CPS: Small: Recovery Algorithms for Dynamic Infrastructure Networks
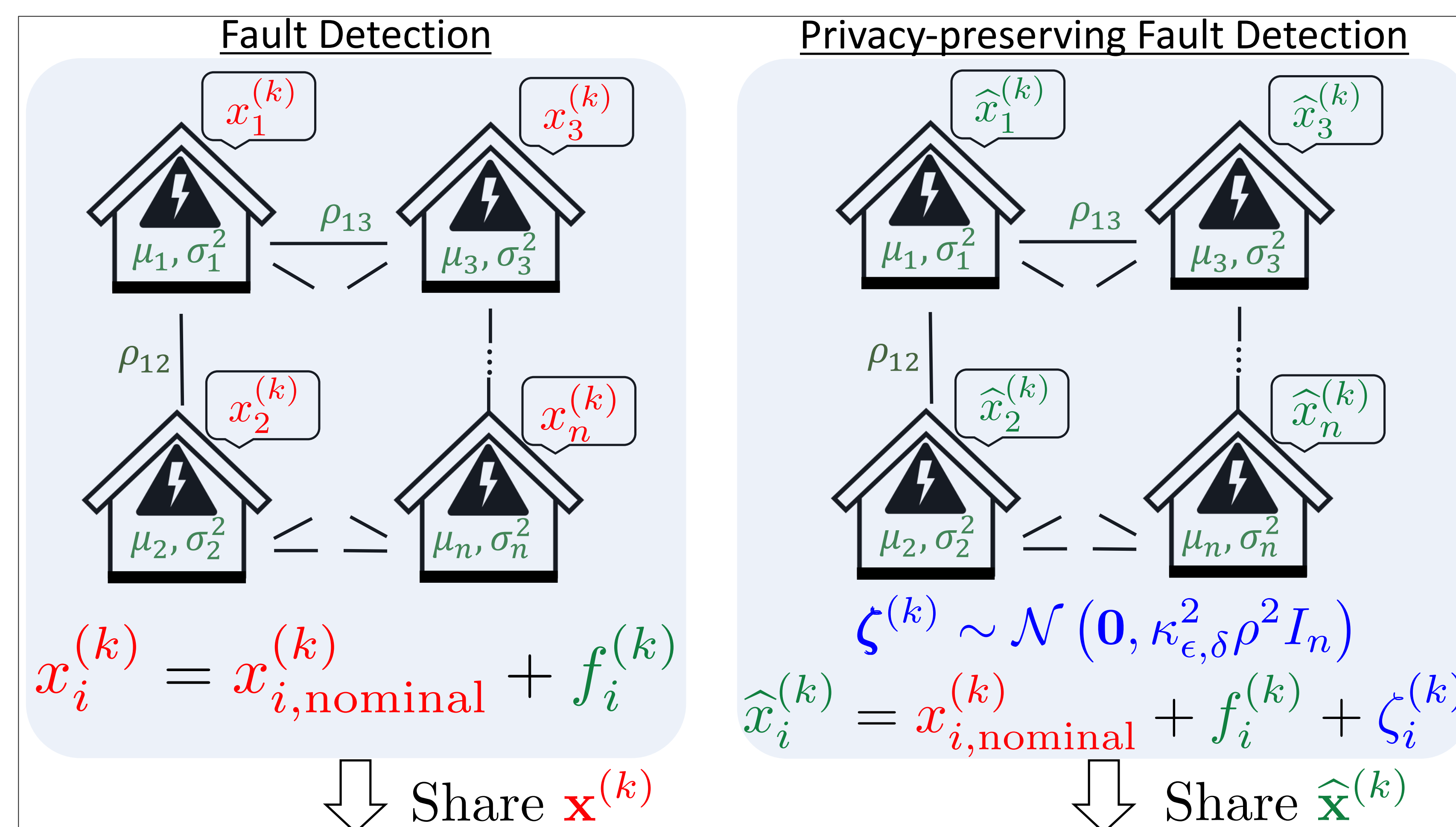
Hamsa Balakrishnan, Massachusetts Institute of Technology

Challenge:

- Modeling, analysis, control, and design of incentives for infrastructure networks, with goal of improving resilience

Solution:

- Data-driven identification and validation of Markov Jump Linear Systems
- Optimal control algorithms
- Outlier detection in graph signals for analyzing disruptions

Fault Detection Privacy-preserving Fault Detection

$$x_i^{(k)} = x_{i,\mathrm{nominal}}^{(k)} + f_i^{(k)}$$

$$\zeta^{(k)} \sim \mathcal{N}\left(\mathbf{0}, \kappa_{\epsilon,\delta}^2 \rho^2 I_n\right)$$

$$\widehat{x}_i^{(k)} = x_{i,\mathrm{nominal}}^{(k)} + f_i^{(k)} + \zeta_i^{(k)}$$

Share $\mathbf{x}^{(k)}$ Share $\widehat{\mathbf{x}}^{(k)}$

Eqn. (4) $\geq h$ Eqn. (7) $\geq \widehat{h}$

Green : Publicly known
Red : Privacy-sensitive
Blue : Privacy noise

μ_i, σ_i : Mean, variance for house i
ρ_{ij} : Correlation between houses i and j
n : Number of houses
f : Additive fault
ϵ, δ, ρ : Privacy parameters
k : Day
j : Additive fault
ϵ, δ, ρ : Privacy parameters
k : Day

Scientific Impact:

- Optimal control algorithms for post-disruption recovery
- Differentially private anomaly detection of correlated data
- Empirical analysis of the equity of congestion pricing

Broader Impact:

- Validated models and methods for infrastructure networks (transportation, smart grid)
- Benchmarking of airline operations
- Privacy-aware fault detection
- Address practical issues of efficiency, resilience, fairness, and privacy