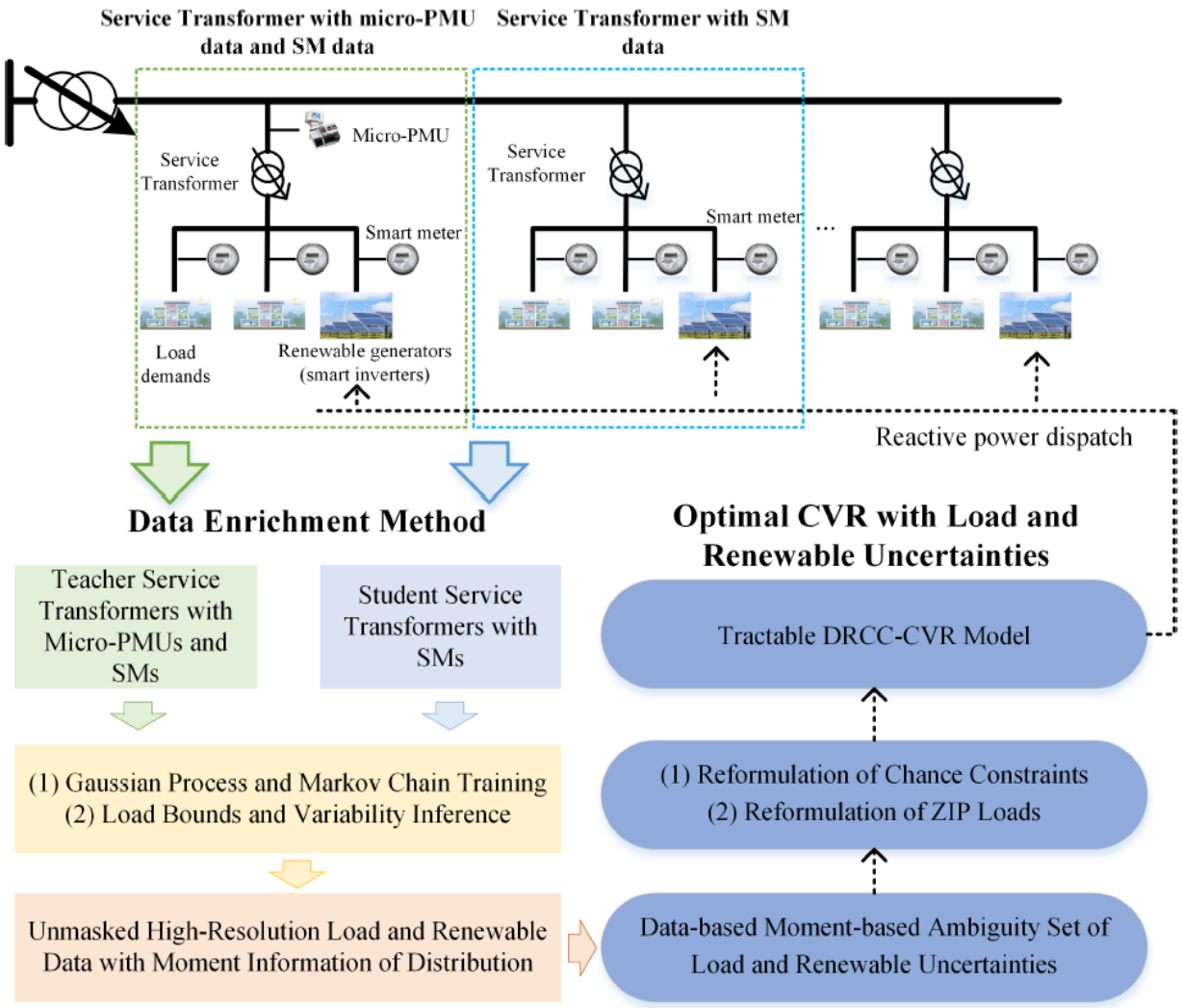
Data-aided Volt/Var Optimization



Distributionally **R**obust **C**hance-**C**onstrained **V**olt/**V**ar **O**ptimalization (DRCC-VVO) model

- Tractable reformulation of DRCC-VVO model

Data-based uncertainty set:

- Data enrichment method with smart meter and limited micro-PMU data
- Moment-based uncertainty sets of load and solar generation

Q. Zhang, F. Bu, Y. Guo and Z. Wang, "Tractable Data Enriched Distributionally Robust Chance-Constrained Conservation Voltage Reduction," in IEEE Transaction on Power Systems, accepted, 2023.

