SMART GRIDS FOR GREEN COMMUNICATIONS

BOB HEILE

The challenge of the smart grid is formidable, and fully explaining all the nuances is beyond the scope of this article. Nevertheless, what makes a grid *smart*, or at least different from the grid of today, is the fact that it must deliver both energy and information. The delivery of both energy and information must also be end-to-end and bidirectional. Energy will be generated both at traditional generation facilities as well as in local or distributed generation facilities. Information covering every aspect of electricity from generation to consumption will also be conveyed.

The motivation for this monumental change is equally broad and is driven by a desire to ensure the future power needs of a region by improving power reliability and quality, generation, and transmission efficiency, expand the use of renewable energy, and implement new load shifting and energy efficiency programs at the point of use that reduce consumption on a per customer basis, while boosting consumer awareness and choice, to name but a few. Additionally, a smart grid is key to more effectively managing and meeting our carbon footprint goals and building a workable electric vehicle infrastructure.

In the United States there are a number of groups and agencies engaged in developing solutions. Perhaps the most visible has been the work of NIST and the Department of Energy over the last year in developing the Smart Grid Roadmap. That work now continues as the Smart Grid Interoperability Panel and is joined by activities from other groups like IEEE, UCA OpenSG, and various other industry alliances and associations who are all working on developing and promoting open standards. The IEEE has a large number of activities and specific standards, both completed and in development, relating to specific pieces of the grid and the communications needed to support its operations. In May 2009 the IEEE launched Project 2030, a project exclusively devoted to the smart grid, to develop a standard called a Smart Grid Guide. It covers the smart grid architecture, information technology requirements, and communication needs. The result will be a useful compendium and complement to the NIST activity on what is needed, what already exists to meet needs, identification of the gaps, and the addition of needed new projects.

Given that our own homes are a key factor in any smart grid equation, the balance of this article is devoted to some of the important things targeted at homes in terms of applications and standards development. Consider the following:

- Over 50 percent of electricity is consumed in the home.
- The home will be the location of the largest number of distribution generation devices.
- The home will be the home base for electric vehicles (EVs).

Impacting consumer behavior in homes will be essential to reduce the growth in electric demand, and because of the sheer number of residences and consumers, workable demand response and load control requires a high level of information, communication, automation, and participation.

One industry alliance that has taken the lead in delivering open energy management solutions for the home is the ZigBee Alliance. ZigBee was launched in 2002 to develop open standards for wireless sensor networks. The idea is simple: make it easy and cost effective to put sensors and controllers in everything, and give them a way to network and exchange information for a variety of purposes. By doing this, we achieve an Internet of Things. By connecting a variety of applications, from heating and air conditioning, lighting systems, and home security systems to things like remote controls, consumers gain greater control of their home and see a variety of convenience, safety, and comfort benefits, as well as an opportunity to save money.

In 2006 several major utilities made the connection that if they could become a part of the home area network (HAN), they would gain the ability to implement new customer programs that had never been possible before and would gain detailed information regarding the status of the grid. What already existed in the HAN environment was the home automation piece. What did not exist was how to build advanced metering infrastructure (AMI) and the associated network communications to make all this realizable and a useful component in the overall smart grid architecture.

In 2007 a large stakeholder community, consisting of chip suppliers, original equipment manufacturers, metering companies, utilities, regulators, and government agencies, assembled in the ZigBee Alliance to tackle the AMI piece and developed what is now known as ZigBee Smart Energy. Even though a very large group of competing interests were at the table, ZigBee Smart Energy was completed at record speed and released along with an initial set of ZigBee Certified products in May 2008. ZigBee Smart Energy delivers a number of benefits including:

- Metering (measurements, historical info, etc.)
- Support for distributed generation
- Demand response (DR) and load control
- Pricing (multiple units and currencies, price tiers, etc.)
- Customer messaging
- Device support for programmable communicating thermostats (PCTs), load controllers, energy management systems, in home displays (IHDs), and more
- Security level options for data that is consumer only, utility only, or shared
- Support for water and gas metering applications

The network communications piece is handled in a few ways. In all situations you need a gateway device supporting two communications streams joining the utility AMI central database to devices in the HAN. The gateway also acts as the trust center and firewall in the ZigBee Smart Energy imple-

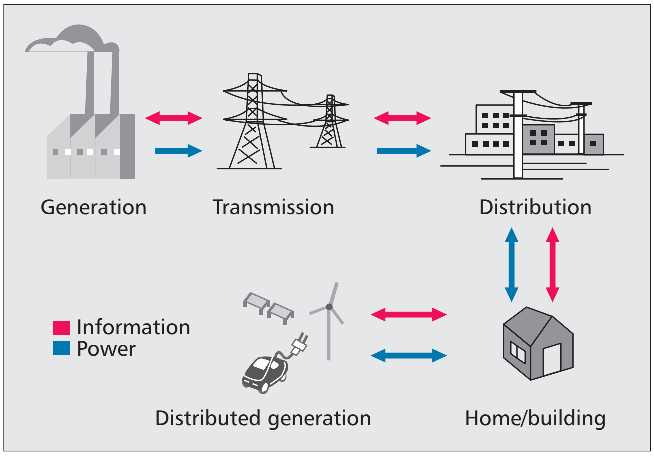

Figure 1. *Smart grid challenges.*

mentation to protect assets on the grid side of the network and allow for different security levels depending on traffic types. Backhaul communications from the gateway can be over the Internet or over a utility- owned network, although most utilities in the United States favor using their own networks from a security and maintenance point of view since most plan to include load disconnect switches as part of the installation and need to serve all customers, not just those with broadband connections.

