Fast Fingerprints for Power System Events

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Acknowledgements

arpa·e
CHANGING WHAT'S POSSIBLE

Institute for Computational Sustainability
ICS

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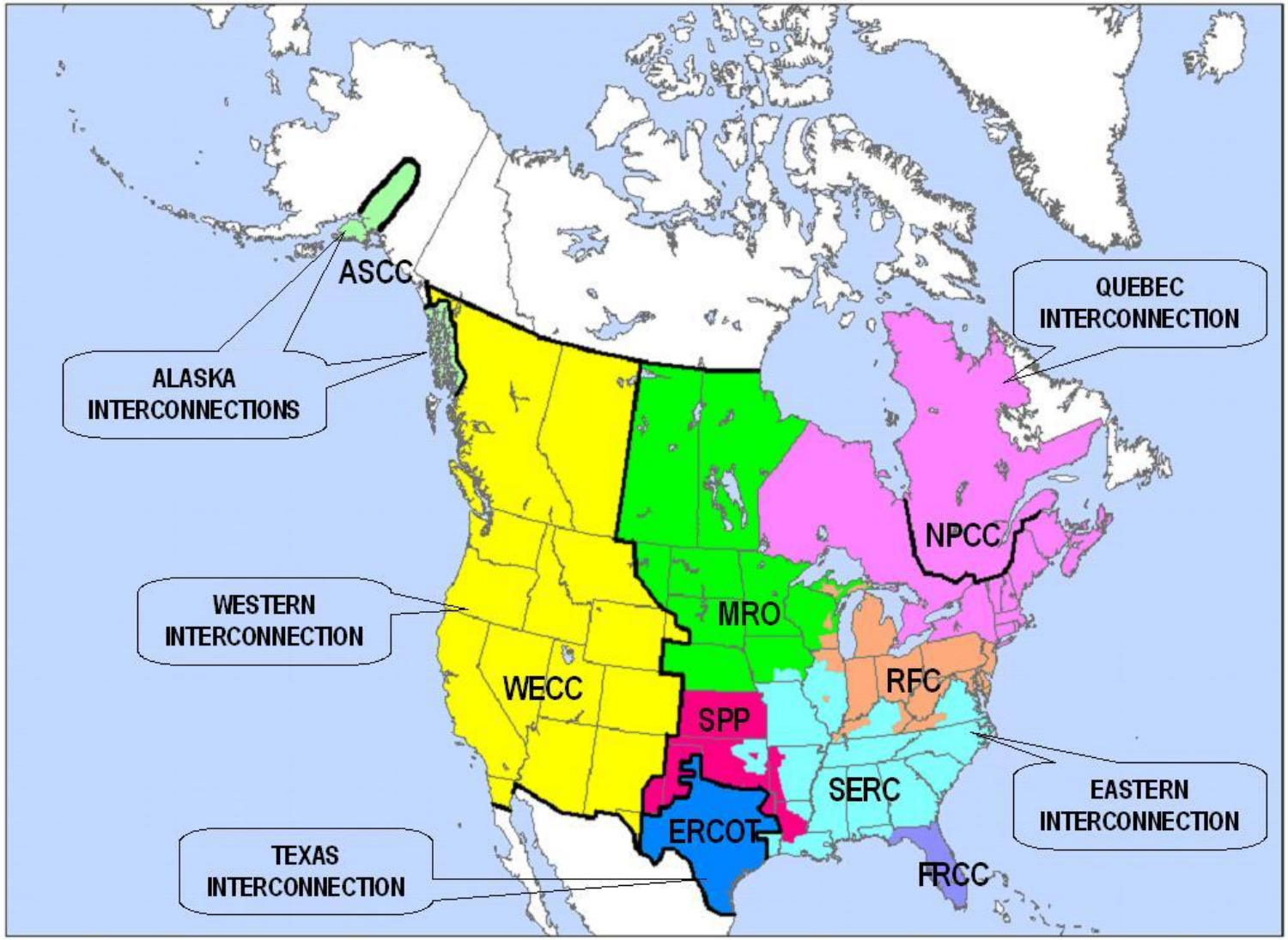
Biggest Machine(s) in the World