Data-aided Volt/Var Optimization

Deterministic problem

$$\min_x f(x)$$
$$s.t. \quad g_1(x) = 0$$
$$g_2(x) \le 0$$

ξ: **Uncertainty of loads and DERs**

ϵ : Tolerance rate

$$V^{min} \le V_{i,\phi,t} \le V^{max}$$
$$\mathbb{P}\{V_{i,\phi,t} - V^{max} \le 0\} \ge 1 - \epsilon$$
$$\mathbb{P}\{-V_{i,\phi,t} + V^{min} \le 0\} \ge 1 - \epsilon$$

Chance-constrained problem

$$\min_x \max_{\xi \sim \mathbb{P} \in \mathcal{P}} E_{\mathcal{P}}\{f(x,\xi)\}$$
$$s.t. \quad g_1(x) = 0$$
$$\mathbb{P}\{g_2(x,\xi) \le 0\} \ge 1 - \epsilon$$

Tractable distributionally robust chance constrained VVO model

$$\mathbb{P}\{a(x)^T\xi + b(x) \le 0\} \ge 1 - \epsilon$$

$$a(x)^T\mu + b(x) + \sqrt{\frac{1-\epsilon}{\epsilon}}\left\|\Sigma^{\frac{1}{2}}a(x)\right\|_2 \le 0$$

Moment-based ambiguity set

$$\mathcal{D}_\xi = \left\{\xi \sim \mathbb{P} \in \mathcal{P}: E_{\mathbb{P}_\xi}[\xi] = \mu, E_{\mathbb{P}_\xi}[\xi\xi^T] = \Sigma\right\}$$

μ, Σ **:** Mean and covariance of loads and DERs uncertainties

Data enrichment

Purpose: statistically uncover the uncertainties of load and DERs with SM and limited micro-PMU data

- Step1. Gaussian process regression

$$GPR^*_{s,1}: P_a(t) \to P^{upper}(t)$$
$$GPR^*_{s,2}: P_a(t) \to P^{lower}(t)$$

- Step2. Markov chain model

$$MC^*_s: \{P_t(m-2), P_t(m-1)\} \to \mathcal{P}_r(P_t(m))$$

- Step3. Weights for SM and micro-PMU data

$$W_s = \frac{W'_s}{\sum_{s=1}^{N_t} W'_s}$$
$$W'_s = \frac{1}{N_c N_C^S}\sum_{i=1}^{N_c}\sum_{j=1}^{N_C^S}\left\|P_i - P_j^S\right\|$$