The implementation of these utility networks is quite varied although most use some form of wireless communications to a concentration point and then an available backhaul technology such as GPRS, DSL, PLC, or WiMAX from there back to the central database. Having a single standard is less urgent since this portion of the network connects fixed infrastructure. Nonetheless, there is active work ongoing to develop such a standard in IEEE802.15.4g.

The communications between the gateway and the HAN is mainly over a standard ZigBee wireless sensor network that meets several important requirements established by the utilities. HAN products need to be based on open standards, in a competitive market with no single-vendor lock-in. They need to be low cost, support high levels of security, and ideally support global reach. Plus, there needs to be a large pool of people who understand the technology. For many of the utilities in North America, the meter with integrated load disconnect is the logical gateway. There are currently over 40 million ZigBee Smart Energy meters in the process of being deployed.

Some obvious use cases are clear. For ZigBee Smart Energy equipped devices (HVAC, appliances, smart plugs, etc.), consumers can request a meter read and historical data by using an in-home display, PCT, set-top box, computer, or smart phone. For legacy devices lacking ZigBee Smart Energy, consumers can power the device on and see the change in meter data. The end result is the consumer can now begin to quickly associate what it costs to operate various devices in the house.

Another scenario focuses on time-of-use pricing. During peak price periods, consumers can manually power devices off and/or change temperature settings. They can also program devices equipped with ZigBee Smart Energy to automatically respond to these utility price signals, or voluntarily allow the utility to have direct access and control while maintaining the

