High Fidelity, Year Long Power Network Data Sets for Replicable Power System Research

Project GridData, DOE/ARPA-E

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Outline

• Overview of the Project

• First ideas
  – An new format
  – Network types
  – Problems
  – Transformations

• Open questions
Project Team

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• Pascal Van Hentenryck (Michigan) [CS/OR]
  – optimization for power systems, computer systems
Name of the project
– intended to last beyond the ARPA-E project

Grid Data For Good (GDG)
Project Overview

• **Format**
  – new format capturing networks with high-fidelity

• **Modeling**
  – specifying components, devices, and corrective actions accurately

• **Test cases**
  – RTE test cases: French transmission systems at various voltage levels
  – Synthetic benchmarks: transforming realistic test cases

• **Validation and analysis tools**
  – validating test cases for realism and difficulties

• **Obfuscation and disaggregation**
  – from real test cases to anonymous test cases preserving their essence
Why a new format?

A format appropriate for computational tools in power systems

• Key features:
  – high fidelity
    ► describes the components used in industry
      → including discrete behavior, modeling of corrective actions, ...
  – standardization of the components
    ► schema and equations
  – extensibility
    ► easy to add new components
  – general-purpose
    ► can represent a wide range of problems
Example: Substation Topology

Bus-Branch

Bus-Breaker

Node-Breaker
Advanced Features

- The format will go beyond the network format
  - it will include new concepts that are typically hidden in internal tools

- Key objective
  - automate, at a high level, many such tools
    - e.g., no need that the entire world reimplement a per-unit transformation

- New concepts
  - network types
  - problem types
  - transformations
Network Types

- **A network type specifies**
  - parameters (aka data or constants)
  - decision variables (what algorithms can decide upon)
    - e.g., active power of a generator
  - state variables (what describes the system state)
    - e.g., phase angles
  - additional required attributes
    - attributes that must be present
  - components
    - the set of components supported by the “targeted” algorithm
Problems: Preliminary Specification

- **Purpose**
  - define what a problem is

- **Key ideas**
  - include a network type
  - include an objective function: e.g., minimizing squared differences to generator set points
  - include additional constraints: e.g., Security constraints = Multi states
  - may include selection of parameter values: e.g., activation of AGC

- **Objective functions (and constraints)**
  - component wise: expressed directly in terms of their fields and parameters
  - almost all interesting problems satisfy this!
Transformations:

- **Purpose**
  - Transform a network into another network

- **Key ideas**
  - the network specification is very general
  - we can specialize it for different problems
  - we can transform it into a different network
  - we can specify a (feasible) solution
  - we can compose them

- **Benefits**
  - same syntax
  - one tool for specifying the network and its transformation
  - documentation (provenance)
Some open questions

- **Dataset are not self contained, we need mathematical models to understand the meaning of data.**
  - E.g: HVDC LCC reactive response, remedial actions, ....
  - Do you need to exchange mathematical models and not only data?
  - Is there emerging standards to do this? Modelica?

- **Corrective actions are sometimes implemented using closed loop controls. Any credible SCOPF must take into account these actions**
  - How to that using only a static modeling? Computation of final steady states?
  - Is using multi states a possible solution? (Base case) + (Post contingency state)+ (Post contingency & corrective actions state)
  - The consistency of the modeling of each component is critical (time response)
  - Do we need to include explicitly the dynamic behavior through DAE in optimization problems? Scalability? Computation time? Data management?

- **Active Distribution Networks (ADNs):**
  - How to take into account ADNs in power system optimization? Simplified responsive aggregated models?
  - How to define these aggregated models? Complexity even larger than the unsolved load modeling issue!