Demand Response — Technology for the Smart Grid*

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Demand Response programs have been around for decades and have proven to be an effective means for utilities to manage system peaks by controlling customer loads. For residential consumers, these programs traditionally entailed the direct load control of large appliances at the home such as air conditioning systems, hot water heaters, and pool pumps. For the most part, these were one-way systems based on signals sent via pager, power line communications, energy management system, or telephone to the controlling devices to temporarily turn off or cycle the desired appliance during peak conditions. The utility benefitted from a better ability to manage demand and supply, while the customer benefitted from financial incentives for program participation. This approach proved to be an effective demand control solution and continues to work well today.

Enter…the Smart Grid. The US Department of Energy and other key electricity industry stakeholders identify active consumer participation in Demand Response as a key characteristic of Smart Grid. Advanced Metering Infrastructure (AMI) systems, now deployed as part of growing Smart Grid initiatives, provide significant foundational platforms for engaging consumer response to extraordinary Demand Response events. By supplementing this technology with Internet usage, utilities can enable energy consumers to actively manage system capacity. According to Internet World Stats, 77.4% of the population in North America is connected to the Internet; up from approximately 31% in 2000.

AMI implementations are one avenue to engage the consumer; many utilities ensure that the system they deploy supports Demand Response functionality through connectivity into the home via the Smart Meter. Since the middle of the last decade, AMI vendors have been preparing their systems to support this functionality through industry initiatives such as the ZigBee® Alliance. The Alliance promotes the integration of low-power wireless sensor and control network technology into the meter to act as a communicating gateway to devices in the home. These devices are used to both inform the consumer of ongoing energy usage and to control the significant discretionary loads available in the home. These Smart Meters and two-way AMI networks then enable the measurement and verification capabilities that allow the utility to verify which controlling devices participated in a Demand Response event and how much load was removed. Figure 1 depicts the classical architecture for connecting devices in the home via the Smart Meter.

DEVICES AND CAPABILITIES

Current and upcoming products allow the residential consumer to support these Demand Response programs. Consumers can access these products through the local utility, retail electric providers, and, to a limited extent, retail outlets such as consumer electronics and home improvement stores. A fully deployed Home Area Network (HAN) can include direct load control devices connected directly to large appliances, programmable communicating thermostats (PCT) to manage the heating and cooling system, and in-home displays (IHD) to provide near real-time energy usage information. These in-home displays can also inform the consumer of critical electricity pricing events that are part of a utility's Demand Response program.

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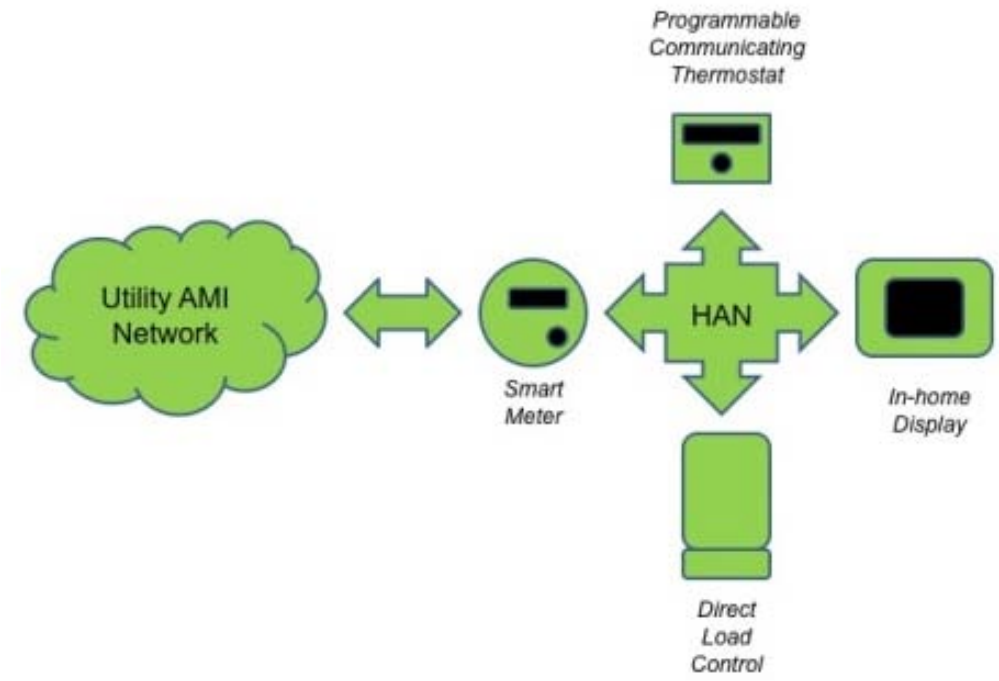

Figure 1. Electric AMI Meter Connected HAN

The capabilities of each of these devices are quite varied. For instance, the IHD can display energy usage in both kilowatt-hours and dollar value. It can show information for the current day and bill-to-date, and estimate the monthly bill. It might estimate the consumer's carbon footprint, connect to the Internet, and act as an alternate gateway to the HAN for the utility (as opposed to the Smart Meter).

CONNECTING TO THE HAN

Connecting to the HAN can occur in several ways. Current Smart Grid implementations most commonly transmit to the meter through the AMI network, and then connect to the devices in the home. Because this new technology and business model of expanding utility involvement with consumers is a significant change, limited trials have been undertaken to prove system capabilities, system interconnectivity, and consumer acceptance. Some of the initial trials have used the AMI vendor's native technology between the meter and the HAN devices. This was a viable, reasonable approach, particularly because industry standards governing this connectivity and devices were not available. However, when designing future trials and deployments, utilities should be cognizant that AMI vendor controlled technologies in the HAN may limit the types of devices. Open, interoperable devices may represent a better option. Utilities should also consider long term expected availability of these devices. The AMI vendor may decide to no longer support its native technology in these devices as standards are developed and universally accepted.

