On-Line Dynamic Security Assessment: Its Role and Challenges for Smart Control Centers

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A very simple version of Smart Grid

Hardware / software added to a power system to achieve:

• A more autonomous responsiveness to events that impact the electrical power grid
• Optimal day-to-day operational efficiency of electrical power delivery

Focused areas:

Demand management

Renewable-based systems

Information technologies

Transmission grid
Smart Transmission Grid

- System monitoring and visualization
- Real-time modeling and validation
- Real-time analyses
- Predictive analyses
- Controllability
- Information for dispatchers/operators
- Interactions with power market
Smart Control Center

• Modernization of control centers involves development and application of technologies in many areas

• One of these that is critical to the grid operation: Dynamic Security Assessment (DSA)

• This is to answer three basic functions:
  – How well a system condition can withstand credible contingencies (degree of stability)
  – What is the maximum secure power transfer under these contingencies (stability limits)
  – What can be done to prevent possible insecurity (remedial control actions)
What does this mean?

• Assume that a system is operating at a point A
  – Measured by some system parameters (e.g. interface flows)
  – Determined to be secure for all credible contingencies
• We need to know what is the secure region within which the system can move
• If the system needs to move to an insecure point for some reason, what needs to be done to ensure the system security
  – For example, special protection system settings
Analysis and computation requirements

• Need to work with **models** of an interconnected power system
  – The full Eastern US/Canada interconnected system models have more than 60,000 buses and 8,000 generators

• Use various **mathematical techniques**
  – Powerflow
  – Time-domain simulations

• Examine a set of **contingencies** over a range of **system conditions**
  – N-1, N-2, N-G outages, etc.
  – Different load levels, generator dispatches, power transfers, etc.

• Ensure that a set of **security criteria** are met
  – Steady state (thermal, voltage)
  – Dynamic (voltage, transient, small signal, frequency)
Challenges

• DSA has been traditionally performed using off-line studies

• Problems with this approach:
  – Number of possible conditions and contingencies becomes unmanageable as system complexity increases
  – Exact system state is rarely accurately captured by forecast
  – Most study results are never used resulting in high wastage
  – Conditions which usually cause problems are often not studied off-line (such as an N-1 event evolving into N-3 event)

Solutions

Avoid using forecasted system conditions for DSA . . . perform the calculations on-line in real time
On-line DSA functional overview

Measurement
- SCADA
- WAMS
- Other

State Estimator
External Equivalent
Auxiliary Data
Modeling

Complete System Model

Reporting and Visualization
- Result Display
- System Status Monitoring

Contingency Screening
Stability Limit Determination
Remedial Actions
Computation

Operator Invoked Controls
Closed-Loop Real-Time Controls

Other Functions
- Study Mode
- Result Archive
- System Security
- Failover Protection
- Alarm
- Analysis Tools
Main benefits

• System security status monitoring
• Stability limit determination
• Recommendations for preventive/corrective control actions
• Impact assessment of renewables on system security
• Verification of Special Protection Systems (SPS)
• Transaction settlements in power market
• Determination of active and reactive power reserves
• Scheduling of equipment maintenance
• Support to PMU/WAMS applications
• Calibration and validation of power system models
• Preparation of models for system studies
• Post-mortem analysis of incidents
• System restoration
State-of-the-art

• On-line DSA is not new; it has been proposed, discussed, and developed for over 40 years
  – It has matured in the past decade

• This technology has been increasingly included as one of the advanced network applications in EMS

• Performance
  – Real-time models with 13,500 buses and 2,500 generators
  – Processing of 3,000 contingencies and 40 stability limits
  – Computation cycle within 20 minutes
Applications of on-line DSA

- At least 7 out of 10 ISO/RTO in North America have, or are implementing, on-line DSA systems

- On-line DSA systems using Powertech’s DSATools™ software have been implemented in 35 control centers around the world
Application example – EirGrid

- The Irish national grid company
- Interconnected to Northern Ireland through AC and to UK through DC
- Small system but with high wind power penetration
  - Maximum wind generation recorded in 2009 supplied 43% of total load (this is 78% of the installed wind capacity)
  - The aim is for 40% of electricity to be produced from renewable energy sources (mostly wind) in 2020

- The question: what is the highest amount of wind generation allowed at any given instant of time?
  - Subject to thermal, voltage, frequency, and stability criteria
EirGrid’s WSAT application

- A Wind Security Assessment Tool (WSAT) is installed in EirGrid control center as a real-time application
  - Based on Powertech’s DSATools™ technology
- Provides max allowable wind generation for
  - Real-time condition
  - Forecast condition (integrated with wind forecast data)
Questions?