Grid Event Fingerprints and PMUs

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Basic picture

- Direct state measurements (e.g. via PMU) at some buses
- Not enough for complete observability
  - Because of incomplete deployment in local grid
  - Because of interactions with neighboring parts of grid
- Goal: Check for fingerprint of significant events
  - Efficient computation via linearized model
  - Filter to avoid excessive solver work
- Steady state for now; transient in future

Status

- Previous report (March call)
  - Basic method for diagnosing 1-2 lines
  - Initial accuracy results on IEEE 57-Bus network
- New progress
  - Diagnose line failure *or* substation reconfiguration
  - Tests with noise
  - Tests larger network (2393-bus Polish network)

Revised framework

- Measure change in voltage $E\Delta v$
- Model change in voltage under contingency satisfies

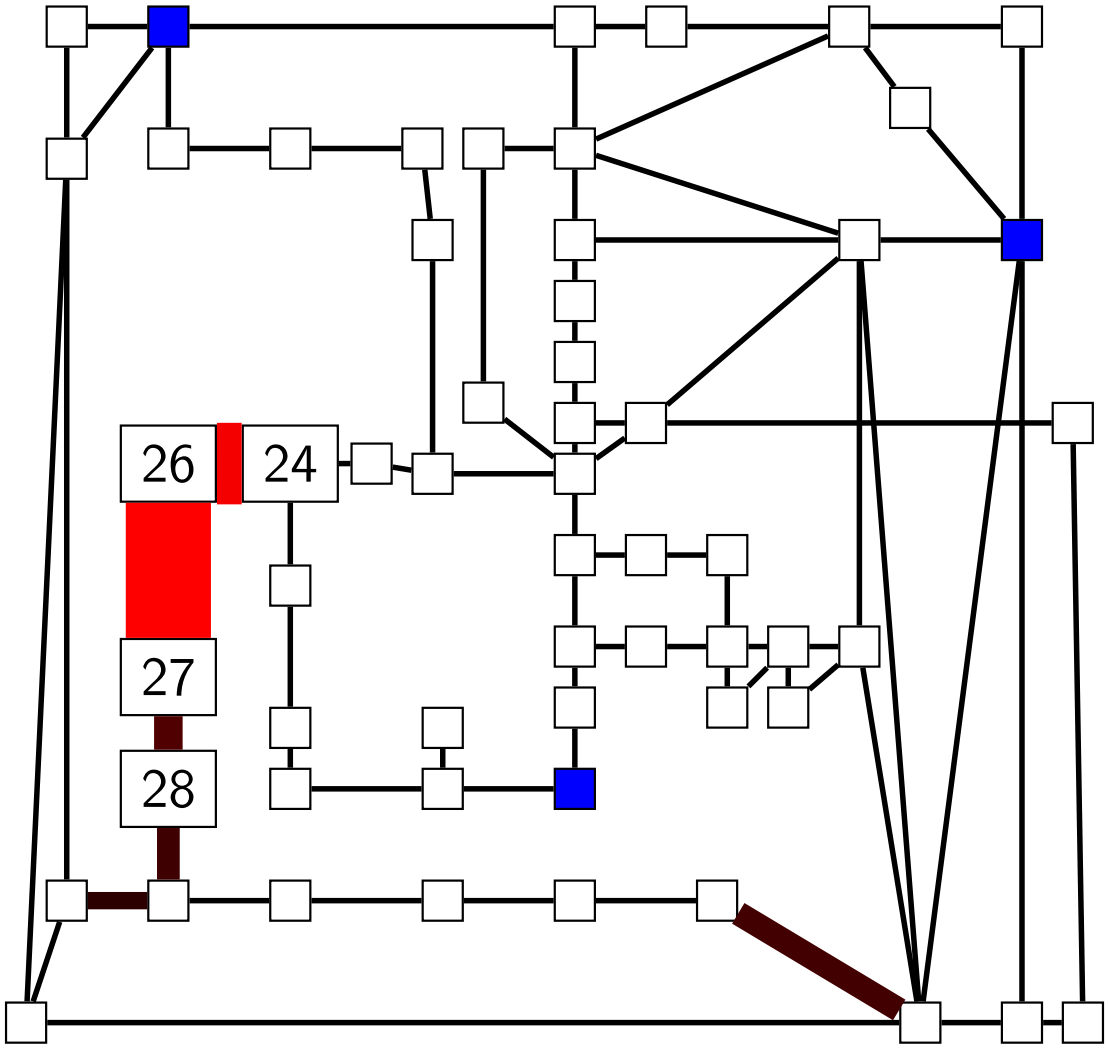
$$\begin{bmatrix} A & U \\ V^T & D \end{bmatrix} \begin{bmatrix} \delta v \\ \lambda \end{bmatrix} = \begin{bmatrix} r \\ 0 \end{bmatrix}$$

  where A is a previously-factored Jacobian.
- Note $\delta v = A^{-1}(r - U\lambda)$, so

