Scaling Security Constrained Optimal Power Flow to Multi-Timestep

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Team Performance History

Challenge 2

Event 3: 2nd overall
Final Event Outside of prizes

Challenge 3

Event 2 1st overall
Event 3 3rd overall
Final Event Outside of prizes

Move to multi-period

Challenge 2

- 5 minute time-limit
- Up to six nodes available
- Single-time period

Challenge 3

- 10 minute time-limit
- Single node – no parallel computing
- Multi-time period – up to 48 steps

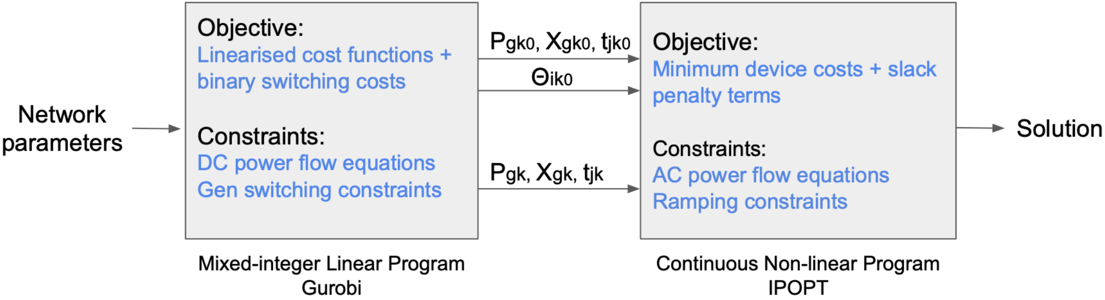
Minimum number of decision variables to guarantee feasibility

(no. of devices $\times$ 2 + no. of buses $\times$ 2) $\times$ no. of timesteps

Minimum number of constraints (not including bounds)

(no. of devices + no. of branches $\times$2 + no. of buses $\times$2) $\times$ no. of timesteps

Basic Approach



Time coupling

1. Ramping limits
2. Unit commitment decisions – up and down time
3. Energy constraints

Time coupling

1. **Ramping limits**

$$p_{j,t} \leq p_{j,t-1} + \Delta$$

$$p_{j,t} \leq p_{j,t}^{max}$$

2. Unit commitment decisions – up and down time
3. Energy constraints

Approach 1: Exact method

Keep a set of variables for every time-step

Pros: Maintains whole feasible space

Cons: For our approach, even after throwing out unit commitment, this would not reliably finish in 10m for networks larger than 4k.

Approach 2: Conservative single time-step

Finding a single solution that will be feasible for all time-steps

$$p_{j,t}^{min} = \max(p_{j,t}^{min} \forall t)$$
$$p_{j,t}^{max} = \min(p_{j,t}^{max} \forall t)$$

Approach 2: Conservative single time-step

Finding a single solution that will be feasible for all time-steps

$$p_{j,t}^{min} = \max(p_{j,t}^{min} \forall t)$$
$$p_{j,t}^{max} = \min(p_{j,t}^{max} \forall t)$$

Pros: Extremely fast and relatively successful.

Cons: Economically inefficient. In rare cases there were instances where $p_{j,t}^{min} > p_{j,t}^{max}$.

Approach 3: Reduced number of time-steps

Break the control horizon into a smaller number of steps

- Pick a time-step mapping (e.g. break the 48 time-steps into four groups)
- Create a set of decision variables for the reduced time-steps

$$p_{j,\tau}^{min} = \max(p_{j,t}^{min} \forall t \in \tau) \quad \text{etc...}$$
$$p_{j,\tau} \leq p_{j,\tau-1} + \Delta \quad \text{etc...}$$

Pros: Economic improvements over single time-step.

Cons: Due to system variables v, θ it is not possible to cluster time-steps for each device. Therefore, it is hard to pick the best time-step mapping. Methods for finding the optimal time-steps would eat into available time.

Bonus: Speculation about where out mistakes might have been

1. Ignoring reserve products initially (and later only adding them in a heuristic way)
2. Two-stage linearized approach was less resilient without parallel computation
3. Line switching (?)
4. Throwing too much out – energy constraints, contingencies