Learning and Optimization
for Smarter Electricity Infrastructure
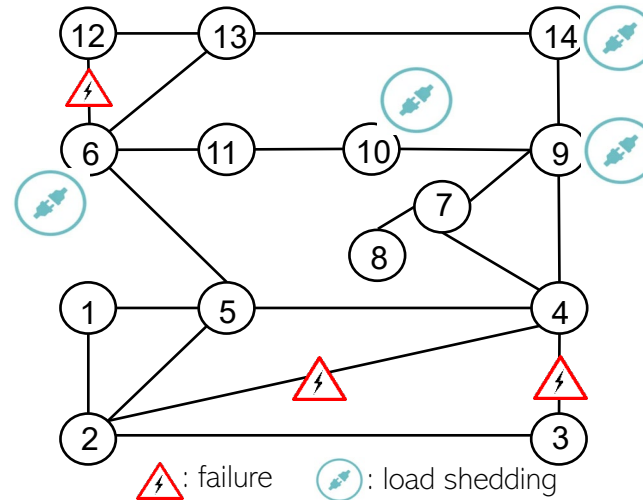
Hao Zhu
haozhu@utexas.edu
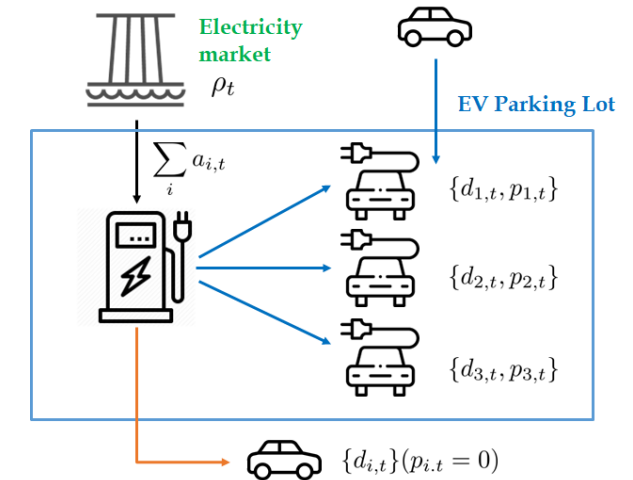http://sites.utexas.edu/haozhu/
@HaoZhu6

Topology-aware learning for real-time market:
Simple model for efficiency & adaptivity

Scalable learning for grid emergency responses:
Fast mitigations under limited data

Integrated infrastructure:
Effective participation in electricity market for EV charging station

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Learning Optimal Power Flow

➢ Graph learning leverages topology dependence (locality) of key OPF outputs

  ▪ Locational marginal price (LMP)

