CASE STUDY

Standardization and Integration Consulting and Test Services

Accelerating Interoperability of a Transactive Energy System in the PNW Regional Smart Grid Demonstration Project

The Client

Over the past decade, the Pacific Northwest region has been a pioneer in the nation's emerging smart grid agenda, contributing technology, utility applications, customer engagement strategies, and policy. The Pacific Northwest Smart Grid Demonstration Project (PNW-SGDP) took the region's involvement in smart grid to a new and exciting level.

This $178 million project—the largest of the 16 smart grid demonstration projects funded by the U.S. Department of Energy under the American Recovery & Reinvestment Act (ARRA)—was a unique demonstration of unprecedented geographic breadth across five Pacific Northwest states: Idaho, Montana, Oregon, Washington, and Wyoming. It involves about 60,000 metered customers, and contained many key functions of the future smart grid.

The Project moved the region and nation closer to establishing a more efficient and effective electricity infrastructure that is expected to help contain costs, reduce emissions, incorporate more wind power and other types of renewable energy, increase power grid reliability, and provide greater flexibility for consumers.

The Issue

The PNW-SGDP employed a revolutionary transactive control system that standardized a scalable, distributed mechanism for exchanging information about generation, loads, constraints and responsive assets over dynamic, real-time forecasting periods using economic incentive signaling.

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Each of the distribution system partners (10 utilities and one university) implemented its own Transactive Control Node that received project signals for price forecasts and initiated some form of response based on its own assets (DR, generation, battery storage, solar PV, VVR, etc).

For the system to function, the 11 implementations had to interoperate smoothly with the "top node" at the PNNL Network Operations Center in Richland, WA. As the Project's test and training partner, QualityLogic was tasked with ensuring the interoperability of these system components.

In a fully functional Transactive Control system, a node receives incentive (price) and feedback (load) signals from its neighbors; uses information from these signals along with local information to modify control of local responsive resources and assets; and generates and then sends incentive and load signals to its neighbors. These functions are performed for each interval defined for the system.

The Solution

During the five-year effort, QualityLogic developed commercial-quality products and gained immense experience in an implementation of Transactive Energy and many other smart grid standards.

Contributions to the project included conformance and interoperability test planning, test development, test automation and testing and certifying product Transactive Nodes; major contributions to smart grid standards and interoperability of the project; analysis of interoperability issues; and monitoring smart grid messages and information for quality.

QualityLogic defined the conformance and interoperability testing for the Transactive Nodes and developed test tools to perform the testing. The QualityLogic Transactive Control Conformance Test System provided developers of the nodes with a cloud-based test harness and set of tests that ensured conformance to the requirements of Transactive Control communications.

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Before a node could be integrated into the system, it had to pass the QualityLogic tests. This ensured a smooth addition of each of the Subproject nodes.

Interoperability Monitoring Services

In addition to the Conformance Test System to ensure that a node met the design requirements, QualityLogic provided interoperability analysis and monitoring services:

- **Baseline System Interoperability** – These tests covered interactions that may not be included or tested in conformance testing. Baseline System Interoperability tests confirmed that system interactions, such as Transactive signals, and interactions with System Management and Data Collection met expected criteria (such as number of messages and expected rate).

- **System Stability** – This set of tests confirmed system operational criteria were met in the presence of errors or when nodes joined or left the Transactive Control system.

- **System Scalability** – This set of tests determined that the systems were scalable and could meet the expected volume of Transactive signals and other messages as new nodes join the system.

Node Certification

A Transactive Control system comprised numerous interacting nodes, each exchanging incentive and feedback signals at regular intervals with its neighbors. QualityLogic's Conformance and Interoperability Test Systems were designed to be used for "acceptance" or "certification" testing (either by QualityLogic or another trusted third party) to ensure that new nodes added to the system would 1) operate as designed, and 2) not negatively impact system operation.

Standards and Interoperability

Two of the five primary project objectives included:

- "Develop and validate an interoperable communication and control infrastructure using incentive signals to coordinate a broad range of customer and utility assets, including demand response, distributed generation and storage, and distribution automation."

- "Contribute to the development of standards and transactive control methodologies for a secure, scalable, interoperable smart grid for regulated and non-regulated utility environments across the nation."

Standards

During the Project, QualityLogic cochaired a Project Standards Working Committee and contributed detailed analyses of the Project-defined Transactive Control protocol and emerging smart grid communication protocols. At the end of the Project, QualityLogic had:

- Developed and presented a workshop on standards and interoperability to the Project participants and at DistribuTECH.
- Completed and presented or submitted over 20 papers, articles and conference presentations.
- Developed in-depth mapping analyses between Transactive Control and 10 emerging smart grid standards, including OpenADR, SEP 1, SEP 2 (IEEE 2030.5), IEC 61850, DNP3. MultiSpeak and others.
- Participated as an original member of the Smart Grid Interoperability Panel Test and Certification Committee.
- Outside the project, QualityLogic became the leading developer of test tools and educator on the OpenADR and IEEE 2030.5 standards.

Interoperability

As part of its Project responsibilities, QualityLogic conducted an interoperability survey of 10 Subprojects about their own set of smart grid demonstration projects completed as part of the larger PNW Demo Project. The goal was to understand the ease of integration of new smart grid assets from multiple vendors, issues encountered and lessons learned.

Over 60 different assets ranging from communicating thermostats and water heaters to battery storage systems and solar PV were included in the Subproject demonstrations.

