Secure Algorithms for Cyber-Physical Systems: Resilient Collaborative Distributed Energy Management System

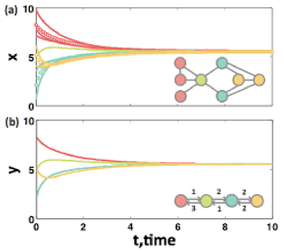
PI: Mo-Yuen Chow, Ph.D. Ph.D. Students: Jie Duan and Zheyuan Cheng | ADAC Lab

Lab website

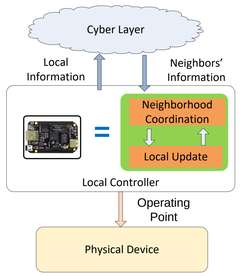
Introduction

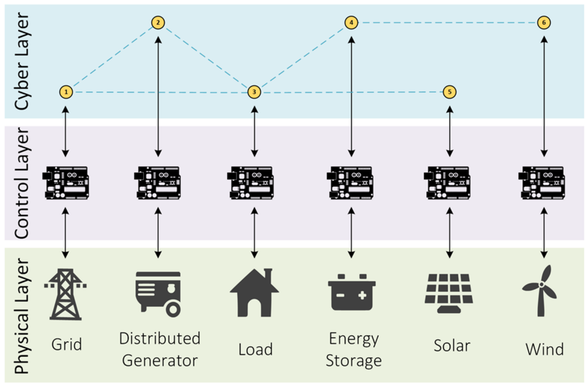
❑ Consensus-based distributed energy management system (EMS):

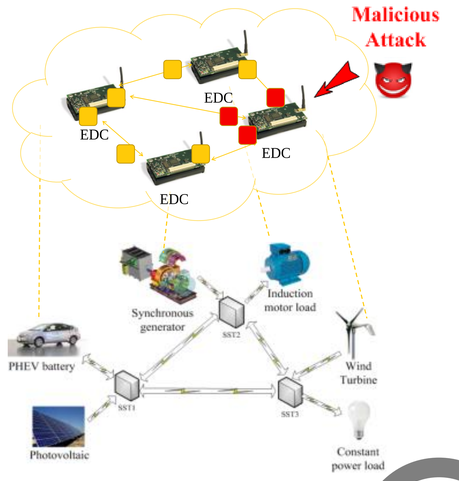
Consensus Network



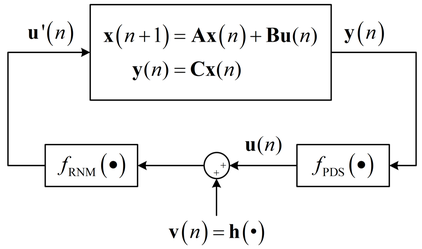
Collaborative Distributed Optimization







❑ Threats:



- Interruption-driven attacks:

$$\mathbf{v}(n) = h_{\text{ò}}\left(\Delta\hat{P}_i, \hat{\lambda}_i, k, n\right)$$

- Infeasibility-driven attacks:

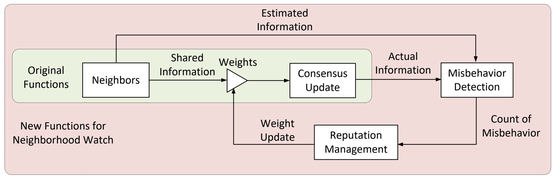
$$\mathbf{v}(n) = h_{\varnothing}\left(\Delta\hat{P}_i, \hat{\lambda}_i, [P_{\bullet}^{\min} \; P_{\bullet}^{\max}], k, n\right)$$

- Profit-driven attacks:

$$\mathbf{v}(n) = h_{\$}\left(\Delta\hat{P}_i, \hat{\lambda}_i, p(k), k, n\right).$$

Reputation System

❑ Distributed attack detection & mitigation:



- Misbehavior detection:

$$e_{ij}^{k+1} = f_{\text{detection filter}}\left(\boldsymbol{\lambda}_{i,est}^{k+1} - \boldsymbol{\lambda}_{i,actual}^{k+1}\right)$$

- Reputation management:
  - Integral filter:

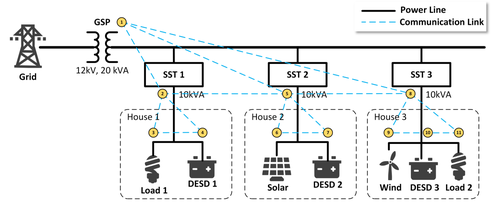
$$G_{ij}[k] = \begin{cases} G_{ij}[k-1]+1, & r_j[k]-\lambda_j[k] \le \gamma(k) \\ G_{ij}[k-1], & r_j[k]-\lambda_j[k] > \gamma(k) \end{cases}$$

