Deploying Optimization Applications for Power Grid Operation

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Agenda

• Current status of optimization deployment
• Path from research to deployment
• Research directions
Current Status of Optimization Applications

Overview

• Have gained acceptance; currently performing critical functions in Control Centers operations:
  – Bulk power grid (EMS): SE, OPF, UC,…
  – Wholesale market (MMS): Market Clearing (SCUC/ED, FTR)…
  – Distribution grid (DMS): VVC, Feeder Switching (AFR, FISR)…

• Have unrelenting demand for faster and smarter solutions
  – Problem definitions/characteristics
  – Solution technology: optimization + others
Current Status of Optimization Applications

Active Set Strategy via SFT

- Market Clearing Engines (MCE)
- Market Control
- Market Database (MDB)
- Market Operator Interface (MOI)
- Market Participant Interface (MPI)
- Simultaneous Feasibility Test (SFT)
Current Status of Optimization Applications

Evolution of SCUC Optimization

1996: Dynamic priority order
Sequential bidding (LR + SB)

2003: Mixed-Integer Programming

2001: Enhanced Lagrangian Relaxation

2013: AIMMS 3.13 & CPLEX 12.5

2016: Hybrid MIP with meta-heuristic and stochastic optimization

Fixed priority order for unit startup and shutdown

Dynamic priority order (LR + DP)
Current Status of Optimization Applications

*Optimization problem characteristics & solution requirements*

- Mildly non-linear AC powerflow
- Many inequality constraints ($N_{br} \times N_{ctg}$), very few binding
- Binding inequalities for (contingency) grid security have dense constraint rows
- Require primal (MW) and dual (price) solutions
- Integer constraints often critical (e.g. SCUC, AFR)
- Special handling: e.g. infeasibility, tie-breaking (price & quantity)
- Close-loop automation for 5-min RT Dispatch cycles
- Complex problems typically analyzed with human-in-the-loop, e.g. interactive scenario definition and analysis
- Consistency, transparency, auditability are critical
- IT/OT Integration required for production deployment
Path From Research to Deployment:  
*The art and science of grid optimization*

![Diagram showing the path from Business Problem to Assess Solution with stages such as Math Model, Data Prep, Optimz Solver, and Assess Solution.]

- Conceptual
- Formulation
- Precision
- Performance
- Decision

Anticipate, Identify, Remedy Gaps

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Business Use Case:
Day-Ahead Market Clearing
R&D Directions

• Extended Problem Complexity:
  – Risk-based decisions
  – Multi-level & distributed decision: coordination, aggregation
  – Extended domain: gas-electric coordination,

• Improved optimization technology:
  – MIP: hot-start, heuristics
  – Stochastic/robust optimization
  – Post-solution assessment & suggestions

• IT/OT Integration
  – Visual analytics
  – High performance computing