The ARPA-e Benchmark Algorithm

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Power Systems Optimization Foundation

- Staff Scientists at Los Alamos National Laboratory
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- AC Optimal Power Flow
  - Convex Power Flow Relaxations (QC formulation)
  - Power Flow Approximations (LPAC formulation)
  - In collaboration with Pascal Van Hentenryck and Hassan Hijazi
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• AC Optimal Power Flow
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• OPF Benchmarking
  • Highlighted significant problems with open-test cases
  • IEEE Task Force on Benchmarks for Optimization Algorithms
  • Power Grid Library Benchmarks (PGLib)
Open-Source Optimization Software

- PowerModels.jl
  - Tool for Research in Power System Optimization
  - Read Matpower and PSSE files
  - State-of-the-art AC-OPF Solutions
  - Convex Relaxations (SOC, QC, SDP, ...)
  - Optimization Based Bound Tightening
  - ...

julia

scientific computing made easy

mathematical optimization in Julia
Open-Source Optimization Software

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Add SCOPF to the PowerModels Toolbox!
My Roles in the Competition
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• Dataset Validation and Ranking
  • Look for problems in the datasets
  • Check that problems are not “too easy”
  • Attempt to rank scenarios based on hardness
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• Dataset Validation and Ranking
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• Develop the “APRA-e Benchmark” Algorithm
  • Test drive the evaluation platform
  • Compare and contrast different solution approaches
Data Validation Example

Public Network Data

Competition Synthetic Network Data

AC–OPF Strict Generation vs Objective Cost

- pglib (n=130)
- goc–o (n=772)
- goc–r (n=773)

Objective Cost (log, $/mw/h)

Generation (log, mw)

- ieee
- rte
- pegase
- grid data
- other
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The Benchmark Algorithm
Basics of the ARPA-e Benchmark Algorithm

Initial Operating Point (DC-OPF)
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- Initial Operating Point (DC-OPF)
  
  - Check Contingencies (DC-PF)
    
    parallel workers (72 in competition)
Basics of the ARPA-e Benchmark Algorithm

Initial Operating Point (DC-OPF)

Check Contingencies (DC-PF)

violations (ptdf cuts)

Secure Operating Point (e.g. DC-SCOPF)

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Basics of the ARPA-e Benchmark Algorithm

- **Initial Operating Point (DC-OPF)**
  - parallel workers (72 in competition)
  - Check Contingencies (DC-PF)
  - violations (ptdf cuts)

- **Secure Operating Point (e.g. DC-SCOPF)**
Basics of the ARPA-e Benchmark Algorithm

- Initial Operating Point (DC-OPF)
- Check Contingencies (DC-PF)
- Secure Operating Point (e.g. DC-SCOPF)
- AC-Crossover Solver

Flow:
- Initial Operating Point to Check Contingencies with violations (ptdf cuts) to Secure Operating Point
- Secure Operating Point feeds back to Check Contingencies with no violations
- Parallel workers (72 in competition)
Basics of the ARPA-e Benchmark Algorithm

Initial Operating Point (DC-OPF) → Check Contingencies (DC-PF) → Secure Operating Point (e.g. DC-SCOPF)

- violations (ptdf cuts)
- no violations

parallel workers (72 in competition)

AC Contingency Solvers (i.e. code2) → AC-Crossover Solver
Basics of the ARPA-e Benchmark Algorithm

- Initial Operating Point (DC-OPF)
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- Secure Operating Point (e.g. DC-SCOPF)
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Notable Engineering Details (see poster session)

- parallel workers (72 in competition)
- violations (ptdf cuts)
- no violations

AC Contingency Solvers (i.e. code2)
The ARPA-e Benchmark Algorithm Source Code
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https://github.com/lanl-ansi/PowerModelsSecurityConstrained.jl
PowerModels with Security Constraints

• Solve Grid Optimization Competition Challenge 1 Problems (v0.1)
  • Fully open-source with solvers like Ipopt, Cbc (zero licenses, easy for HPC)
  • Easy to use with faster commercial solvers (e.g. Gurobi)
PowerModels with Security Constraints

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• Broad Goals
  • a foundation for SCOPF research (e.g. the “Matpower” of SCOPF)
  • optimization with contingency constraints
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• More problems on the way, e.g. SCED and SCUC…
Two Concluding Thoughts
Looking back to the 2014 ARPA-e OPF Algorithms Workshop
Optimization Super Heroes

An All-Star Cast!
Thanks!