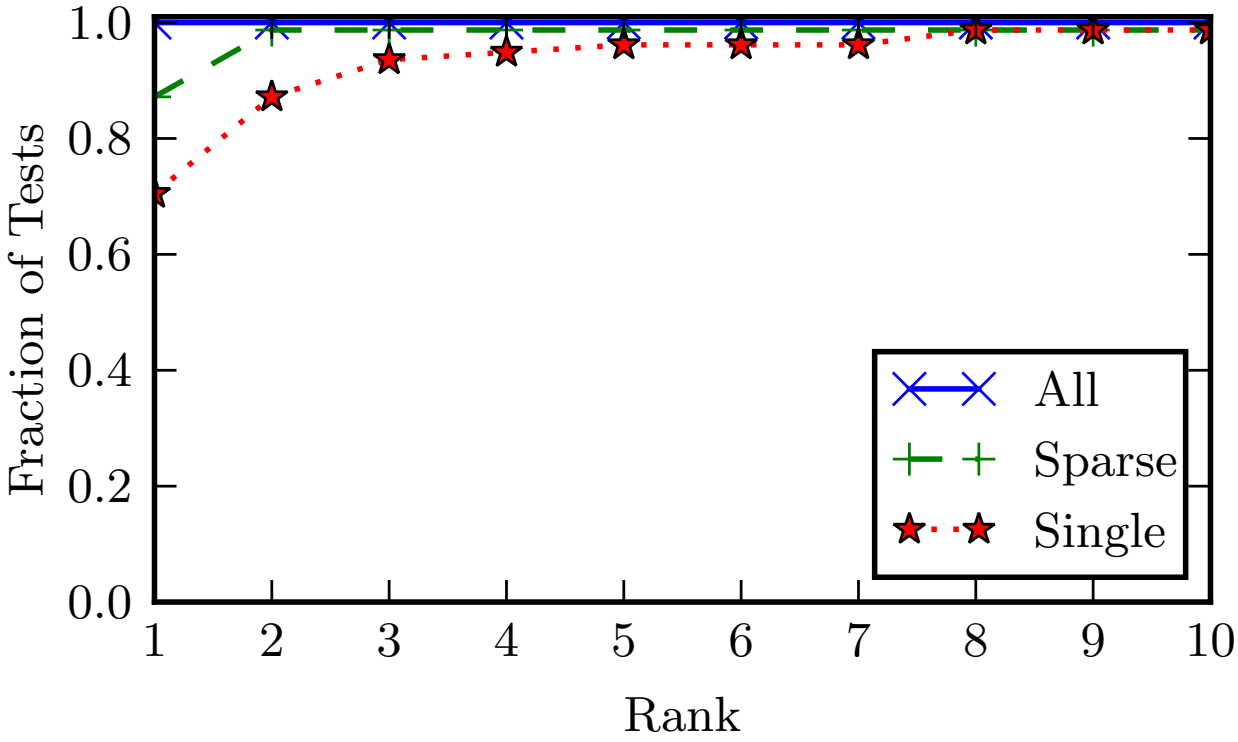
$$\|E\Delta v - E\delta v\| \geq \min_{\gamma} \|E\Delta v - EA^{-1}(r - U\gamma)\|$$

  Use this bound to filter out implausible contingencies
- Rank plausible contingencies by $\|\Delta v - \delta v\|$

