A Lyapunov Function Based Remedial Action Screening Tool Using Real-Time Data

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Background and Motivation

- More grid disruptions in the last decade than any other similar period in history
- A key lesson from the August 2003 event was that grid operators needed increased situational awareness, and improved understanding of remedial action alternatives available to them
- Current practice uses online contingency analysis but operators rely on offline stability studies to determine which remedial actions to avoid
- This project uses a Lyapunov approach that can rapidly identify which groups of remedial actions will likely result in stabilizing trajectories

Technical Approach: Concept

- Conventional power system models are highly nonlinear (smooth) dynamical systems with multiple equilibria
- These multiple equilibria shape the dynamics of the nonlinear dynamical system
- Solely relying on time-domain simulations of such highly nonlinear systems, which are initial-condition dependent, to explore all scenarios can be a time-consuming exercise if possible at all
- What is needed is a set of tools that reduce this search space by predicting, without completely relying on time-domain simulations, what type of system trajectories are convergent

Validation on RTDS®

RTDS® simulator at FSU-CAPS

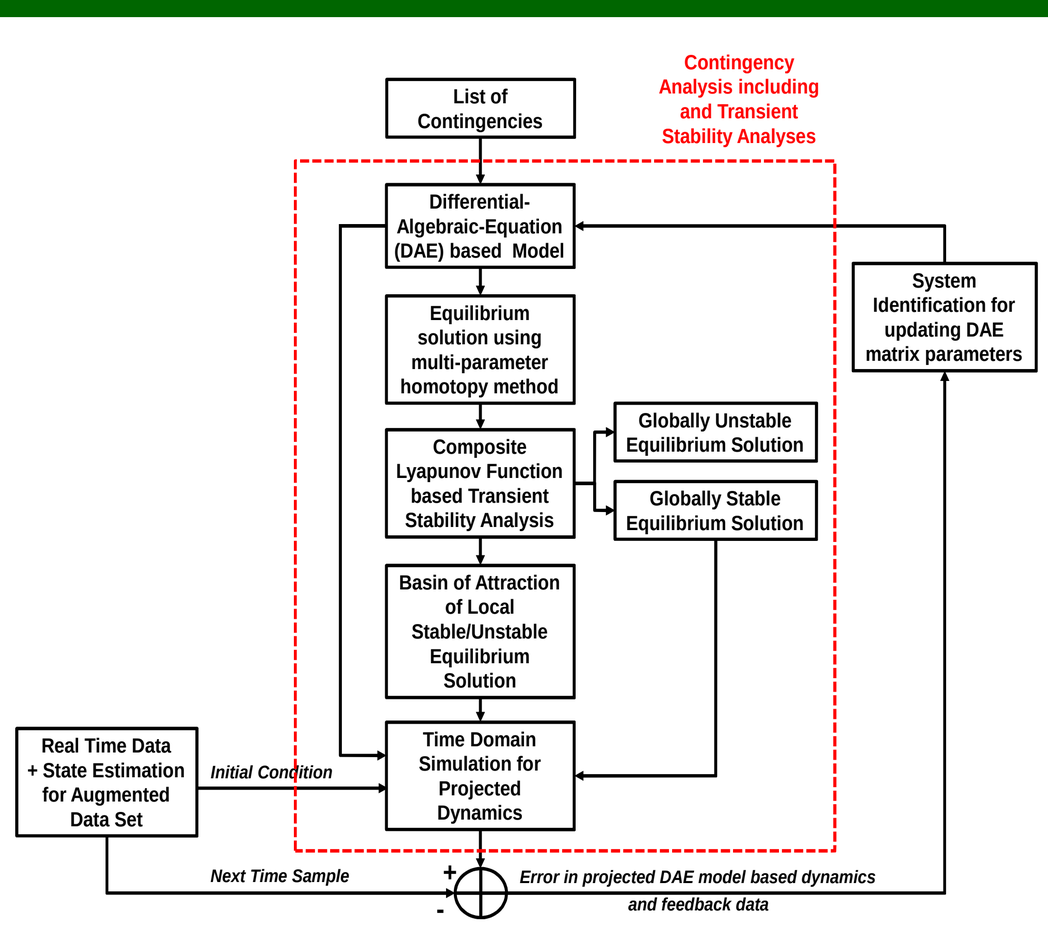
- An RTDS® model based on real network data will be built
- Since the model will run in real-time, it will mimic the behavior of real-system
- PMU hardware will be installed to stream measurements from systems simulation

