RobuSmart: Measuring and Optimizing Smart Power Grids against Cascading Failures

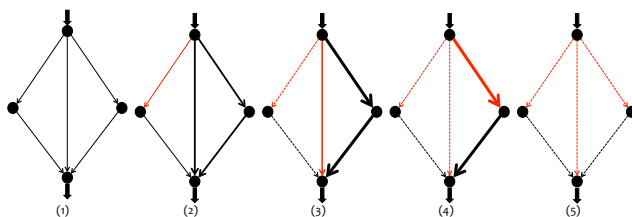Yakup Koç, Evangelos Pournaras, Martijn Warnier, Robert Kooij and Frances Brazier

Blackouts

- Virtually stops the daily life
- On average once every 13 days just in USA
- Economic cost in the order of tens of billions dollars annually (just in USA)
- Mainly due to **cascading failures** in Power Grids

Cascading Failures in Power Grid

Due to line overloads:

Topological aspects
- Number/types of busses
- Density of transmission lines

Operative state
- Homogeneity of load distribution
- Loading level of the components

Objective: Can we **assess and optimize** the robustness of power grids against cascading failures?

Proposed Robustness Metric

Captures the topological and operative states of the power grid

Nodal Robustness
- Node-level robustness against failures by cascading overload
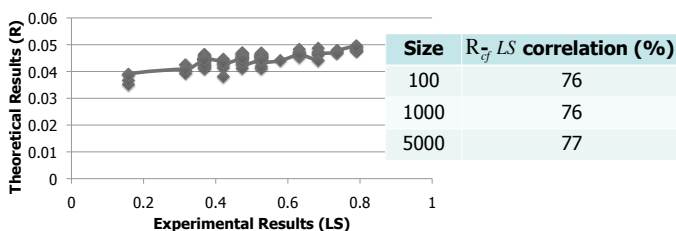- An entropy-based approach

Nodal Significance
- How important a node is during cascading failures?
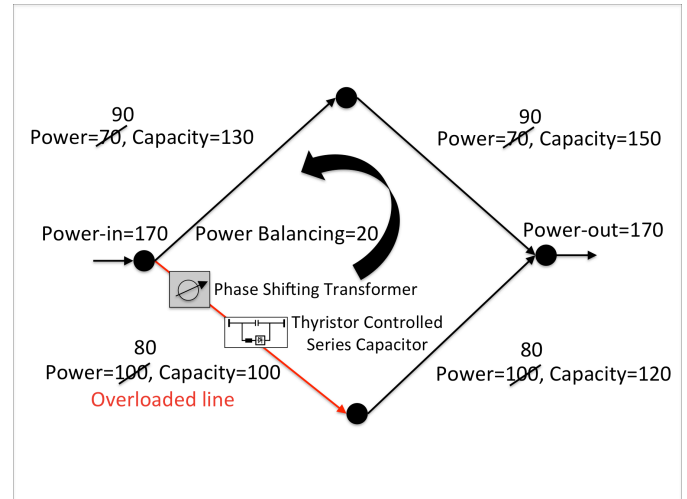- Relative amount of power distributed by a node

Robustness Metric

Quantifies power transmission grid robustness with respect to cascading failures
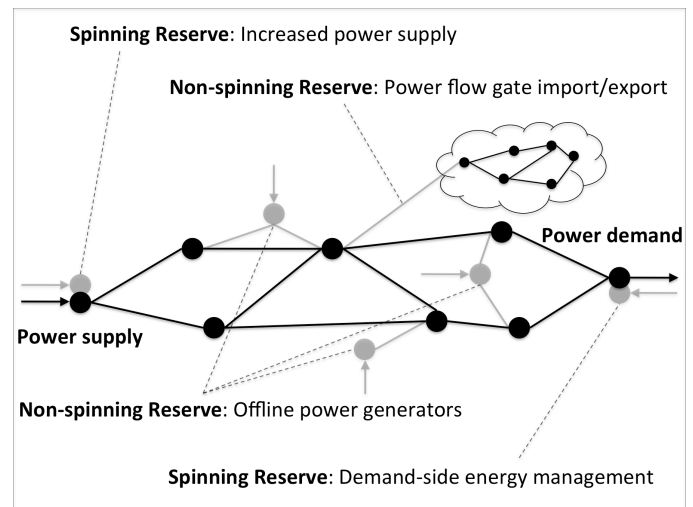
Experimental Verification

Size	$R_{\overline{c_f}}$ LS correlation (%)
100	76
1000	76
5000	77

Online Robustness Optimization

1. Load-balancing

2. Utilization of operating reserves

Spinning Reserve: Increased power supply

Non-spinning Reserve: Power flow gate import/export

Power demand

Power supply

Non-spinning Reserve: Offline power generators

Spinning Reserve: Demand-side energy management

Conclusion & Future work

Experimental verification shows the proposed metric anticipates the cascading failure robustness of a given power network

Online robustness optimization is possible
  - *Load-balancing*
  - *Utilization of operating reserves*

Next: Prototyping and evaluating parallel and distributed algorithms for online optimization of robustness metric

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