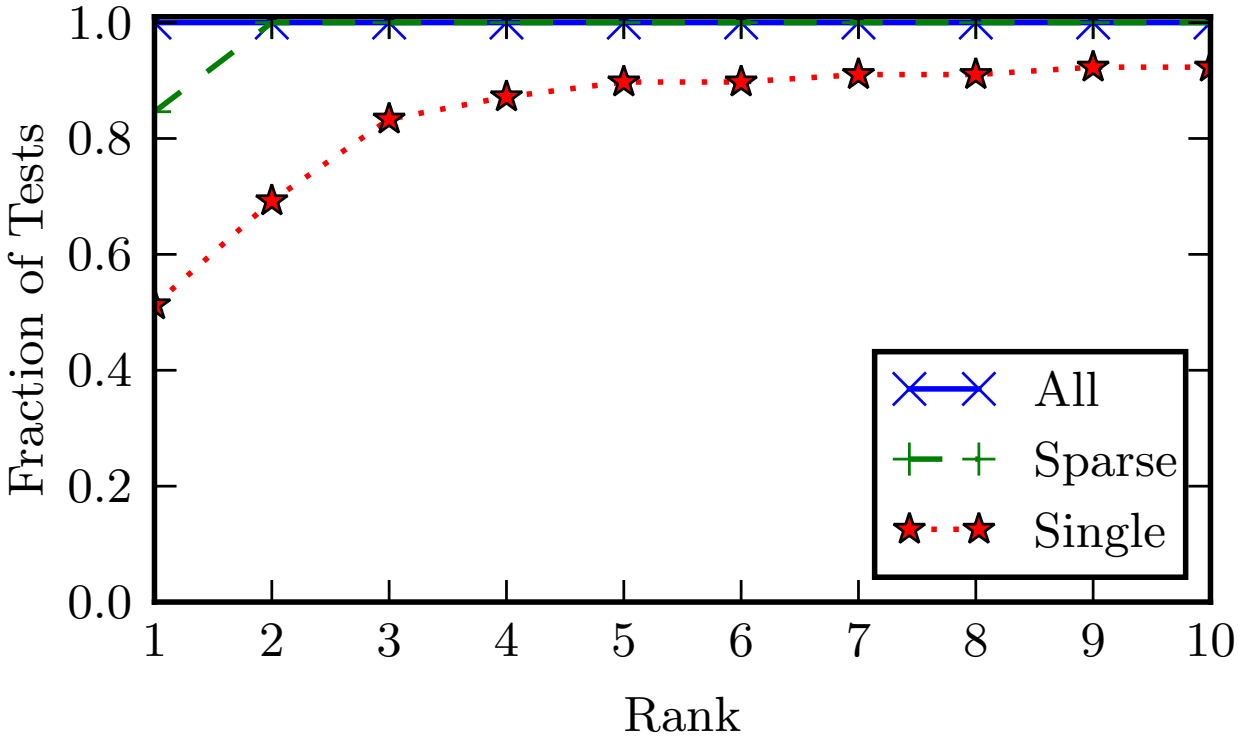
Accuracy: Line Failures



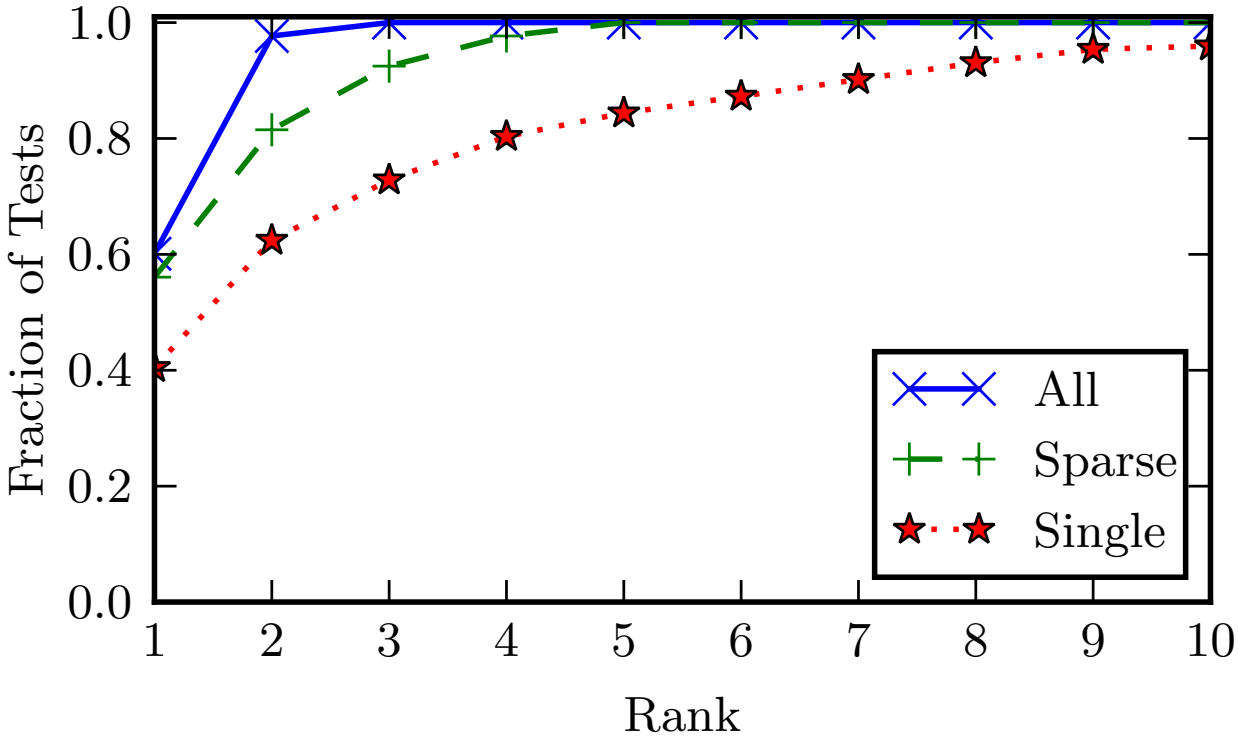
