Large-Scale Automated Model Builder

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Outline

- Load Flow Model Builder Concepts
- Automated Model Builder Applications
- Overview of Model Building Process
- Future Directions

Applications

- Future Chronological Power flow models are required for many tasks/applications:
  - AFC/ATC calculations
  - Outage analysis
  - Transmission planning
  - Market applications
  - Near term operations tasks

Model Building Concepts/Overview

- Start from static “all-in” model as a starting point
  - Typically MMWG or NERC IDC seasonal model for planning
  - EMS based for market applications and near term applications
- Apply dynamic events – incremental changes for selected time window
  - Generation and transmission outages
  - Load forecast
  - Additional subsystem-based transfers
- Dispatch generation
- Solve AC load flow

Model Building Complexities

- Past experience says it is not that simple. Why?
  - Developing models manually or via user developed scripts requires significant effort and can be the most time consuming part of the study. Not a reliable approach for large scale projects that need to be repeated regularly .
  - Problem is in capturing details, making and tracking numerous small changes
  - Difficulty using “pure database” approach involving in-service and out-of-service dates, particularly with dynamic data inputs such as outage schedules
- Handling of external areas
  - Require/desirable to use data for multiple control area
  - Typical transmission modeler concerns:
    - If it is a lot of effort to develop a model for my control area, can it be done for external control area?
  - Would that external area “bless” that dispatch?

Initial AMB Application: AFC/ATC Calculations for OASIS Posting

- FERC orders 888-890, 729
  - Mandate a calculation and posting of Available Transfer Capabilities on economically viable paths that is consistent, transparent, reproduce-able, and representative of the most current system forecast data available
  - AMB is the backbone of AFC/ATC solution
- Joint Reliability Coordination Agreement
  - Initially between MISO and PJM, now includes several other entities
- Data sharing and coordination makes it feasible
  - NERC SDX for load forecasts and outages
  - External OASIS reservation information
  - NERG tags for energy schedule information
  - External flowgate AFCs via Coordinated flowgates

Status and Implementation details

- Used by many major Eastern Interconnection companies for several years now
  - PJM, TVA, MISO and others with combined peak exceeding 400,000 MW of load, 3 times zones

- Automatically builds
  - 48 hourly models every hour
  - 168 hourly/35 daily models multiple times per day
  - 18 monthly models
  - Totals more than 1,800 LF models per day, all models are AC solved

- Computed flowgate AFCs and sensitivity factors directly feed into PowerGEM AFC/ATC process

AMB Applications: Reliability/System Security Analysis

- Reliability Analysis of Approved outages
  - Example – One AMB user creates Eastern Interconnection wide models for next 35 days and performs full AC N-1 analysis – daily
  - By-product of AFC/ATC process
- Near-term what-if scenarios
- With proper data, setup can be used to build transmission planning growth scenarios
- The AMB process can build models from an online EMS 'seed' case, allowing breaker-level detail for contingencies and evaluating outages

