Paper No: 20PESGM0225

UNIVERSITY OF TORONTO

External System Generator Outage Localization Based on Tie-line Synchrophasor Measurements

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Discovery Grant NSERC RGPIN-2016-06674

Background

- Problems: limited observability and information of the external system
- Proposed method: solve for the largest injection change

$$\Delta \boldsymbol{I}_l = \boldsymbol{A}_l \Delta \boldsymbol{I}_g$$

Limited Tie-line PMU measurements

Shared CISFs

Injection change due to outage

$$\begin{bmatrix} \\ \\ \\ \end{bmatrix} = \begin{bmatrix} \\ \boldsymbol{A}_l \\ \\ \end{bmatrix} \begin{bmatrix} \\ \\ \\ \\ \end{bmatrix}$$

NOT INVERTIBLE

Clustering + inverse problem

$$\Delta \tilde{\boldsymbol{I}} = \tilde{\boldsymbol{A}}_l^{-1} \Delta \boldsymbol{I}_l$$

$$\begin{bmatrix} \\ \\ \\ \end{bmatrix} = \begin{bmatrix} \\ \tilde{\boldsymbol{A}}_l^{-1} \\ \\ \end{bmatrix} \Rightarrow \mathcal{G}^* = \arg\max_i |\Delta \tilde{I}_i|$$

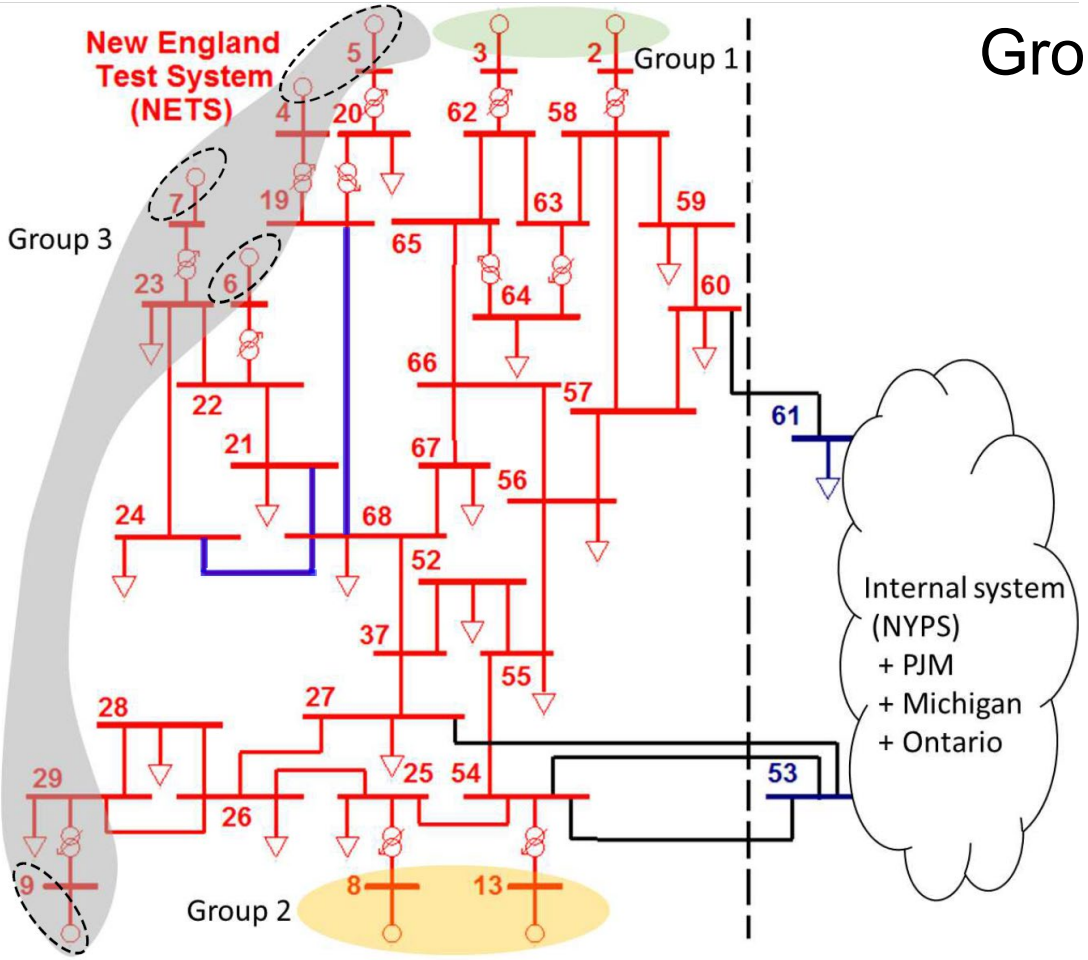
Group Injection change due to outage

Approximate CISFs based on QR decomposition

Tie-line PMU measurements

Outage originating **Group**

Results (68-bus system)



