2nd Workshop on Challenges in Next-Generation Analytics for the Future Power Grid: Operational Decision Support Presentation

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Power System Operations

• Tremendous respect for the people who plan and operate the grid!
  – Often a thankless job, that only gets noticed during the rare blackout

• Society is more and more dependent on a reliable grid, so we need even better reliability
  – Avoiding the large “black swan” type events is crucial

• Power grid operation are becoming more and more complex
Visualization and Data Analytics

• Visualizations are ultimately used as an input to human decision making
  — Application dependent: What are the needed decisions? What are the time frame for making the decisions? Who makes them? How important are the decisions? Etc…

• The visualizations that are shown on a screen are the end result of a potentially quite detailed process that usually begins with large amounts of data, and potentially underlying models
  — The dividing line between visualization, data analytics and traditional power system analysis applications is fuzzy
Decision Support: Minding the Analytics

• As the grid gets more complex, a key challenge is to make sure the underlying analytics and models are behaving as expected, and certainly not having glaring errors that can often go unmissed.

• Verification and validation are key!
Transient Stability Example

• A single transient stability solution can generate large amounts of results data
• Operationally thousands of runs may be done for different contingencies
• How much this data needs to be considered is application dependent
  ─ In operations the concern may just be OK or Not OK
  ─ In planning more detailed analysis may be required. Issue is how to determine if the results are “correct”? 
Example of Time-Varying Data: Tabular Displays Do Not Work Well

<table>
<thead>
<tr>
<th>Transient stability results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• System with 16000 buses, 2400 generators</td>
</tr>
<tr>
<td>• Fault occurs at simulation time 2s</td>
</tr>
<tr>
<td>• Triggers a frequency disturbance</td>
</tr>
<tr>
<td>• Frequencies across system generators over simulation time of 20s (time step 0.05s)</td>
</tr>
</tbody>
</table>
Questions:

- Is the system responding as expected?
- How to separate out the patterns?
- How to incorporate geographic information in the visualization?
2400 Generator Results Visualized in a Geographic Context

- 10 distinct frequency responses identified
- Visualized on actual geographic location with “spark-lines”
- Different color dots = generators of a cluster
Blackout Prevention and Decision Support

• Many large-scale blackouts have time scales of several minutes to a few dozen minutes
  — this time scale allows for operator intervention, but it must occur quickly to be effective (extreme emergency control)
• Operators can’t respond effectively if they do not know what is going on— they need “situational awareness”
• Decision support tools need to be designed (at least in part) to meet the needs for the small about of time when making quick, accurate decisions could be crucial!
Extreme Emergency Support

• The control room environment during such an event might be quite different
  – Advanced analysis tools not working, unfamiliar system state, high level of stress, many decision makers

• Designing software for extreme conditions is challenging since users seldom encounter these conditions.

• August 14th, 2003 Example: Because of the stressed system conditions, the contingency analysis result displays had many entries
  – Many phone calls were coming in
A Few Topics for Discussion

• What are we getting right?
• Where do we need to improve?
• How much do we consider the extreme situations?
• How much do we rely on models? When to go modelless?
• How do we validate approaches?
• How do we leverage all the new data that may be available?
• What existing work to leverage? How do we work together?