The development and adoption of common industry standards often signals the maturing of a technology and may prompt its more rapid acceptance and deployment. Standards provide a framework for wider development of devices and solutions while reducing the risk of adoption for new market participants. Many of the early Demand Response trials have been deployed using ZigBee low-power wireless technology integrated into the Smart Meter, which then serves as the entry point into the HAN. Some of these trials were performed with manufacturer specific profiles, which define

how data is defined within the HAN. Later trials then transitioned to a more standard profile using the ZigBee Smart Energy Profile version 1.0 (SEP 1.0). The ZigBee Alliance recently announced that its ZigBee SEP 1.0 has reached the 100th ZigBee Certified product milestone. ZigBee Smart Energy Profile version 2.0 (SEP 2.0), though not published yet, has been identified by NIST in its Framework and Roadmap for Smart Grid Interoperability Standards, along with Homeplug (powerline networking technology), Z-wave (proprietary low-power wireless networking) and OpenHAN (HAN specification). Utilities have been anticipating the finalization of SEP 2.0, and some are awaiting its release before deploying any significant quantity of HAN devices. Regardless of this anticipated release, many are moving forward with full scale AMI meter deployments that incorporate SEP 1.0, with an expectation of the ability to upgrade these Smart Meters to SEP 2.0 once its released.

Other opportunities exist to connect to the HAN without a dependency on the AMI system or the Smart Meter. These typically consist of a gateway device connected to the consumer's broadband Internet or with an imbedded cellular modem. In these cases, the HAN gateway can connect to the Smart Meter via ZigBee (or another commonly supported communication path), but the meter does not serve as the gateway or HAN controller. In this configuration, the Smart Meter simply provides energy usage information to the HAN. All other data, including the control of devices for Demand Response events, or communication to the consumer via an IHD may not flow via the Smart Meter. Instead, it may travel directly to the HAN through this alternative connection. Figure 2 below is an example of a typical network showing connectivity from the AMI network through an electric meter, and alternatively through a broadband gateway device.

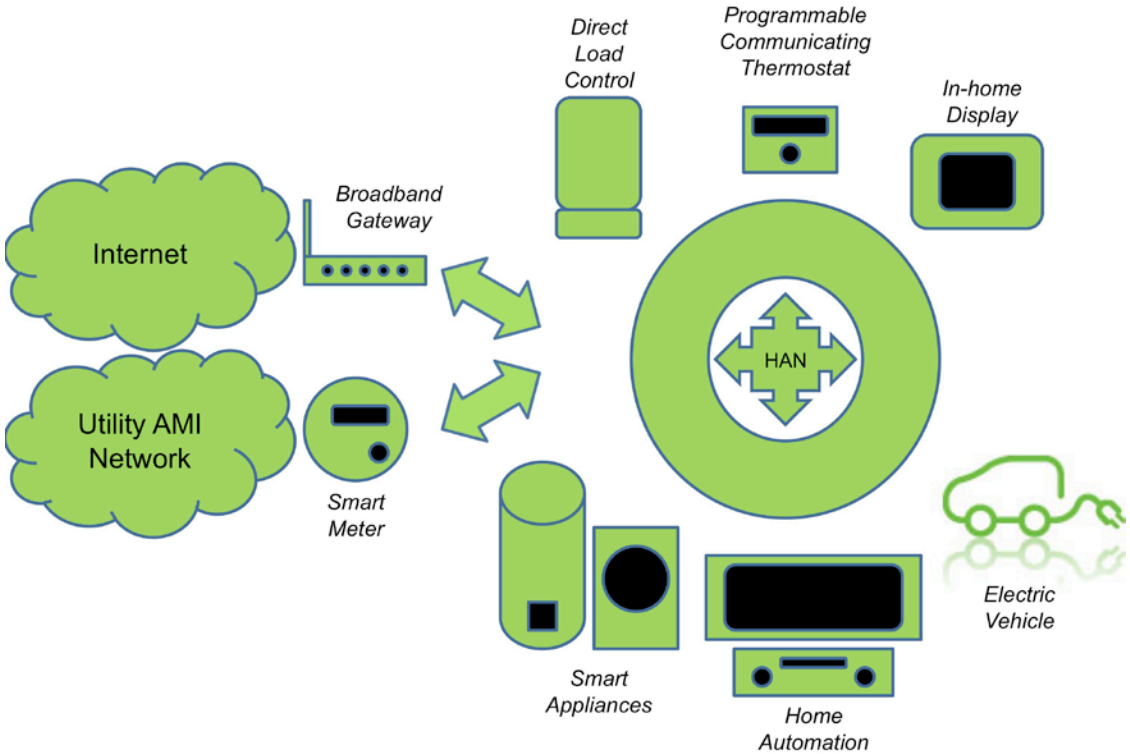

Figure 2. Electric AMI Meter and Broadband Gateway Connected HAN

SUMMARY

Utilities across North America are fulfilling key components of their Smart Grid initiatives by rolling out Smart Meter and AMI systems. They are designing these systems to support and enable highly valuable Demand Response programs. Several trials have been initiated to gain technology experience, in addition to raising consumer acceptance of the programs and the various devices that will be available to participants. Various options exist to enable the connection with the consumer, and these options will continue to evolve as the capabilities of the Smart Grid matures.

About the author

Mr. Lipski provides expertise in support of utility Smart Grid and Demand Response solution initiatives. His 20+ years of experience include positions with Elster, Landis+Gyr (formerly Cellnet Technology, Inc., Atos Origin and Schlumberger), and LODESTAR Corporation. He holds a BS in Electrical Engineering and an MBA.