

Ensuring the Operational Security of Power Grids Using On-Line Dynamic Security Assessment Technology

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Overview of the presentation

- Dynamic security assessment
- What is on-line DSA
- Why doing DSA on-line
- Brief description of on-line DSA
- Advantages
- Applications
- Benefits

About Powertech

Powertech Labs Inc. is a fully owned subsidiary of BC Hydro located in Surrey, BC, Canada

Dynamic security assessment

Dynamic Security Assessment (DSA) is an evaluation of the ability of a power system to withstand a defined set of contingencies and to survive the transition to an acceptable steady-state condition

- Required in power system planning and operation
- Insecure conditions may appear as
 - Overloading in transmission equipment
 - Unacceptable voltage deviations
 - Unacceptable frequency deviations
 - Voltage collapse
 - Transient instability
 - Poor or unstable oscillations
 - Frequency instability
 - Others

What is on-line DSA?

- **Objective**: ensuring secure operation of a power system
- What's the difference from the conventional (off-line) approach?
 - Start from a **real-time captured**, or forecast, system condition
 - Consider all applicable security criteria and credible contingencies ("compliancy")
 - Include high fidelity system models ("model-based analysis")
 - Perform analyses automatically, periodically, and efficiently
 - Present results in simple, straightforward way security margin, operational limits, remedial actions required, etc.

Today, on-line DSA is a mature application running in many control rooms around the world

Why doing DSA on-line?

- Improved grid security . . . prevent blackout!
- Better situational awareness in control rooms
- Dealing with unpredictability and uncertainty in grid operation
- Maximized use of transmission capacities
- Requirements in power market operation
- NERC compliancy (TOP, etc.)
- Fast and accurate controls
- Reduced cost in staff training
- Technology makes this possible
- More . . .



Three key elements in on-line DSA



Algorithm



analysis

Trajectory

sensitivities

- Distributed/ parallel/cloud computations
- Big data analysis
- Probabilistic analysis
- AI methods

New methods are being proposed and applied continuously

Modeling

In addition to the models considered in the conventional security analysis of power systems, additional models or modeling techniques are required for on-line DSA

Examples:

- Dynamic rating
- Node/breaker modeling
- Realistic contingency sequences
- RAS and SPS models
- Renewables
- Real-time closed loop controls
- Real-time equipment status
- External system equivalencing

Integration



On-line DSA

- RT model recondition/match
- Auxiliary data management
- Resource & data sharing
- Analysis scenario creation
- Performance monitoring
- Result processing & display
- Failover & security

Auxiliary databases

Computation engines

Distributed/parallel/ cloud computing

Applications

- The application areas of online DSA have been expanding . . .
 - Monitor system security
 - Determine stability limits
 - Recommend remedial control actions
 - Manage renewable resources
 - Determine/verify special protection systems
 - Mitigate congestion in a power market
 - Determine active and reactive power reserves
 - Complement PMU applications
 - Serve as data sources for dispatcher training simulator (DTS)
 - Help in scheduling equipment maintenance
 - Calibrate and validate power system models
 - Prepare models for system studies
 - Perform system restoration
 - Perform post-mortem analysis of incidents

Who are using this technology?

- At least 7 out of 9 ISO/RTOs in North America have operational on-line DSA systems
 - A dozen or so transmission companies and other utility companies have also implemented on-line DSA
- World-wide, the trend continues
 - UK
 - Ireland
 - Australia
 - New Zealand
 - Brazil
 - Japan
 - Korea
 - China
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Application example: BC Hydro

- Major transfer paths constrained by stability
- SPS (generator tripping) used to ensure system security
- Real-time generator tripping arming requires on-line lookup table update
- On-line DSA is used for the lookup table update
 - A closed-loop control
- Additional functions available to monitor voltage stability and to compute TTC



Application example: BC Hydro (cont'd)

- The lookup tables are updated every 4 minutes to determine
 - Gen tripping required for the current transfer
 - Gen tripping required to achieve max transfer



Application example: National Grid UK

- Motivation for on-line stability analysis (OSA)
 - 60 GW island system with DC Interconnection to Europe
 - Renewables brought more uncertainty
 - Off-line studies no longer adequate
- Capabilities of the OSA
 - Processing 2,000 contingencies for the full grid model in 15-min with 40 CPU cores
 - All critical SPS are modeled
- A special study mode enables engineers to quickly perform studies for various scenarios based on real-time system conditions



Application example: National Grid UK (cont'd)

- Operational experience: since in service March 2014, OSA has contributed to the identification of the following
 - A critical oscillation involving a 8 GW generation group
 - Weak 275 kV transmission system transient instability
 - Generator instability during switching for voltage control
 - Generating station stability risks
 - Local oscillation risks at generating stations
 - Pumped storage unit stability risks
 - Other security violations which led to re-declare transfer limits

Application example: Transpower New Zealand

- Island power system without interconnection with others
- Ensuring acceptable frequency response after the loss of a large unit or HVDC bi-pole is critical to system operation
 - Appropriate active power reserve is required
- A Reserve Management Tool (RMT) is used for this purpose in New Zealand Electricity Market
- RMT runs in the market settlement cycle
 - Full time-domain simulations with reduced network model but detailed dynamic models
 - About 1 min to solve 6 contingencies
 - Tight integration with market data



Reliability benefits:

- On-line DSA has been used as a primary tool to ensure the secure operation of power grids after major natural disasters
 - Hurricane, tornado, flooding, ice storm, etc.
- On-line DSA has identified potential security violations in power grid operation, which were not studied off-line.
- More often, on-line DSA provides valuable information to achieve better situational awareness in control rooms



Environment benefits:

- On-line DSA is able to determine the max level of renewables (e.g. wind) that a system can take from security perspective
- It can also suggest the min level of reserve to meet reliability requirements
- For real-time and short-term forecast system conditions
- This allows minimization of the demand for conventional generation (fossil-fueled, etc.)



Economical benefits:

- On-line DSA gives more accurate power transfer limits
- This results in reduced congestion management cost in a power market
- For example, ERCOT estimated that the use of on-line DSA technology saved US\$27 million in 2011 on congestion management cost



In conclusion

- On-line DSA technology is on the way to becoming a critical tool in control rooms
 - For improving real-time grid security and market efficiency
 - With expanding application areas
 - Bringing significant and measureable benefits
- The technology is maturing and is ready for adoption at various levels of power grid operation