Tale of Two Sensor Systems

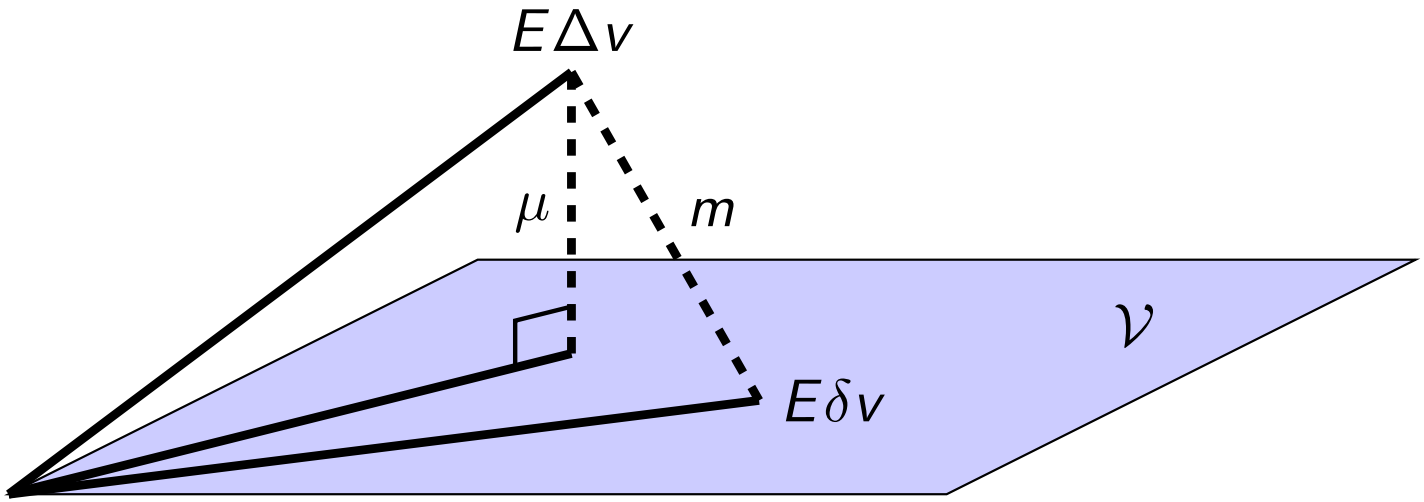
- SCADA (Supervisory Control and Data Acquisition)
  - Non-synchronized measurements every 2–10 seconds
  - Report digital status and power flows
  - Voltages/currents inferred from power flows (state estimation)
  - Complete observability in transmission grid
- Syncrophasors / Phasor Measurement Units (PMUs)
  - GPS-synchronized measurements and 10-30 reports per second
  - Directly report voltage and current angles/magnitudes
  - Partial observability in most places

Best of Both Worlds

- Combine *model-driven* state estimates with PMU observations
- Goal: Identify system events
  (line outages, substation change, generator trips, ...)
- Idea: Match PMU measurements $E\Delta v$ to model predictions δv_c
  - Need predictions for many possible changes c!
  - Each δv_c depends on current state – constantly changing.
- How can we do this fast?

FLiER: Practical Topology Error Correction Using Sparse PMUs.
Ponce and Bindel, arXiv:1409.6644

Partial Predictions



- Find *subspace* $\mathcal{V}_c$ containing predictions $E\delta v_c$
- Bound: subspace distance $\mu(c) \leq$ mismatch $m(c)$
- Sort events by ascending $\mu(c)$
- Check $c_1, \ldots, c_k$ until $\mu(c_{k+1}) \leq \min_{1 \leq j \leq k} m(c_j)$

Ongoing Related Efforts

- Spectroscopic event identification (Eric Lee, Nate Rogalskyj)
  - Goal: Identify state from ringdown/ambient oscillations
  - Approach: Residual + bound generation similar to FLiER
- SECURED: Synthetic regulating reserves (Eaton, CMU, ANL, LLNL)
  - Goal: Reduce regulating reserve req'ts to offset VER
  - Approach: Fast distribution-level coordinated demand response
- GridCloud (Birman, WSU)
  - Goal: Fast, reliable cloud infrastructure to communicate PMU data
  - Approach: Replication for performance and reliability
  - See Edward Tremel talk/poster