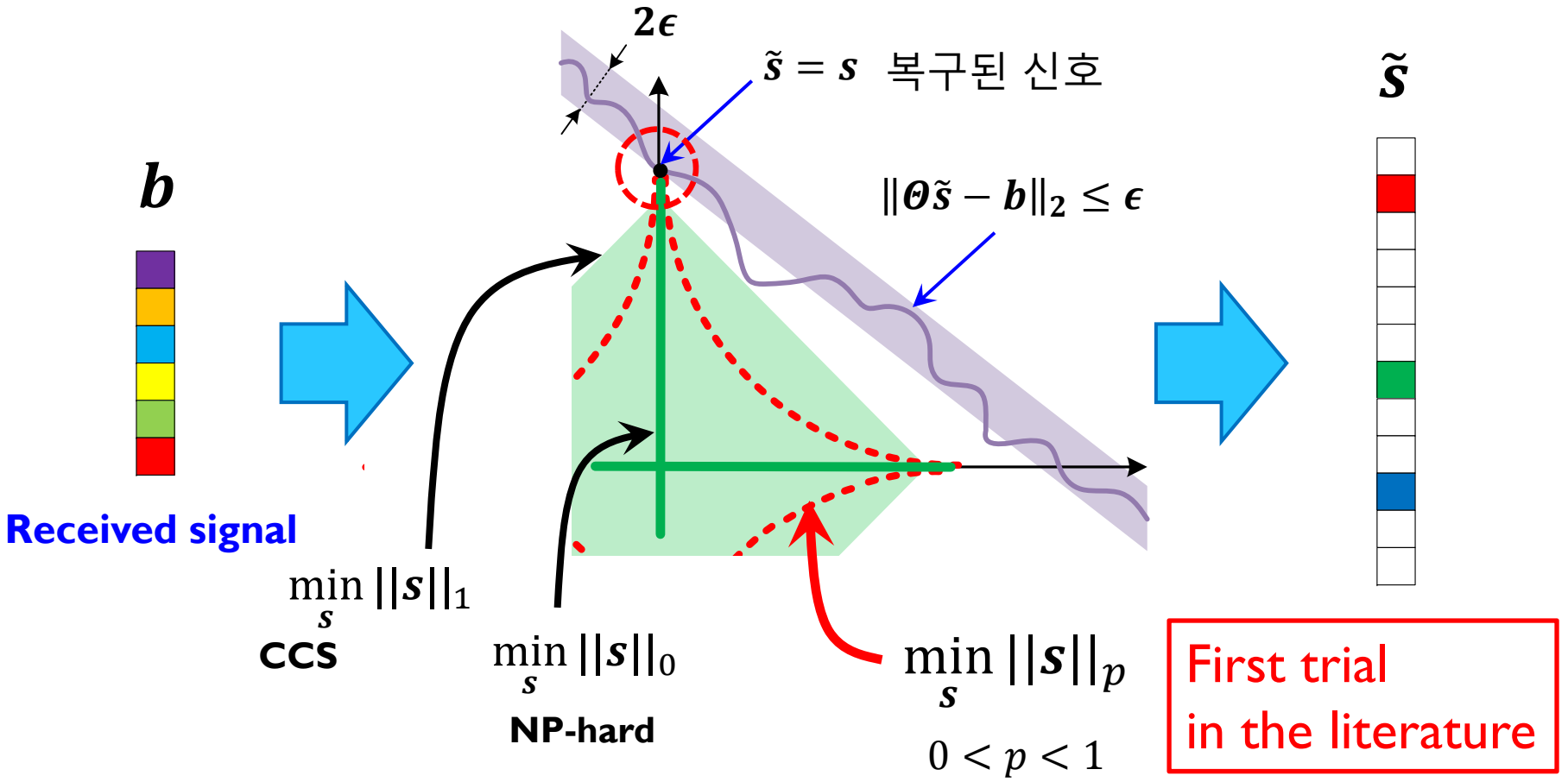
$$\boldsymbol{s} = \Psi \boldsymbol{h} \rightarrow \tilde{\boldsymbol{h}} = \Psi^T \tilde{\boldsymbol{s}}$$



NCCS-based Feedback – proposed

- CSI recovery
  - With noise and error

$$s = \Psi h \rightarrow \tilde{h} = \Psi^T \tilde{s}$$



Theoretical Analysis

- Convex Compressed Sensing(CCS)-based scheme

$$\min_{\boldsymbol{s}} \|\boldsymbol{s}\|_1, \qquad \text{subject to} \quad \boldsymbol{\Theta s} = \boldsymbol{b}.$$

- Non-Convex Compressed Sensing(NCCS)-based scheme

$$\min_{\boldsymbol{s}} \|\boldsymbol{s}\|_p, \qquad \text{subject to} \quad \|\boldsymbol{\Theta s} - \boldsymbol{b}\|_2 \leq \boldsymbol{\epsilon}.$$

where $0 < p < 1$.

