Numerical Libraries

Summary of Discussion on Day 1

Kendall Demaree

- Data Governance – semantic models
- Data storage
- Functional librarires
- Functions, platforms, short term values
- Innovation
- Versioning, security, standards
- Reproducible, automated testing
- Commercial terms matter
- Support needs
- Integration is a large cost item

Scott Backhaus

- Power system applications to motivate the libraries
- Wind generator failures add to the large number of likely contingencies
- Extreme statistics
- Chance constrained OPF
- Aggregated dynamic distribution load
- Load model libraries needed

Bruce Palmer

- GridPACK
- High level abstractions modules
- Reduce explicit communications
- Commonly used functionality for HPC power system applications
- Parallel software
- Math modules, solver modules, etc.

Jean-Baptiste Heyberger

- In the past RTE develops everything, including low level solvers
- EUROSTAG
- PEGASE, simulation of very large systems
- DAE SUNDIAL
- DC OPF
- AC OPF
- Promote open solutions

Questions

Numerical libraries: Library design, parallel computing techniques, mathematics to enable more efficient computation.

- Advanced solvers, advanced algorithms
- What are key open mathematical research questions problems?
- What are the key open numerical techniques that are broadly needed for the power grid applications? What performance requirements must they meet? What other operational requirements?
- How do we provide databases to drive research and validate approaches?
- How do we work together to maximize progress and transfer new technologies out of research?
- What are the added values compared to existing libraries?

Issues Discussed

- Power system applications
- Solvers
- Algorithms
- Math/Numerical Methods
- Requirements

Power System Applications

- Dynamic security assessment (Use Case: large number of contingencies, PMUs)
- Dynamic state estimation (Use Case, PMUs state monitoring, observability, extracting info on dynamics)
- Renewable MW forecast
- Multi-temporal-spatial scale model
- Stochastic optimization/scheduling
- Real time path rating (Use Case including dynamics)
- Restoration planning – both transmission and distribution
- Decision support
- Extreme events with stochastic generations (Use Case: Cascading, catastrophic events)
- Aggregation of dynamic distribution load
- Energy planning
- Topology estimation (can overcome bad data?)
- Better categorization based on utility business

Solvers (Parallel computing and large-scale, sparsity implied)

- Linear algebraic equations (e.g. algorithm improvement for sparsity, Use Case)
- Nonlinear algebraic equations (Use Case)
- Eigenvalues (Use Case, compute the most relevant EVs)
- Dynamic simulations (Use Case: real time dynamic security, parallel version of existing software)
- Differential algebraic equations
- Constrained and unconstrained optimization (linear, nonlinear and discrete, Use Case: Integer variables)
- Dynamic model reduction
- Stochastic optimizer

Algorithms

- Class of nonlinear optimization problems important to power systems
- Class of parallel computing power system application solvers (Use Case)
- Least square
- Filtering (dynamic systems)
- Uncertainties quantification (Use Case, developing probability distribution functions based on statistics)
- Scenario generation
- Dimension reduction (Use Case: link to visualization and decision support)
- Integration of discrete optimization with nonlinear power flow model
- Discrete events in continuous systems
- Optimal control of dynamic systems
- Benchmarking with existing tools

Math/Numerical Analysis

- (Bender's) Cut
- Uncertainties propagation
- Large scale, sparse, direct/iterative linear solver in parallel (Use Case)
- Semi-definite programming
- Correlated random input
- Analysis and control of distributed dynamic systems
- Graph theory for partitioning
- Extreme statistics (Use Case: rare, patterns of cascading)

Requirements

- Verification (Test cases and quantifiable metrics)
- Performance (Robustness and consistency)
- Realistic, synthetic test cases (Real environment)
- Benchmarking, performance profiling for various tasks (Use Case)
- Diagnosis of software
- Goal-driven test cases
- Secure software
- Establish a community of libraries, build a multidisciplinary community, Use Case)