



FEATURES

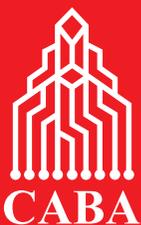
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Seamless Integration of Smart Grid

By Ken Wacks

A smart grid is an integrated system of systems. The traditional electric grid constituents are generators, transmission towers, distribution lines, and meters. Other systems being added to smart grids are demand-response premises networks with attached devices and distributed energy resources (DER). DER may include photovoltaics, windmills, and fuel cells. To make the grid smart, these systems must interoperate. This means that systems developed independently, possibly using different and incompatible technologies, must be made to work together to keep the lights on.

In the winter 2008 issue of *iHomes & Buildings*, I introduced the GridWise Architecture Council (GWAC). We are a panel of 13 experts appointed by the U.S. Department of Energy to guide utilities and equipment suppliers toward smart grids. Rik Drummond, a GridWise colleague, and I delivered a presentation last year on interoperability and conformance that I will summarize.

This topic is of key importance for successful smart grid deployments to ensure seamless integration.

Conformance = Interoperability

Before we can determine if products work together, we must determine if they were designed and built properly. Each product must be tested for conformance to a standard. An underlying assumption is that the correct standards were chosen to implement a design that meets smart grid requirements.

Conformance is a prerequisite to interoperability. All international standards are required to include a conformance clause. This clause specifies what is required for a manufacturer to claim that a product complies with the

standard. Complex devices will require a test regime to confirm compliance.

Conformance tests are applied to a single “device-under-test” (DUT). Devices that each comply with a standard may not necessarily interoperate. If they are intended for a network, we must check that they can co-exist on the network without interfering, and most-importantly, that they can work together to perform a joint function. Cooperation is the essence of interoperability.

What are standards?

We depend on standards constantly. When we plug into a power socket, a standard ensures that the plug fits the outlet. A smart grid incorporates many standards for communications networks and devices. Some methods for residential energy management need home system standards. These are engineering rules for interconnecting appliances and devices using a home network.

Standards define the data that appliances send to other appliances. When all appliances use the same standard, they can be connected to a home network and understand commands. A command might be TURN ON or PLAY LOUDER or MAKE WARMER.

Variety of interoperability tests

Some interoperability tests are less challenging than others. Figure 1 shows home appliances designed for connection to a home network. The home network links to a utility smart grid. The utility might send price data or notification of unusual events such as hot weather requiring energy conservation to prevent power failures.

Interoperability among devices sharing a common

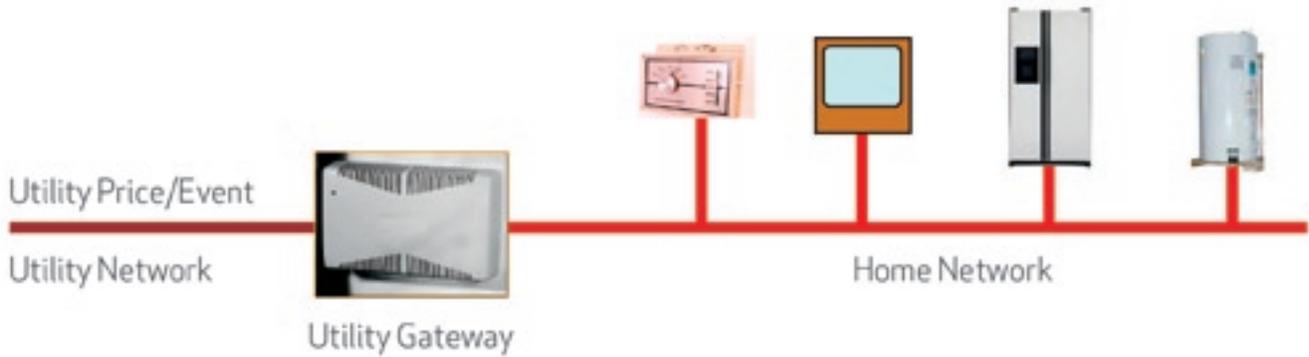


Figure 1 – Energy Management with Smart Appliances

communications protocol is simpler to test than testing a protocol translator, such as the utility gateway in the figure. Some of the additional challenges include testing signal and code conversion, and maintaining proper timing.

Utilities need test regimes to accommodate a variety of customer gateways and premises equipment for commercial and residential customers. For interoperability to succeed, manufacturers must conform to a standard and must provide access points for tests to be conducted. The need for these tests is a new concept for consumer products such as appliances since very few are networked and interoperate.