Group injection change estimation:

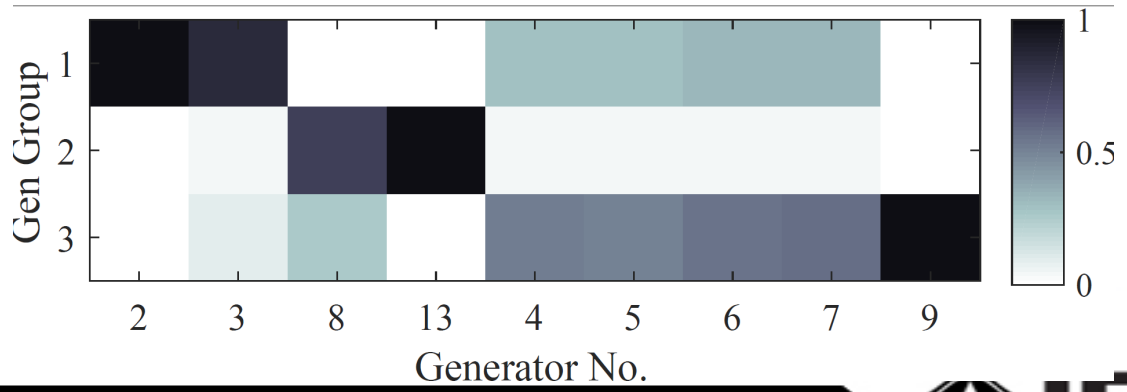
$$\Delta \hat{\boldsymbol{P}}_r = \mathrm{Re}\{\tilde{\boldsymbol{A}}_l\}^{-1} \Delta \boldsymbol{P}_l$$