- Step.4 Extract first two moment information of loads and DERs uncertainties

$$(\mu^*, \Sigma^*) = arg\min_{\mu,\Sigma} f(\mu, \Sigma; P_t(m))$$

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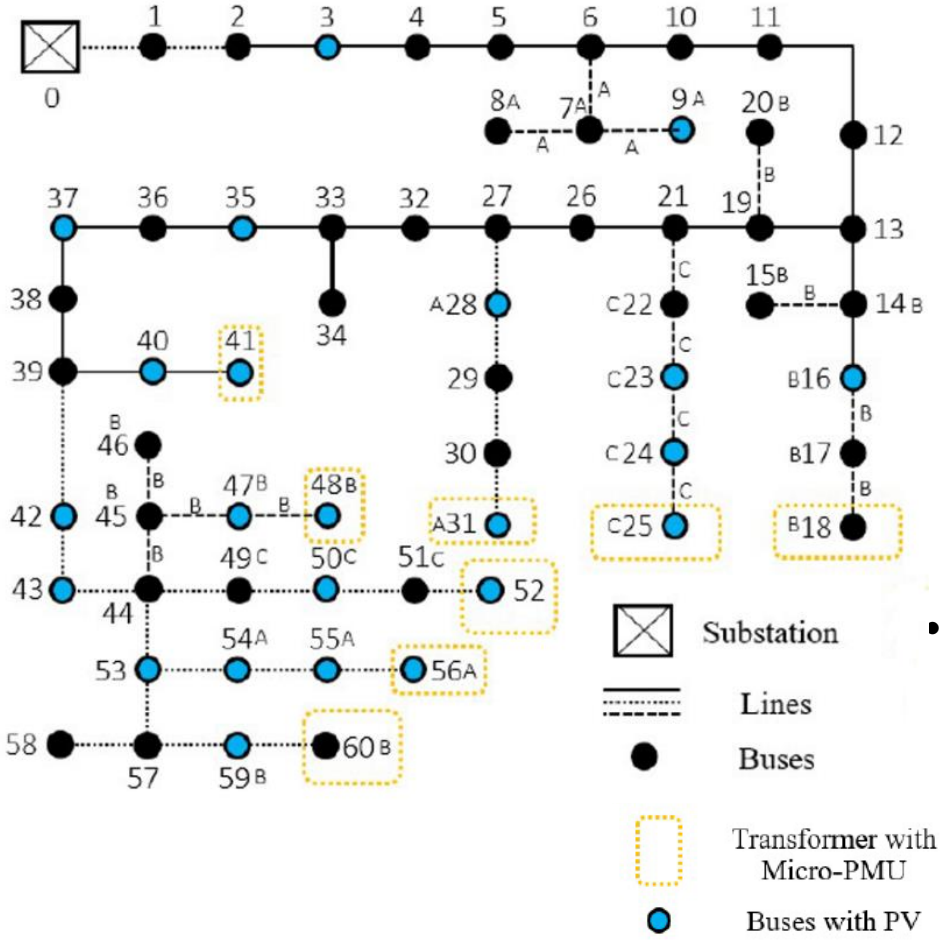
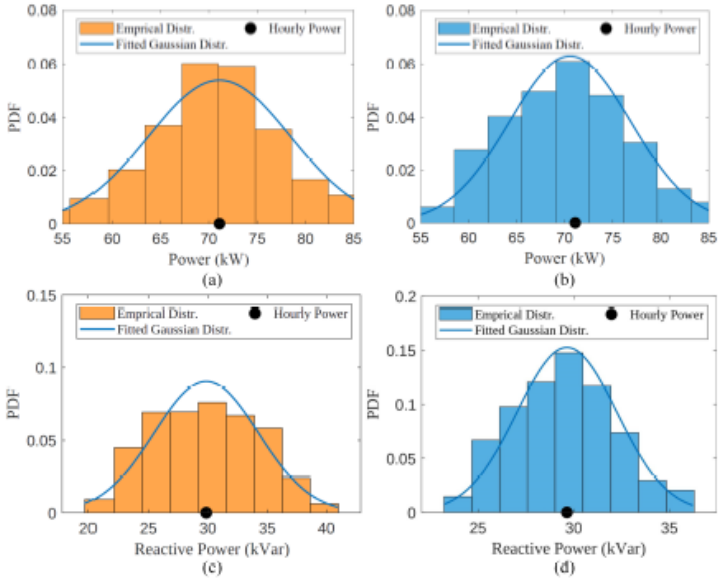
Data-aided Volt/Var Optimization

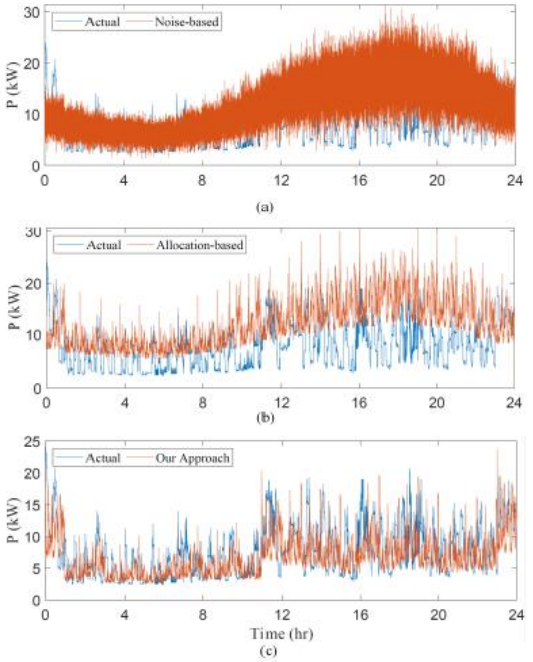
- A real distribution feeder with smart meters and micro-PMUs



- Extract mean and covariance



- Result comparison of data enrichment methods



- Result comparison

	Energy (kWh)	Reduction (%)	Computation (sec)
Base Case	958.045	-	-
RO-CVR	934.178	2.491%	18.312
DRCC-CVR	898.616	6.203%	21.911

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