Theoretical Analysis

- Norm

$$\|x\|_p = \begin{cases} \left(\sum_{i=1}^{n} |x_i|^p\right)^{1/p}, & p \in [1, \infty) \\ \max_{i=1,2,\ldots,n} |x_i|, & p = \infty \end{cases}$$

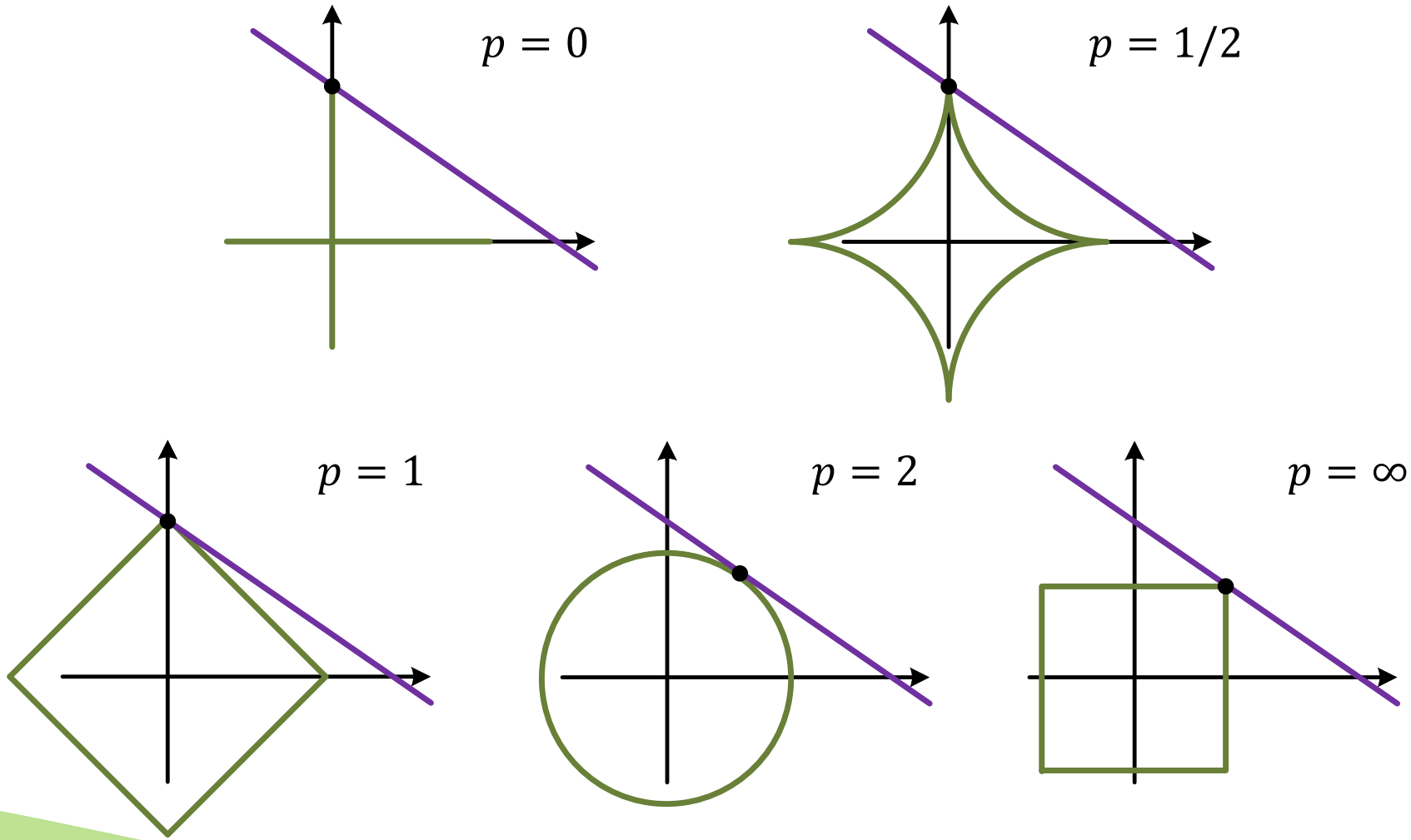
$$\|x\|_0 = |Supp(x)| \quad \text{where} \quad Supp(x) = \{i : x_i \neq 0\}$$

- Quasi-norm

$$\|x\|_p = \left(\sum_{i=1}^{n} |x_i|^p\right)^{1/p} \quad \text{where} \quad 0 < p < 1$$