The result was a detailed survey report documenting the various products and systems developed by the project members as well as the lessons learned. The benefit to the project was a smooth process for achieving interoperation of systems developed by multiple vendors and developers using a new communication protocol.

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Signal/Data Quality Monitoring and Analysis

One of the challenges Transactive Control systems face is getting all of the nodes running properly, exchanging the Transactive signals and then acting on the pricing and load information. A companion challenge is the assurance of the quality of the data being exchanged between nodes as well as data being collected for M&V purposes. All nodes in the Transactive Control system were instrumented and conformed to a common set of messages and data formats, and that allowed QualityLogic to create a set of monitoring and analysis tools.

These tools monitored the connectivity of the nodes, as well as the quality of the information that was exchanged. Using this information, QualityLogic created a set of interoperability and data analysis reports that were instrumental in identifying system startup, connectivity and signaling issues in the system. With one quick glance at these reports, it could be determined if a node was connected or not, or if the price and load signals were being exchanged properly.

QualityLogic also provided data analysis and visualization techniques that helped in identifying modeling or other issues with respect to creation of the Transactive Control signals. These detailed analysis reports assessed the quality of the system model and the accuracy of the prediction models used in the incentive and feedback signals.

Lessons Learned

QualityLogic did not work with each of the Subprojects on the design and implementation of their unique set of experiments, and they encountered significant issues during the project. On the other hand, the integration and commissioning process QualityLogic was responsible for (the interoperability of Transactive nodes between the top node and each utility node) went smoothly because of the planning, test tools and process we implemented.

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The interoperability lessons learned by the various Subprojects are informative for utilities and others embarking on new smart grid pilots and demonstration projects. Most of the Subprojects had difficulty integrating all the devices in the project. Some devices were new, even for the manufacturer, so many "work-a-rounds" were done to make all the systems in each Subproject work together. Also, there were numerous instances of vendor bankruptcies or near bankruptcies, causing much uncertainty and development of project contingencies for communications if a vendor failed or a system couldn't be made to communicate. With that backdrop, the following key lessons were learned:

1. Opt to choose products that have been tested more fully, are market ready with financial backing, offering long-term support commitments, and are better able to integrate with current systems. Implementations adhering to industry standards (where defined) should be specified in the project design process.

2. Pay attention to communication interfaces at the start of a project and during design. Utilities tend to spend large amounts of time on electrical connections up-front and less on communications. Equal time should be spent with communication connections.

3. Immature communications standards can be more challenging than no standards at all. This occurs because implementing immature standards that change frequently often requires replacement of existing hardware. This is not required with a proprietary integration. Also, frequent standards changes seen with immature standards require many more work-arounds or proprietary equipment modifications to get things working.

4. Put a key human resource in charge of each communication interface between devices to assure a clearly-written requirement is developed between vendors before installation.

5. Lab test systems prior to deployment. When a standard protocol is used, different vendors may use optional registers, different release versions, or different areas in the standard that need to be accessed by a connecting system.

6. Spend time in a bench test or test lab environment to assure interfaces between systems interoperate as needed, whether the systems use standards or not. When systems are deployed in the field, it will be easier to determine that communication issues are related to field conditions and not general communication issues.

7. Use normal product development methodologies, including prototypes, field trials and utility laboratory testing prior to installation. Better product development cycles by vendors and lab testing by utilities prior to deployment identifies and eliminates issues such as data corruption, difficult upgrades and communications errors.

8. Make available a qualified technical person to guide the entire integration process between devices. That person needs to be provided with the time and skills throughout the project to dig into technical problems between vendors and resolve them.

9. Be mindful of the initial interface information provided by vendors. The sales people may not know or want to explain the limitations of their systems going into a significant project.

10. Avoid falling into the routine of using your current vendor based on loyalty or anticipated ease. Interoperability may be just as easy, or easier, with a new solution and new vendor rather than the current vendor and their existing solution.

11. Get vendor commitments on data requirements, such as accuracy and data flow rates, up front to ensure all performance needs are met — lab testing is encouraged to prove this out. This is necessary to understand the capabilities and limits of any supporting system or infrastructure, regardless of the technology used — each has its own peculiarities.

12. Establish an interconnection lab or bench testing system prior to any field deployment. Part of the work an interconnection project lab should include a testing and certification program (if an industry program does not exist) and Subprojects should develop a good understanding of what it takes to support a well-developed standards program for the communications systems used.

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The Outcome

The final "Technology Performance Report" concluded that, "Because the interface was specified the same for all transactive nodes in the project's transactive system, the individual implementations were amenable to conformance testing...The transactive system was deployed, tested, and validated, providing region-wide connection from the transmission system down to individual premises equipment, enabling dynamic response by assets at the end points." QualityLogic was responsible for the testing to ensure correct communications, as well as message monitoring and QA.

The PNW Regional Demonstration Project provided an excellent platform for QualityLogic to bring its expertise in communications protocol standards to the smart grid. We designed and implemented a successful interoperability integration process; researched and evaluated emerging smart grid standards; provided data quality services and collected interoperability lessons from the Subproject participants.

Based on this smart grid expertise, QualityLogic offers others assistance with:

- Evaluating and specifying smart grid communications standards
- Training on system interoperability
- Acceptance testing and test tools to be used for acceptance testing
- Integration testing using commercial or custom-developed test tools
- Certification testing tools and services
- Information flow monitoring and quality control.

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For More Information

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