High performance computing platform at MSU

- It will receive PMU data from FSU-CAPS lab located at Tallahassee
- Ethernet communication will be used
- Based on the simulation results, actuating signals will be sent to the operation/control center

Project Objectives

1. To develop a Lyapunov function based method of transient stability analysis that can be solved at real-time speed without the use of massively parallel computation resources
2. To apply the method developed in (1) to perform remedial action screening (RAS) at real-time speed. Also develop research-grade algorithm implementing this feature
3. To validate the methods and algorithms, including real-time performance, developed in (1) and (2), on a large-scale real-time digital simulator (RTDS®)
4. To incorporate in the tool described in (2) above the capability to update system status in real time
5. To develop a visualization tool for operator interface



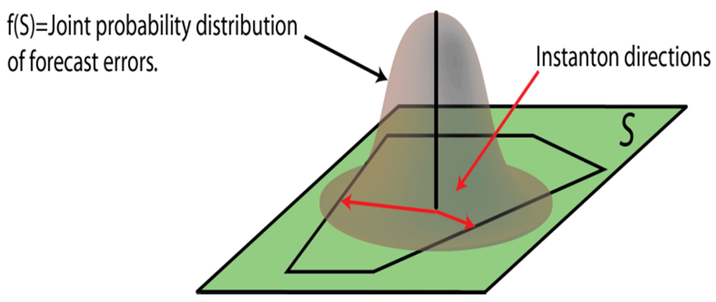
Project Team

- Michigan State University (MSU)
  - Joydeep Mitra (PI)
- University of Illinois Chicago (UIC) and NextWatt LLC
  - Sudip K. Mazumder
- Florida State University Center for Advanced Power Systems (FSU-CAPS)
  - Omar Faruque
  - Mischa Steurer
  - Rick Meeker
- Los Alamos National Lab (LANL)
  - Scott Backhaus
  - Misha Chertkov
  - Russell Bent
- LCG Consulting (LCG)
  - Sidart Deb
- Southern California Edison (SCE)
  - Juan Castaneda
  - Michael Montoya

Comprehensive Approach

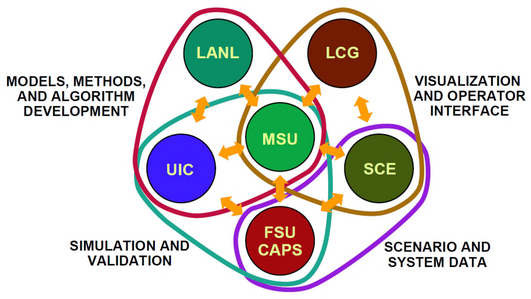
- Multi-expertise project team for theoretical and algorithmic development
- Real-time interaction, demonstration and validation using equivalenced utility system and scenarios simulated on RTDS® cluster
- Integration with a visualization and operator interface tool (similar to SCADA displays in control rooms, but with embedded RAS)
- Vetting by utility partner

Statistical Trajectory Analysis



An instanton measures the distance and direction from the most probable configuration of the uncertain resources to the boundary of the feasibility domain in the space *S* of fluctuating network injections. The instanton also quantifies the probability of encountering failure along this direction

Project Functions and Deliverables



1. Online Remedial Action Screening Tool

   Computer software integrated with visualization tool and operator interface
2. Test Bed and Operator Training Facility for Remedial Action Screening and Grid Security Research
3. Workshops and Project Web Site
   - Research outcomes disseminated through journals, conferences, workshops
   - Articles, reports, webinars published on web site