  ▪ Voltage magnitude

➢ Model simplification: N^2 to N

➢ ac-OPF feasibility regularization

➢ Topology adaptivity
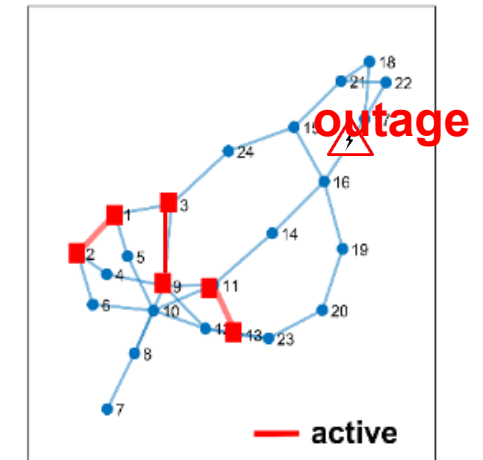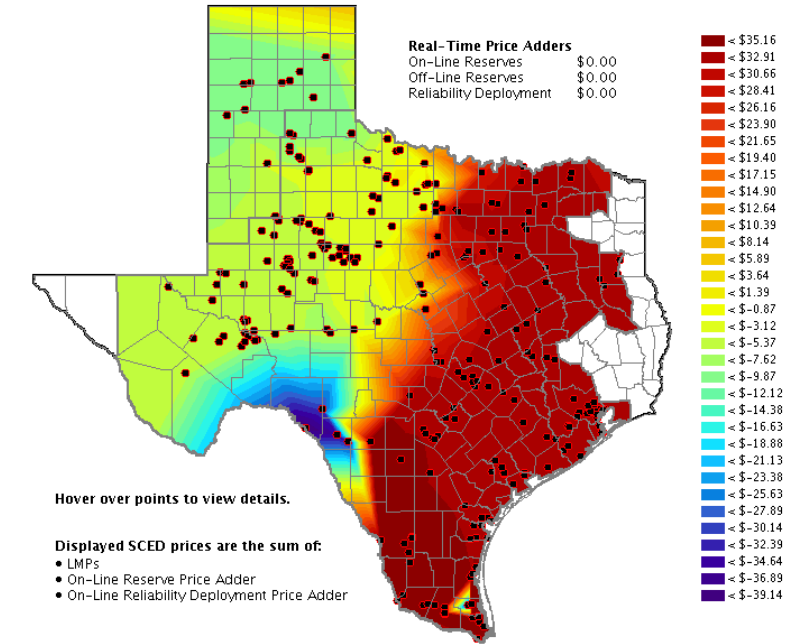
S. Liu, C. Wu, and H. Zhu, "Topology-aware Graph Neural Networks for Learning Feasible and Adaptive AC-OPF Solutions",
IEEE Trans. on Power Systems, (Early Access), 2023. **DOI:** 10.1109/TPWRS.2022.3230555

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Optimal load shedding (OLS)

➤ A special case of ac-OPF: GNN-based prediction possible [Kim et al'19]

➤ Network-wide info. exchange affected by comm. latency and link failures
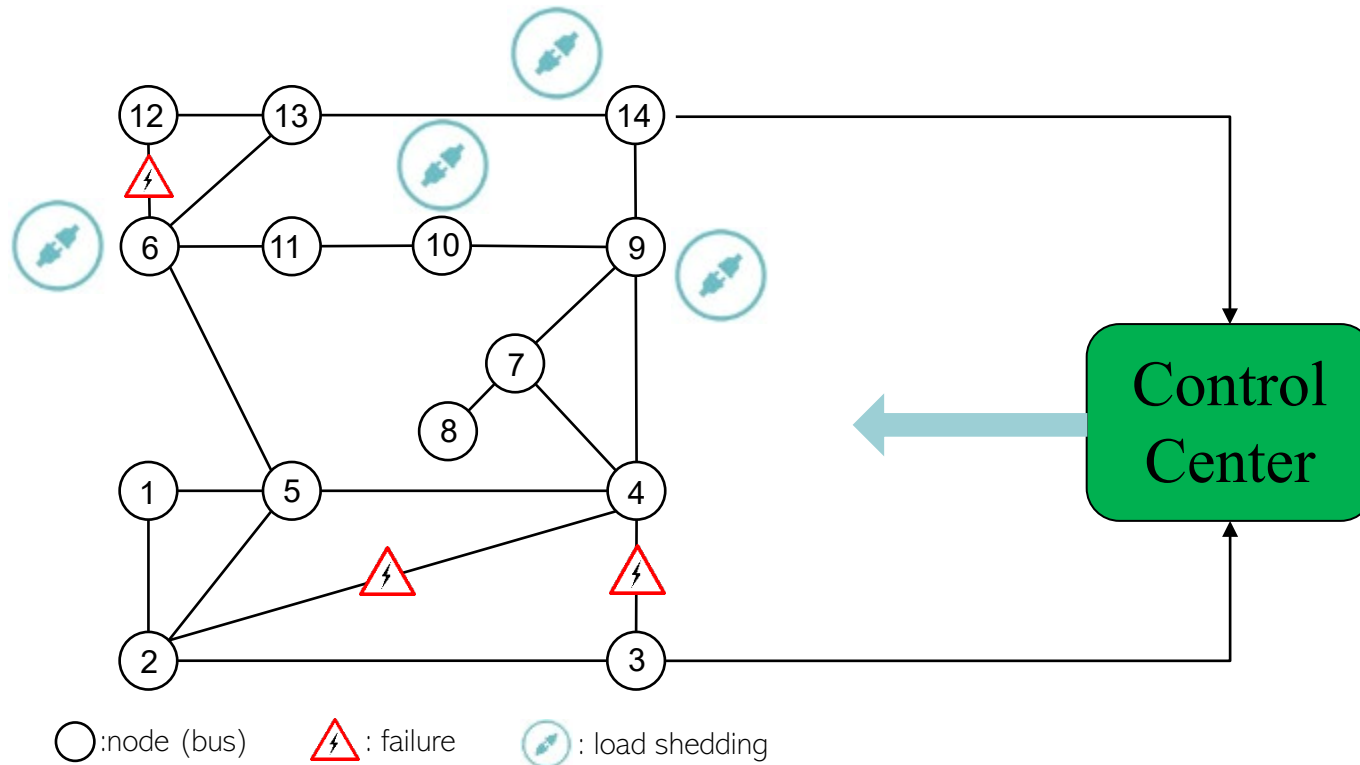
- Can ML enable the implementation of emergency actions in *a scalable, decentralized manner*?

