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Non-Wire Methods for Transmission Congestion Management Through Predictive Simulation and Optimization

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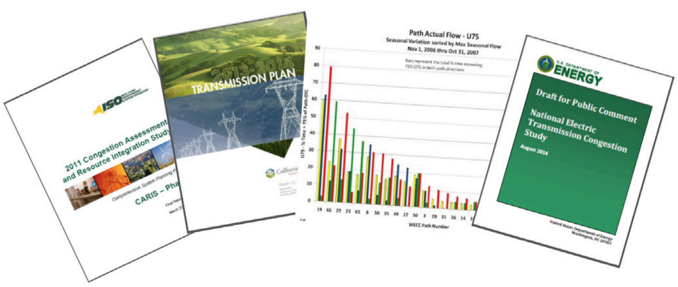
Partners: Quanta Technology, PowerWorld Corporation, and Bonneville Power Administration

Critical Need

» On the U.S. power grid, transmission congestion:

- Incurs significant economic costs—The New York ISO experienced more than $1.1 billion in congestion costs in 2010
- Prevents renewable integration
- Becomes worse and more complicated due to uncertain and stochastic power flow patterns caused by new generation and demand response.



» Building more transmission lines to address congestion faces significant challenges:

- Transmission build-out lags behind load growth
- Additional constraints exist, including financial and cost-recovery issues, right-of-way, and environmental considerations.

» The current "path rating" practice used to manage electricity flow and congestion is based on conservative ratings from offline studies using worst-case scenarios. This approach is causing artificial congestion.

- Involves many runs of transient stability and voltage stability simulations
- >24 hours for one path rating.

Our Solution

PNNL and partners, using advanced computing-based methods, are developing a real-time path rating prototype tool. This innovation will tap unused capacities, enable optimal use of transmission assets and reduce the need for building new transmission lines.

» Short-term goal: Develop technologies that determine the amount of unused capacity, in real time, by reducing computation time from hours to 10 minutes

» Long-term goal: Integrate unused capacities in power grid operation and markets.

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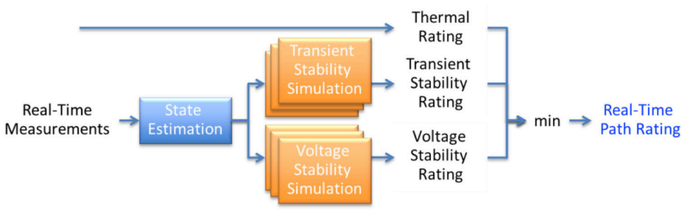


Diagram conveys how measurements and forecasts are translated into a realistic path rating that maximizes use of transmission assets and relieves congestion.

Proposed Technologies

» Develop High Performance Computing (HPC)-based transient and voltage stability simulation with innovative mathematical methods

» Develop HPC-based real-time path rating capability

» Demonstrate the non-wire method on a commercial software platform with real-life power system scenarios.

Proposed Targets

Metric	State-of-the-Art	Proposed
Simulation speed	3-5 times slower than real time	10-20 times faster than real time
Path rating study interval	Months	<10 minutes
Asset utilization	Conservative	Enhanced by ~30%

Results to Date

Massive Contingency Analysis

Goal: Evenly allocate contingency scenarios across available computing processors.

» Approach: Dynamic computational load balancing with a global counter

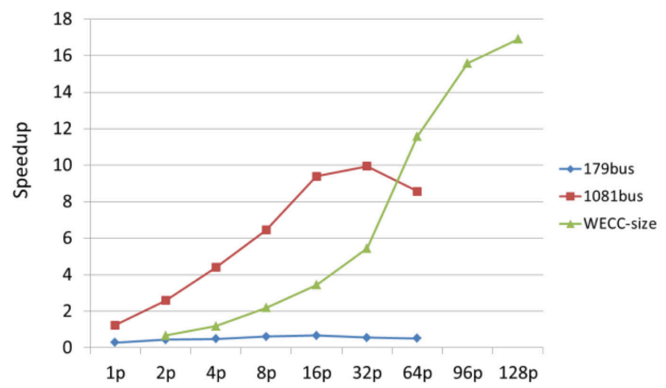
- Implemented in GridPACK™
- Tested with 400 contingencies of a WECC-size system with near-linear speedup
- 12.7s to complete 400 contingencies using 400 processors.

Parallel Transient Simulation

Goal: Obtain 10x speedup compared to today's commercial tool.

» Key algorithms:

- Decoupled models for calculating states in parallel
- Identified KLU linear solver for solving network coupling
- 15.8s to complete one 30s dynamic simulation for a WECC-size model with 8 processors.



Benchmark: PowerWorld simulation on a laptop with 1.8 GHz processor

Fast Voltage Stability Simulation

Goal: Develop a non-iterative method to find voltage stability boundaries.

» Approach: Combination of several methods: Continuation power flow; X-ray theorem; Orbiting method; High-order numerical method

- Validated accuracy against PowerWorld
- Used only 9.5s to find a new boundary point after initial point is identified for a WECC-size model, 10.64 times faster than today's approach.

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