Conformance testing

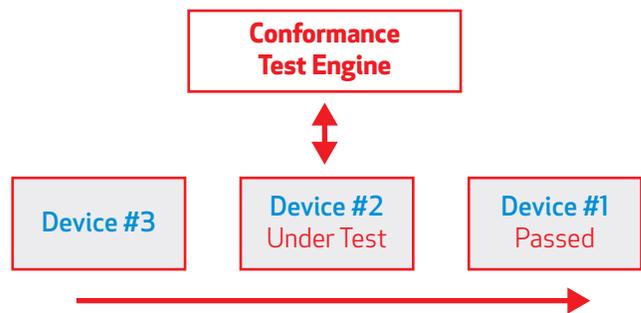
Conformance testing ensures that the requirements of a standard have been implemented. For a communications protocol, this means that the signals, data packets, and messages must be programmed correctly.

The elements of a testing regime include a test list, a test plan, and performance requirements as summarized in the following table.

A Testing Regime	
Test Element	Description
Test List	Message format and meaning. Data packet format, coding, error checking Signal values, timing, sequence
Test Plan	Test equipment Device-Under-Test (DUT) jig Test cases for each Test List item
Performance	Test result Product diagnosis

Device testing may be implemented using a conformance engine on a production line as illustrated in Figure 2. The device-under-test may be hardware, software, or a sub-system. Each device-under-test is connected via a test jig to test equipment. The results are PASS or FAIL. If the device is complex, the failure may be analyzed and the device sent for repair. If the device is a low-cost integrated circuit, it is usually discarded.

Figure 2 – Production Line Conformance Testing



Testing referenced standards

A principle of engineering is that new designs draw upon and enhance existing technology. Often a standard is not self-contained. Rather, it references other standards as requirements, called “normative references.” This means a device conforming to the new standard must also conform to the other standards that are cited as normative references.

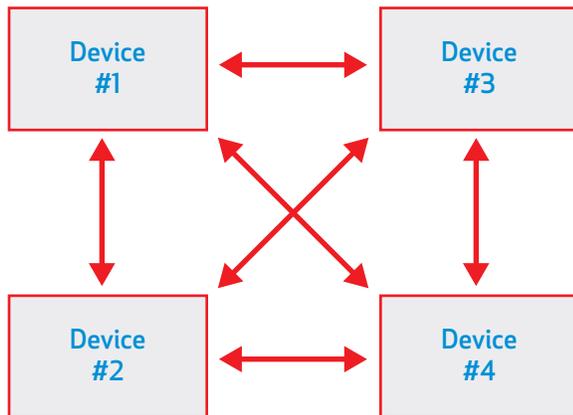
As explained, interoperability testing depends on successful conformance testing as a prerequisite. However, conformance tests for other standards, possibly written years ago, may not be reliable. The only solution is to acquire the referenced standards and review the conformance requirements. It may be necessary to fix any faulty conformance tests before attempting interoperability tests.

Interoperability testing

The descriptions of a test list, test plan, and performance for interoperability testing are similar to conformance testing. However, the process is more complex. Multiple jigs are required in order to examine two or more devices for interactions.

We assume that each device has already been tested for conformance to the standard and has passed. Now we test that the devices can work together productively. As the block diagram in Figure 3 shows, each combination of devices must be tested to ensure interoperability.

Figure 3 – Production Line Interoperability Testing



Key Steps to Interoperability

Interoperability testing depends on conformance testing. A well-written standard with a clear and complete conformance clause is essential. A complex standard may have multiple profiles or subsets. For example, a single communications standard may include profiles for one-way transmission, for interleaved two-way, and for simultaneous two-way. Each profile requires a conformance clause.

Over the life of a product, technology may improve and standards may be updated. Therefore a life cycle for interoperability maintenance is required.

The GridWise Architecture Council has identified interoperability as essential for a smart grid. Although testing for interoperability may be complex, there are methodical procedures for performing these tests to ensure a functioning smart grid. **H**

Dr. Kenneth Wacks has been a pioneer in establishing the home systems industry. He advises manufacturers and utilities worldwide on business opportunities, network alternatives, and product development in home and building systems. In 2008, the United States Department of Energy appointed him to the GridWise Architecture Council. For further information, please contact Dr. Wacks at 781.662.6211; kenn@alum.mit.edu; www.kenwacks.com.