○ :node (bus)   ⚠ : failure   ⊘ : load shedding

Decentralized OLS policy

➤ Each load center uses a decision rule that maps from local data only

○ : node (bus)   △ : failure   ◈ : load shedding
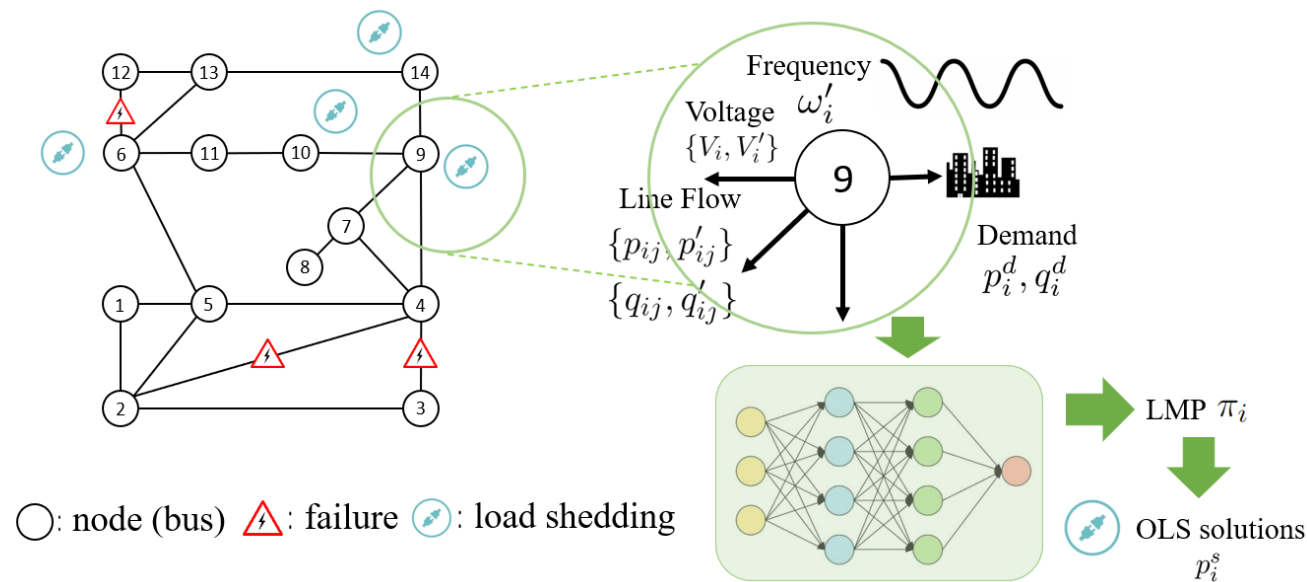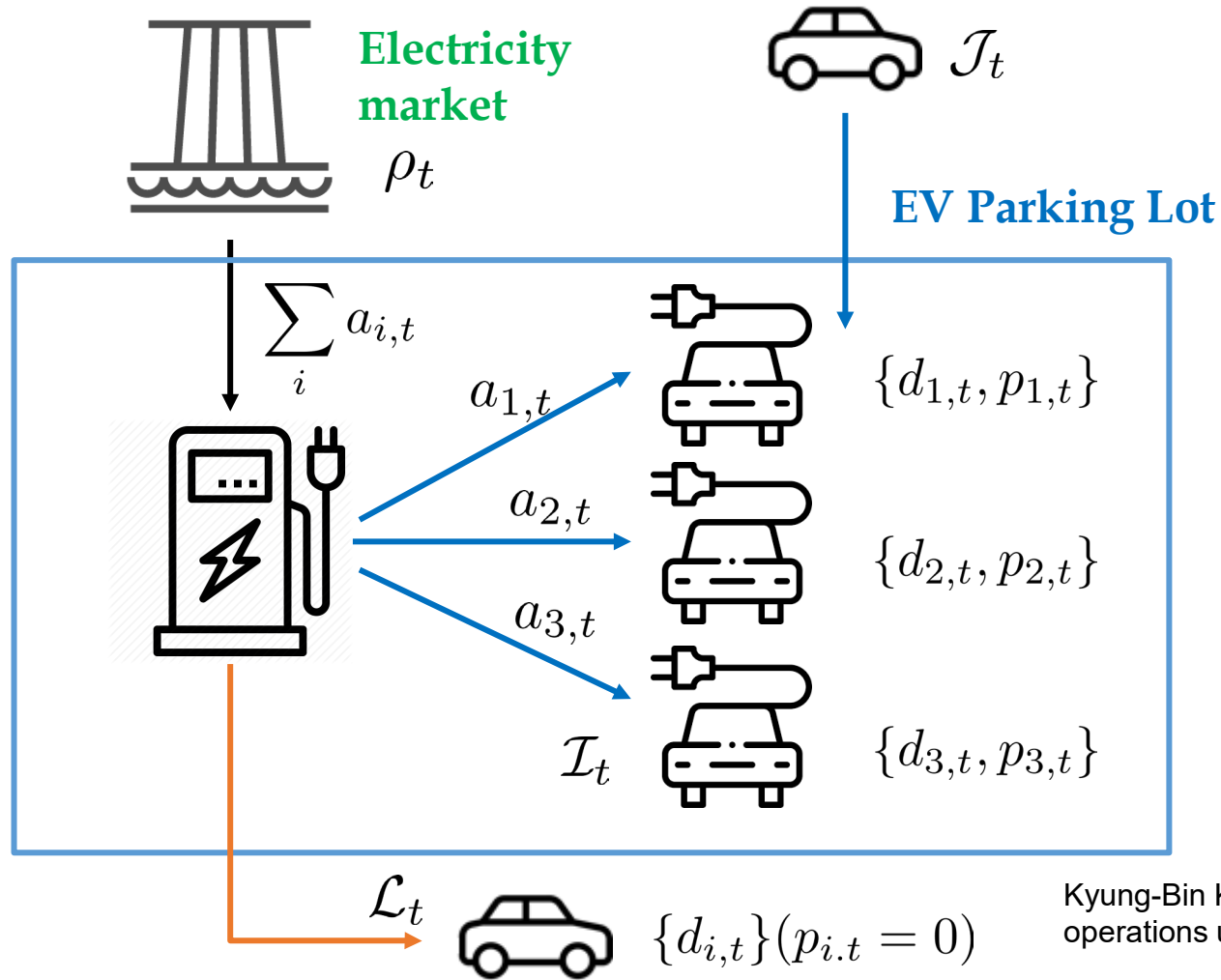
➤ Local input feature:

$$\boldsymbol{x}_i = \left[p_i^d, q_i^d, V_i', \{p_{ij}'\}, \{q_{ij}'\}, \omega_i' \right]$$