Estimated group injection change

Approximate ISFs

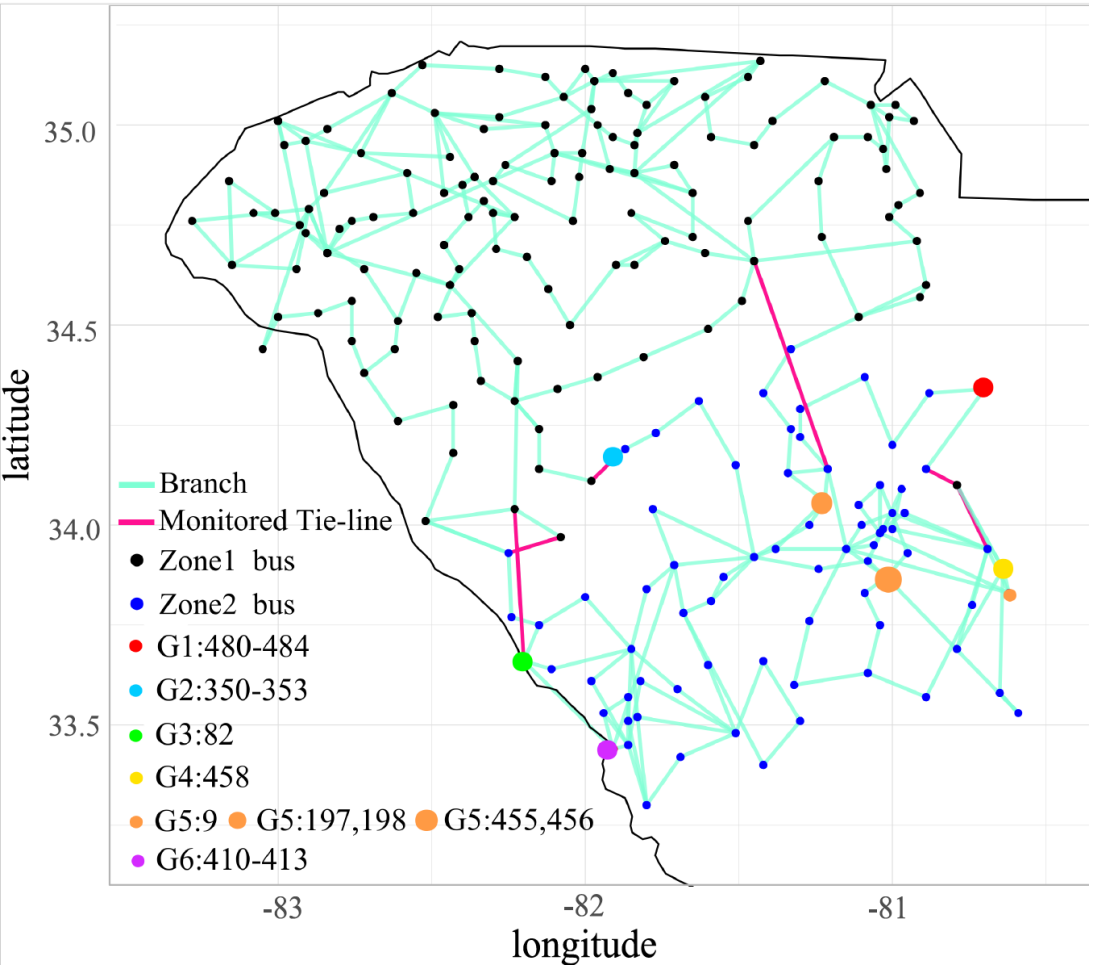
Tie-line PMU measurements

	Mean estimation error
3 tie-line PMUs	22%
3 tie-line PMUs + 3 PMUs	10%

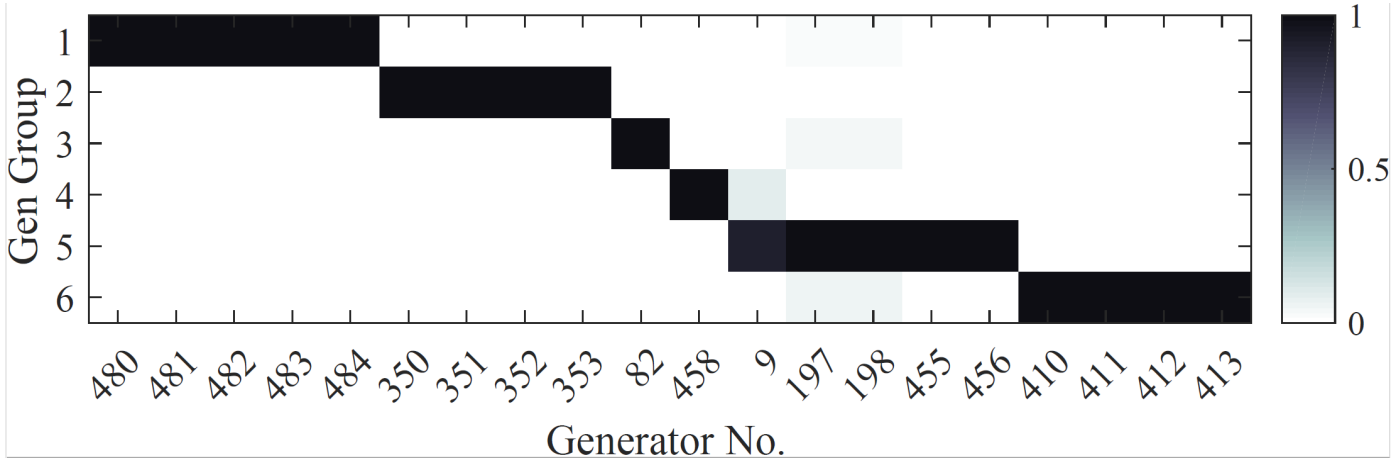


100% localization accuracy

Results (500-bus system)



6 tie-line PMUs: 6 groups
Highly similar CISFs within each group



100% localization accuracy

Mean group injection change estimation error: 5.4%

Conclusions/Recommendations

- Localize external system generator outage to the originating cluster given limited PMU measurements with great accuracy
- Provide estimation of the group injection loss
- Great for online application and as a complementary approach to frequency-based methods
- Provide incentives to share CISFs and PMU data between operators