Theoretical Analysis

- Signal recovery by l_p-norm



Simulation Results

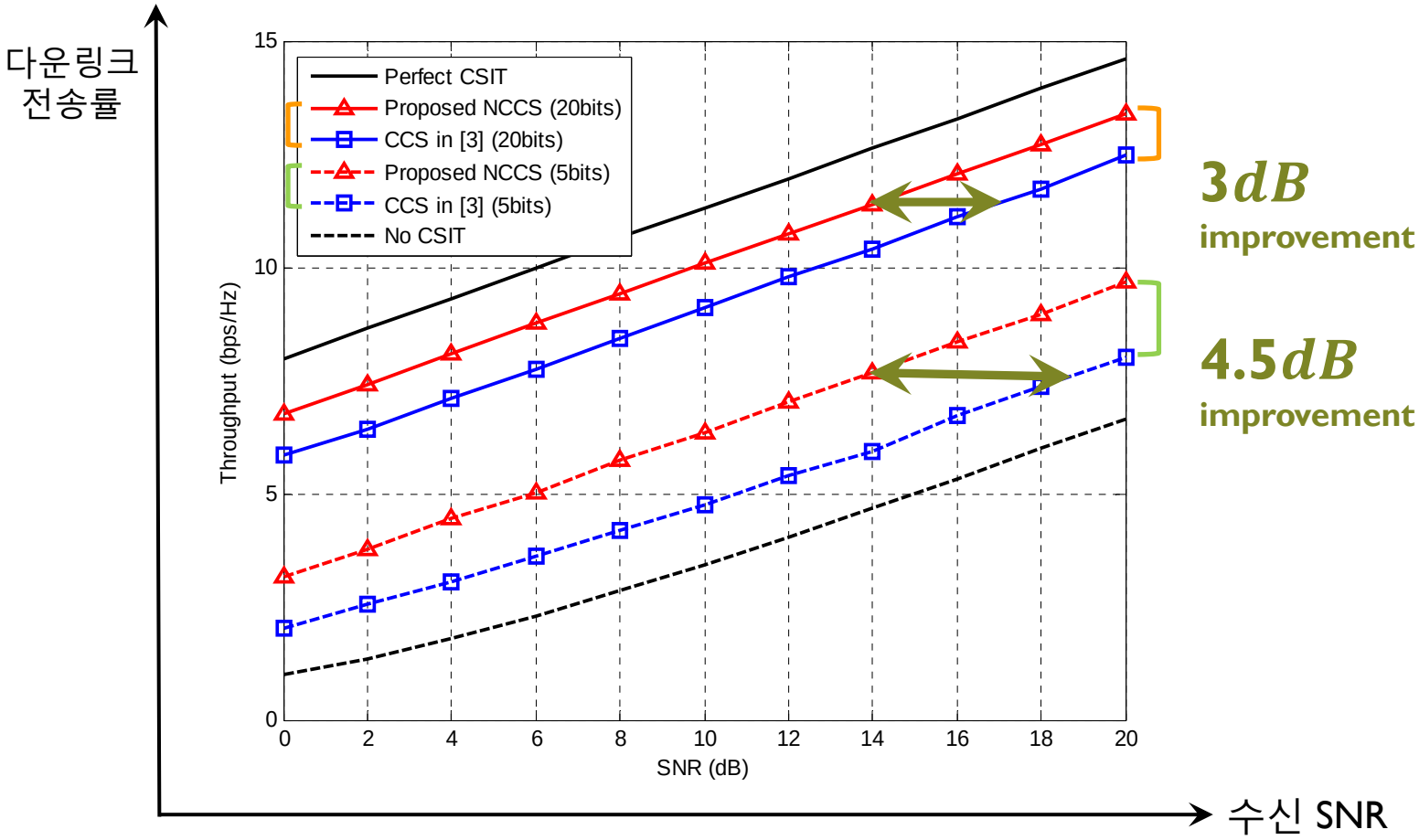
- Parameters

주요 파라미터	실험 설정 값
기지국 안테나 수 N_t	256개
사용자 안테나 수 N_r	1개
공간 상관도를 갖는 MIMO 채널 모델	uniformly-spaced linear antenna arrays [3]
Feedback 비트 수	5, 20 비트
측정행렬 Φ	Random *Gaussian* matrix
성김화행렬 Ψ	Discrete Cosine Transform(DCT) matrix
l_p-norm	$p = 0.1$
압축률	$\eta = 0.25$
Convex CS 복구 알고리즘	Orthogonal Matching Pursuit(OMP)
Non-Convex CS 복구 알고리즘	Iterative Reweighted Least Squares(IRLS)

[3] P. Kuo, H. T. Kung, and P. Ting, "Compressive Sensing Based Channel Feedback Protocols for Spatially-Correlated Massive Antenna Arrays," *in Proc. IEEE Wireless Commun. and Networking Conf. (WCNC)*, pp. 492-497, Apr. 2012.

Simulation Results

- 다운링크 전송 시 전송률 비교



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Conclusions

Any Questions?

NCCS 기법을 Massive-MIMO시스템의 CSI 피드백에 적용

NCCS 기법의 특성으로 인해, 기존 CCS 기반 피드백보다

→ 피드백 값이 부정확하더라도 효과적으로 CSI 복구 가능

→ 양자화 오류 및 잡음의 영향 극복

주어진 실험 환경 하에서, 기존 CCS 기반 피드백보다

20비트 피드백을 사용한 경우 → $\boldsymbol{3dB}$ **이득**

5비트 피드백을 사용한 경우 → $\boldsymbol{4.5dB}$ **이득**