➤ Local marginal price (LMP):

$$y_i = \pi_i^*$$

Yuqi Zhou, Jeehyun Park, and Hao Zhu, "Scalable Learning for Optimal Load Shedding Under Power Grid Emergency Operations," *PES General Meeting (PESGM)* 2022. https://arxiv.org/abs/2111.11980

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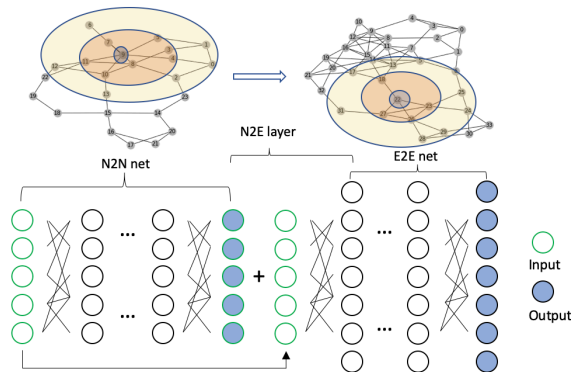
EV charging station (EVCS) problem

- ➢ Randomly arriving EVs with demand and parking time requests
- ➢ *Highly complex* problem space due to large, *varying* number of EVs
  - ▪ RL policy search becomes difficult
- ➢ We developed an efficient, reduced-order representation by using the EV priority measure

Kyung-Bin Kwon and H. Zhu, "Efficient representation for electric vehicle charging station operations using reinforcement learning," HICCS 2022. https://arxiv.org/abs/2108.03236

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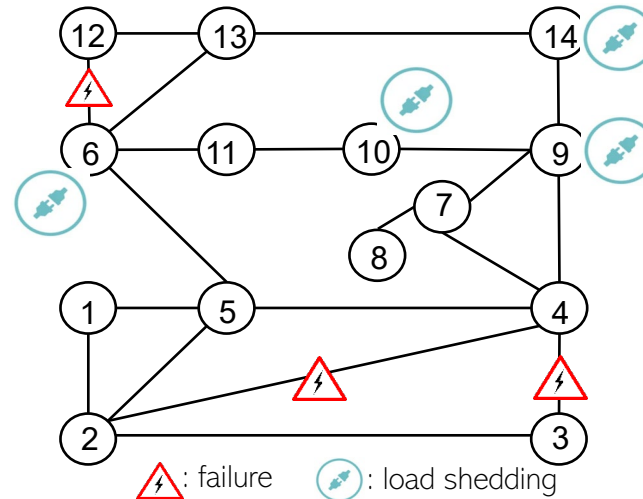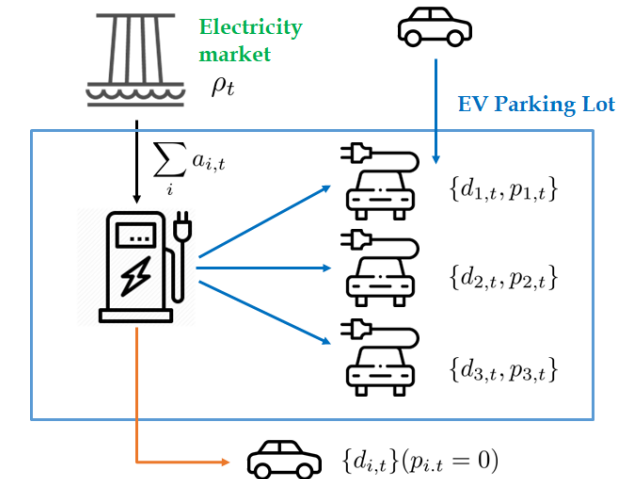@HaoZhu6

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