Accuracy: Line Failures



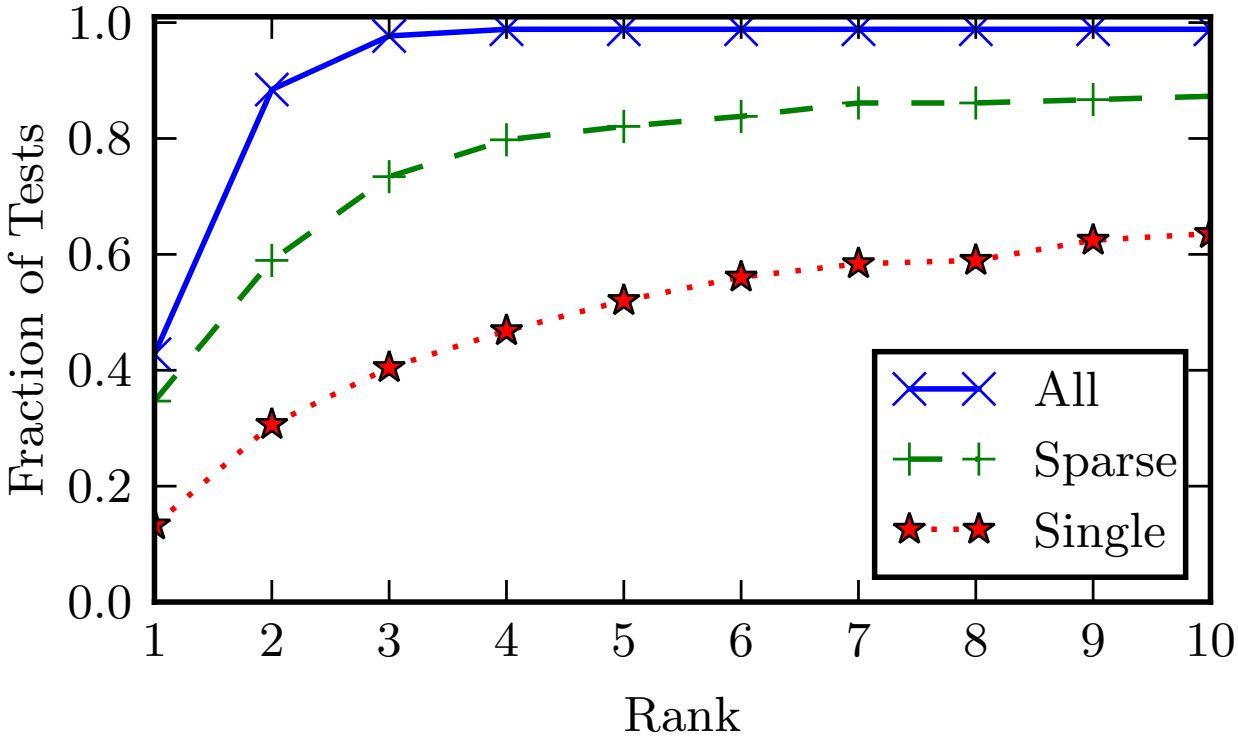
Accuracy: Line Failures (noisy)



