Large-Scale Security-Constrained Optimal Power Flow (SCOPF)

Jeremy Lin, Ph.D
PJM Interconnection
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General Optimal Power Flow (OPF) Problem

- **Objective Function**: cost/bid minimization, active/reactive loss minimization, minimum control movement, etc.
- **Constraints**: power flow balance (equality constraints); lower and upper limits of system equipment (inequality constraints); contingency constraints.
- **State Variables (x)**: bus voltage magnitudes ($|V_i|$), relative bus voltage angle differences (δ_i) with respect to the reference angle.
- **Control Variables (u)**: active power (P), reactive power (Q), generator voltage magnitudes ($|V_G|$), transformer taps, phase-shifters, etc.

Theory versus Practice

- AC-OPF versus DC-OPF
- In DC-OPF, nonlinear system is approximated as linear system; DC-OPF is currently used as the market clearing tool in current electricity markets
- ACOPF is a nonlinear and nonconvex problem, which poses computational challenges and other issues
- AC-OPF solution needs both convergence and proof of its global optimum
- Convex relaxation, linear approximation, ???

Future Challenges

- SCOPF is a general problem with applicability beyond the current electricity markets.
- Network size gets larger with diverse resources and equipment
- Higher level of uncertainties (renewable output, loop flow, transactions, etc.)
- Multi-objective, multi-period OPF; modeling of demand response, storage, PARs, HVDC, FACTS, etc.
- With increasing number of continuous and integer variables, the complexity of power system optimization just grows!!

ARPA-E GRID DATA
Grid Optimization (GO) Competition – Phase I

- Large-scale, realistic, validated, open-access power system model for AC-OPF (benchmark test system)
- Multiple objective functions of optimization problem possible, but cost minimization (SCED) is the most dominant and relevant
- To be able to handle higher number of constraints which are sometimes in conflict (constraint violations may be acceptable?)
- At least, *N-1* secure, but *N-1-1* or *N-2* secure are welcome
- Near-global optimal solutions are acceptable?
- Algorithm solution provides state (voltage magnitude and angles) and control variables (generation set points) of the system

From System Operator/Market Operator Perspective

- SCOPF solution guaranteed (convergence)?
- Is the optimal solution good? or bad? (global vs local optimum)
- Any constraint violation? How it handles these violations if they show up? Does the algorithm stop or skip them?
- Solution time (computation time) reasonably fast?
- Are optimal solutions easy to explain to stakeholders?
- Any other hidden problem or issue in the algorithm?