AMB Applications:
Automated Outage Evaluation Analysis

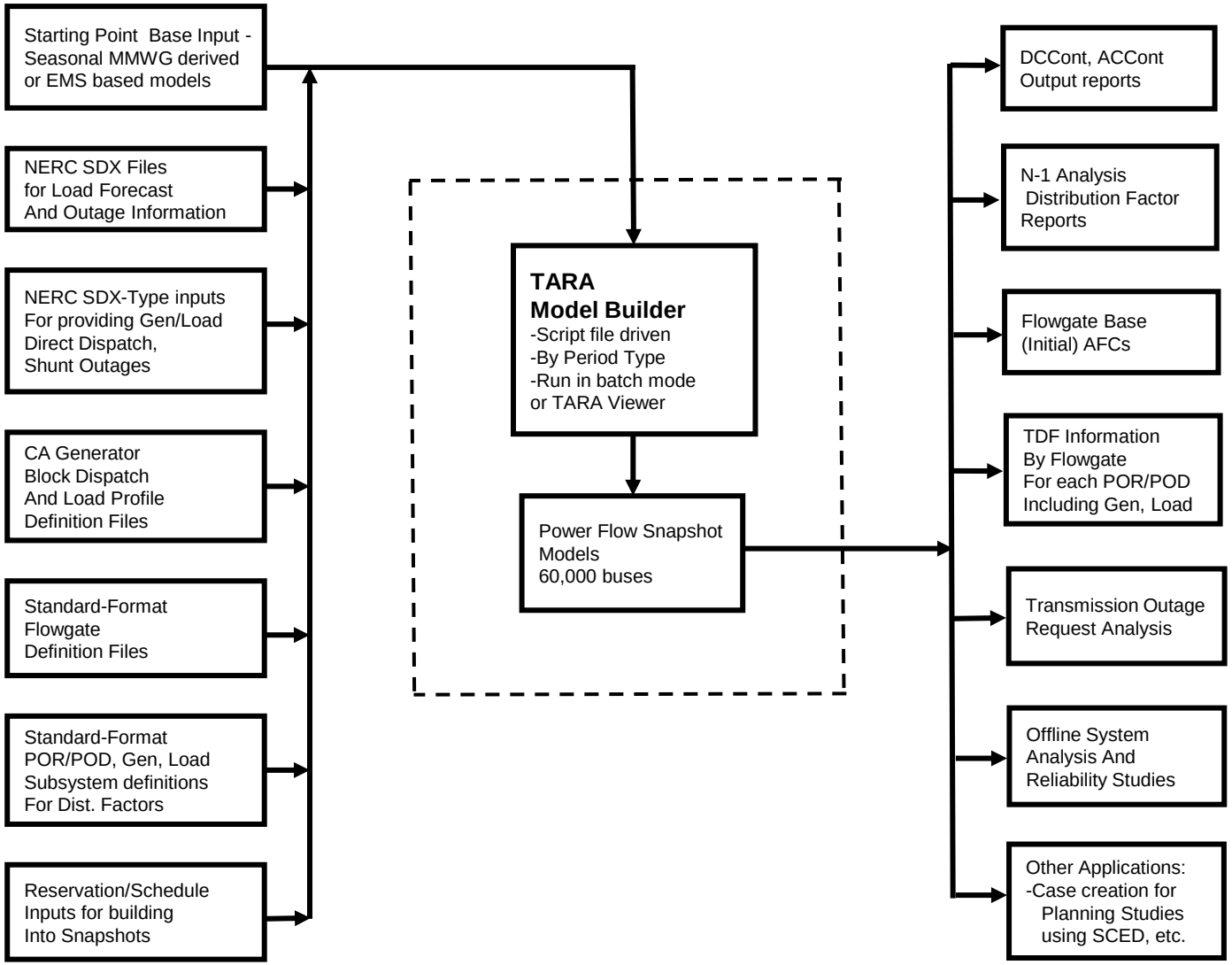
- Build models for various future time periods. Examples:
  - Next day hourly models or just peak/off-peak model
  - Near term 35 daily models
  - 90 daily models representing months 6 through 9
- Automatically evaluate all outages occurring in the study time window
- Evaluate outages
  - One at a time
  - In order of submission
- Decline or approve based on reliability impacts
- Find new outage opportunity window

Common Requirements

- Models should represent multiple control areas
  - MMWG/IDC load flow models represent the best available Eastern Interconnection wide load flow models for planning applications
    - Up to 60,000 buses, 100+ control areas

- Created models should be AC solved
  - Reliable and high performance is critical
- Constructed in an automate-able and reproduce-able/auditable manner
- Time horizons
  - Hourly
  - Daily (representative peak and off-peak models)
  - Monthly peak

TARA AMB Process



Where to Get Input Data?