  - Reputation index:

$$rep_{ij}[k] = \left(\eta G_{ij}[k]+1\right)/\left(\eta k+2\right)$$

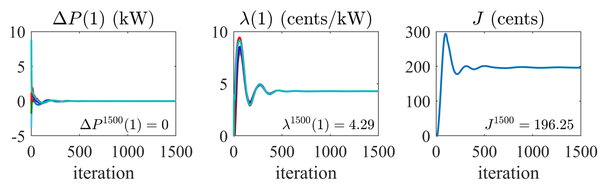
Testbed Validation

❑ FREEDM GEH microgrid:



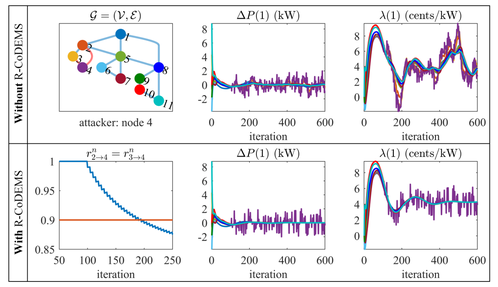
❑ Normal system response:

$$[\Delta\mathbf{P}^{n}(k)\;\boldsymbol{\lambda}^{n}(k)]^{\bullet} \rightarrow [\mathbf{0}\;\boldsymbol{\lambda}^{*}(k)]^{\bullet}$$

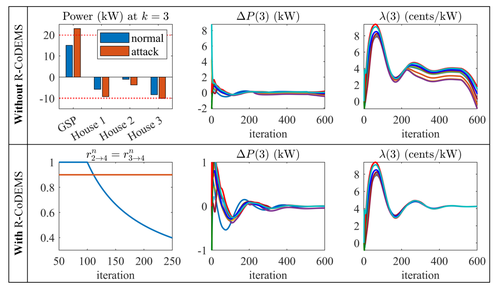


Attack Responses

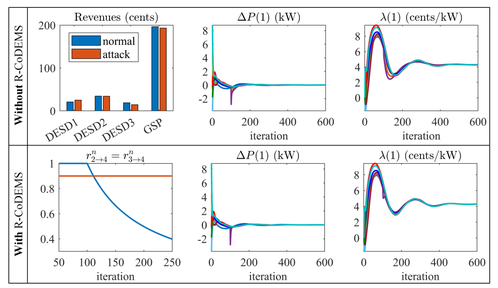
❑ Interruption-driven attack:



❑ Infeasibility-driven attack: overload GSP



❑ Profit-driven attack: DESD3 attacker

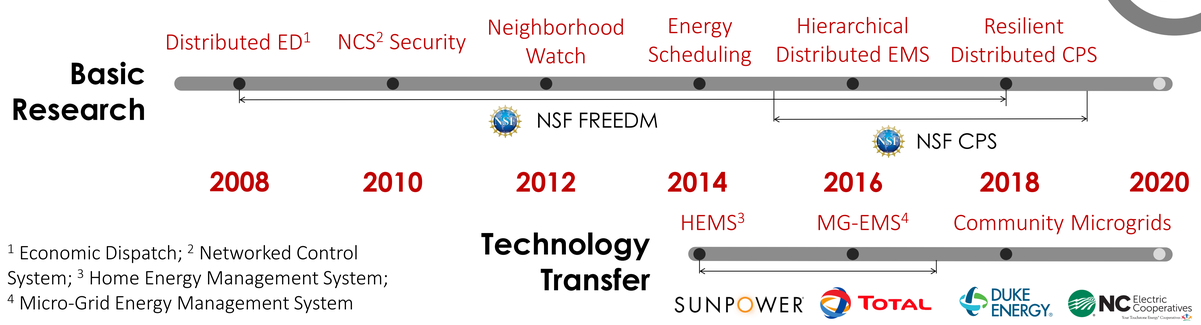


PI Bio

- **Mo-Yuen Chow** (chow@ncsu.edu)

- Dr. Mo-Yuen Chow is the founder and the director of the ADAC Lab at NC State University. His recent research focuses on distributed control, and fault management with applications on smart grids, PHEVs, batteries, and mechatronics/robotics systems.

Research and Development



[1] Economic Dispatch; [2] Networked Control System; [3] Home Energy Management System; [4] Micro-Grid Energy Management System

Collaborators

NSF

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