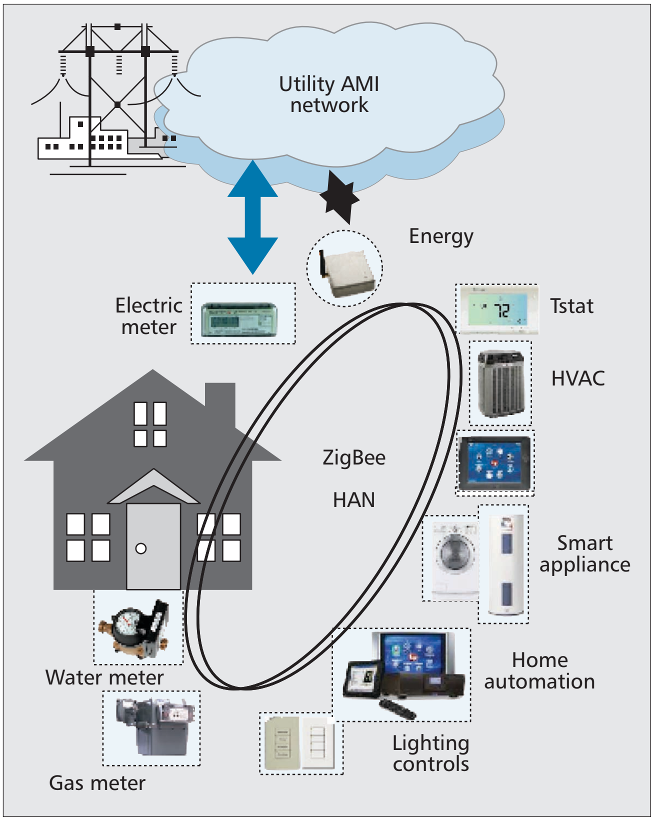

Figure 2. *Zigbee home area network.*

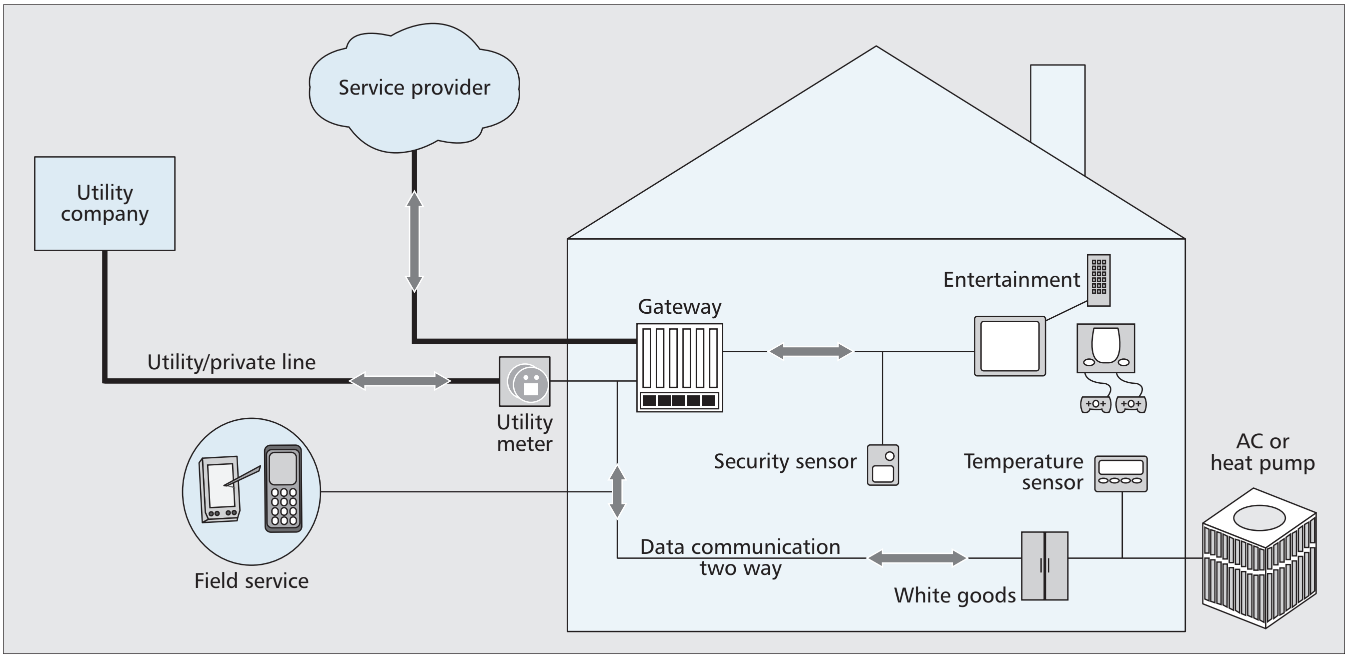

Figure 3. *Utility connections in the home.*

option to override utility control. When there is enough advance notice of a peak event, heating and refrigeration equipment can be set to preheat/cool before the event and reduce usage during high rates. The result is that utilities gain the ability to manage peak events more efficiently and effectively, and consumers see little loss in convenience or comfort — two important elements to instill lasting changes in consumer behavior.

If EVs become a significant part of our future transportation infrastructure, the same tools that allow the consumer to become a more intelligent user of energy will be essential for maintaining grid performance with EVs. These tools will ensure smart grid integrity as well as set the stage for energy storage and recapture via EVs. Because vehicles are obviously mobile, standards become critical to achieve anything useful and ubiquitous.

EVs are not just another consumer appliance; they are significantly more challenging. Most people normally arrive at their homes in a fairly narrow window of time every evening. This time period is already associated with peak energy use. Each vehicle can represent as much as a 6 kW load, drawing significantly more energy than the average single-family home. If everyone parks their EV and plugs it in during this peak period, a local feeder or transformer will likely fail. Adding to that, what if you get home, are low on energy, and know you have somewhere to go soon? What if you want the lowest price? What if you plug in somewhere else? ZigBee Smart Energy helps both the consumer and the utility intelligently manage these scenarios.

EVs offer an interesting smart grid opportunity beyond being eco-friendly transportation. They can be used to store energy. EVs can charge during low use periods, and then supply power to the grid during periods of high demand. With the owners' permission, utilities can selectively target vehicles with sufficient spare power to cover a peak event. This new capability results in better management of resources and is significantly more environmentally friendly. Consumers can also benefit independent of the utility by using cheaper night time electricity from their cars to power their homes during peak daytime periods.

The relationship between the smart grid, homes, and consumers is an important and tightly coupled part of the overall system. The energy stakeholders have been enhancing the ZigBee Smart Energy standard to serve the growing set of needs required of the relationship including the ability to run over a variety of mainstream communications protocols, wired and wireless, like IEEE 1901, 802.3, 802.11 and 802.16 in addition to the original 802.15.4.

In the coming months a lot of progress needs to be made on a number of areas relating to this part of the smart grid architecture and design. A few of the major ones are:
- EV infrastructure
- Implementing the programs enabled by smart meters
- Getting consumer buy-in on the value of the programs
- Resolving data ownership and privacy issues
- Completing the next phase of the HAN system definition

Harmonization of the many different groups and interests in the smart grid community on these issues will be a major challenge. To that end, the Alliance is using its open consensus process to gather input from experts around the world. Every week, new organizations are joining and participating in this development. The standards community is being engaged through a growing number of collaboration agreements signed over the last year. In fact, the Alliance recently took the extraordinary step of making drafts publicly available and seeking comment from those who have not had the opportunity to be a part of the drafting process (http://www.zigbee.org/Products/DownloadZigBeeTechnicalDocuments.aspx).
- When it comes to defining and building the smart grid, the hope is that through efforts like this, it is possible to achieve not only consensus solutions on specific requirements, but a harmonized and coordinated systems approach as well. As with anything, time will tell. But with a lot of work and a bit of luck, we can achieve an extensible core architecture capable of growing and evolving as effectively as the Internet does today.