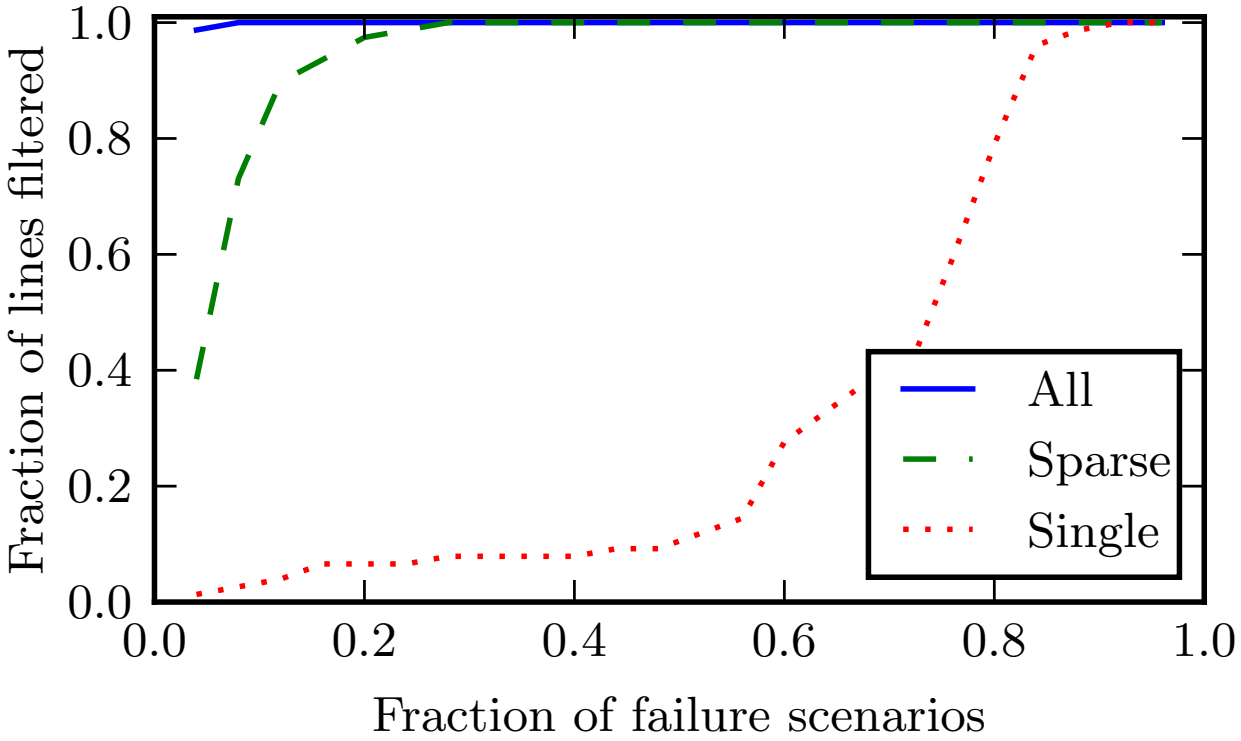
Accuracy: Substation reconfiguration



Accuracy: Substation reconfiguration (noisy)



Filtering effectiveness



Timings: Polish network (2393 bus, $\approx$ 3000 lines)

Line	FLiER (s)	Solution rank / # t's computed	FLiER n.f. (s)
(1502, 917)	0.36	1/2	53.89
(1502, 1482)	028	1/2	62.94
(557, 556)	0.31	1/4	67.49
(2346, 2341)	16.83	23/878	66.79
(909, 1155)	0.29	1/2	67.15
(644, 629)	0.37	1/7	66.77
(591, 737)	0.35	1/6	66.88
(559, 542)	0.50	1/12	66.62
(378, 336)	0.36	1/6	67.13
(101, 94)	0.28	1/2	66.92

For more

FLiER: Practical Topology Error Correction Using Sparse PMUs
Submitted to IEEE TPS, in review
http://arxiv.org/abs/1409.6644