- NERC System Data Exchange (SDX)
- Eastern Interconnection control areas submit/update data several times a day
  - Data time periods range from next few hours up to several years into future
- Members can download information
  - Load forecast for various future time periods
  - Transmission outages
  - Generation outages & de-rates
- System topology in baseline model must align with NERC IDC case
- If NERC SDX data is not available
  - load forecast and outage information provided from 'internal' sources can also be used
- Transactions data
  - External OASIS reservation information
  - NERG tags for energy schedule information

Modeling Outages and Scenarios

- Transmission and Generation outages
  - What to do with outages lasting a fraction of the represented time?
  - i.e. when creating daily peak case, do we include an outage that lasts one hour in early afternoon?
- TARA AMB process utilizes a ‘representative time window’ for selection of outages applied to longer time period models
- Same approach can be used to model future transmission upgrades and retirements

Generation Dispatch Methods

- Block Dispatch – variation of merit order dispatch
  - Divide generation into groups or blocks and dispatch proportionally by blocks
- Direct Dispatch – do not follow economic dispatch rules
  - Hydro, pumped storage, wind, pre-scheduled units
  - User defines output by time of day or time of year
- Dispatch plants or individual units according to bilateral transaction inputs (reservations or schedules)
- SCED (Security-Constrained Economic Dispatch)
  - Economic-based. Provides N-1 secure cases
  - Challenge – running SCED for multiple control areas, as typically each area enforces only internal constraints

Challenges Solving Load flow

- Solving power flow models involving such wide-scale changes is a challenge for fully automated applications using MMWG models
- Using “peak conditions” seed model to create off-peak models is inherently difficult due to voltage schedules, VAR profiles, etc.
- MMWG modeling information may not be entirely correct
  - Conflicting voltage schedules from different control devices
  - Voltage schedule ranges too narrow to arrive at a ‘satisfied’ state
  - Leads to oscillation of controls (taps, shunts, gen setpoints)
- A simple error in a remote area can “kill” the process
- Various solution techniques have been developed to improve the solution or identify local areas causing solution problems

EMS Trend

- Recent requests to use EMS as a base model to build future cases
- Include relevant breakers as zero-impedance lines
- TARA topology processor converts EMS equipment connection descriptions to standard load flow format
  - EMS data formats are not standard yet
- Customer's internal outage and contingency definitions are used
  - Matches EMS equipment names
- Apply a real-time historic load profile to base
- Future work –combine MMWG with EMS model for selected area

AMB performance

- Computers and software are fast enough now
- MMWG models - 60,000 buses
  - Every hour next 48 hourly model – takes ~3-4 min
  - Advance applications using AMB models (such as large scale AC contingency analysis) take more time than AMB model creation
- EMS models
  - 12,000 buses - created 720 hourly cases with N-1 SCED applied – every hour of the month; 45 minutes run time
  - Stress test – tested full EMS model without any reduction for a large ISO
    - has ~200,000 buses, > 150,000 zero impedance lines
    - Successfully tested/AC solved/N-1
    - Normally reduced to ~40,000 buses

Future directions

- Expand usage of existing AMB features
  - Expand usage of EMS models
  - Models on demand
  - Improve/simplify usage of MMWG/IDC models
- Improve data sharing between control areas
- Standardize planning and EMS data formats
- Better integration and more standard solutions for various applications

Possible Future Direction

Centralized AMB process for the whole Eastern Interconnection

Is it feasible?

- Users?
  - All companies within Eastern Interconnection
  - Case repository at a central location
  - Accessible to all participants

Centralized AMB Process for the Eastern Interconnection

- Existing AMB process can be used with little changes
  - Well tested process for several years now
  - Models Eastern Interconnection without any reduction now
  - Someone has to administrate the process
  - Scalable and can be executed in parallel/independently at different locations
- Challenge
  - Quality – it is up to users. The more information control areas submit, the better their local models will be
  - AMB process has to dispatch multiple control areas simultaneously
  - Coordination between control areas requires further discussion
- Future - Centralized AMB with EMS - Phase 2
  - Develop capability to import EMS model for selected control area

AMB Summary

- AMB is a process to create chronological LF models for any future time interval
- Generic, yet customizable approach
  - Can be applied for any company within Eastern Interconnection with incrementally small efforts
  - Most of the information required is readily available via NERC SDX and information shared between companies
  - Can be used by Western Systems companies with a smaller scope, since adjacent company information is not yet readily available
- Tailor-made for processes requiring frequent evaluation of multiple future time horizons such as:
  - AFC/ATC calculation for OASIS posting
  - System security evaluation for facility outage requests

Questions?