TIP 345: Advanced Visualization for Improving State Awareness for the BPA Power System

Context

With the fast deployment of smart grid technologies, including renewable energy resources, the amount of data operators need to handle is growing rapidly. Meanwhile, operators face the challenge of integrating new mechanisms for handling intermittency, like 15-minute scheduling and probabilistic flow and load forecast systems. Today's visualization tools are inefficient at extracting and presenting critical information. Therefore, there is a great need to develop advanced visualization tools to handle data complexity for different applications, in particular, the information associated with uncertainty.

Description

The fundamental approach for this project was: to identify the visualization needs based on practical cases, to identify the critical information and the associated interface for the display, and to develop prototype displays for evaluation against current control room tools.

The Pacific Northwest National Laboratory (PNNL) experts in power systems, ecology, hydrology, and visualization will coordinate with BPA operators and PNNL usability experts to develop the best visualization solutions for BPA's current and emerging operating environments.

The project tasks are as follows:

- ***Work with control center staff to solicit the initial visualization requirements.***
  Using systematic approaches, user researchers work directly with the end-users to understand their goals, tasks, job responsibilities, and the environmental and cultural pressures in which the users perform. By finding patterns among the users, personas and use cases are created to guide the development process.
- ***Develop a data framework to manage data streams.***
  Data management techniques are developed to identify critical information for display. The critical information is extracted from multiple data resources in different file formats. The project develops an underlying data framework for managing both static and dynamic data.
- ***Develop user-centric visualization techniques to present the data efficiently.***
  To address visualization requirements, we adopt and adapt information and scientific visualization techniques to support power system operations, analysis, and decision making. For example, flow visualizations such as stacked charts and story flows address a number of visualization requirements
- ***Evaluate the techniques developed.***
  The project conducts formal usability evaluations that have system operators perform specific hydro operations, or grid operation and analysis use cases using their existing tools, visualization tools developed on the project, and other comparable open-source or commercial tools with related capabilities.
- ***Create a transition plan for the developed technology.***
  We work with stakeholders and BPA to review the tool and determine the transition plan to make the prototype a supported control room software tool.

Benefits

In today's Federal Columbia River Power System (FCRPS), large amounts of data are used to evaluate the system state. There are challenges to getting the most relevant information in front of power system operators, especially about variable resources that contain uncertainty information. Much of the data fusion happens in an operator's brain, encroaching on some of the bandwidth needed for decision making. With the new requirement of 15-minute scheduling and zonal/nodal scheduling, the amount of data will increase still further. The current display techniques that rely on numerical data and tabular displays cannot meet all the operators' needs. This project bid a novel data visual analytic design that could help fuse multidimensional data with uncertainty information allowing timely informed decision making, thus maximizing the value of the FCRPS to all stakeholders.

Accomplishments

The project reached its goal of developing advanced user-centric modular visualization tools to help present critical information from a large amount of multidimensional data in an effective way for improved power system state awareness. Because they are modular, the visualization tools are suitable for other power grid applications such as transmission contingency management, which must also rapidly convert data to information.

The objective to demonstrate the visualization tools through examples from pressing challenges for hydro operations as they integrate 15-minute scheduling and probabilistic flow and load forecasting was also achieved.

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Project Start Date: October 1, 2015

Project End Date: September 30, 2017

Funding

Total Project Cost: $500,000

Deliverables

The project achieved the following:

- Modification to the PNNL Scale Reasoning System (SRS) that integrates time series data from fundamentally different sources and integrate with a single time stamp and presents data in JSON format to be read by HTML displays.
- Full documentation of the SRS middleware solution to be used as requirements Technology Transfer implementation
- Prototype data visualization display for river water management of the integrated Federal Columbia River System (FCRPS) management

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Participating Organizations

Pacific Northwest National Laboratory (PNNL)
Alstom Grid
US Department of Energy

Conclusions

The PNNL Scale Reasoning system (SRS) technology proved to be a very flexible middleware solution for the integration of data from fundamentally different format, time steps and database storage methodologies. Data was easily sorted and formatted to a common time stamp in JSON format that could be read by modern HTLM web based data visualization displays utilizing P5.JS, D3.JS and JavaScript libraries. The prototype data visualization displays take advantage of the vast flexibility of JavaScript and JavaScript libraries to introduce a modern 21st century data visualization experience for real time operators of the federal Columbia River System (FCRPS).