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A Cornucopia of Home Networking Protocols

By Ken Wacks

President Barack Obama has made energy a key policy initiative. The U.S. Congress appropriated $11 billion in the Recovery and Reinvestment Act for energy projects with $4.5 billion allocated to "smart grid" development. The goal of the smart grid is to apply information technology to improve the reliability of electricity and to accommodate local generation, such as solar-voltaic and wind power.

In 2005 and again in 2007 Congress mandated that utilities deploy demand response techniques for adjusting demand to match available electricity supply. Effective demand response involves major energy consuming appliances in the home. Utilities have stared to investigate how to communicate with home appliances via home networks. They are just becoming aware of the variety of communications protocols used for home automation.

Betsy Loeff of *Utilimetrics News*, recently interviewed me about standards for home area networks. Utilimetrics is a trade association of utilities and equipment suppliers focusing on the metering of electricity, gas, and water, plus related customer services such as demand response. Janice Greenberg, the Utilimetrics Membership Services Director, has generously given CABA permission to reprint this article. I enhanced the article with information about a variety of home networking protocols.

Way to Go? HAN Protocols Up For Grabs

[Published March 2009 in *Utilimetrics News*]

Some of the biggest corporate names in advanced metering technology (AMI) – Elster, Landis+Gyr, Aclara and Itron – made the pages of *USA Today* last month. The reason? They came out of their corners swinging when the economic stimulus package looked as though it would require utilities to choose Internet-based networking in order to qualify for some of those 4.5 billion smart-grid dollars provided by the recovery bill.

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In fact, Utilimetrics helped lead the fight. CEO Joel Hoiland quickly contacted Congressional leaders to clarify the downside of dictating technology options in the bill. In a letter to Ed Markey, chairman of the House Subcommittee on Energy and Environment, Hoiland explained that each utility charts its own road map toward the smart grid, and "requiring technology specifics in the 'stimulus package' preempts service providers, regulators and consumers from designing" the best solution to suit their needs.

Not surprisingly, industry outcry prompted legislators to water down the stimulus bill's language. Now the package calls for utilities to use "Internet-based or other open protocols and standards if available and appropriate" in their AMI deployments. But, uncertainty remains surrounding AMI communications protocols, especially those related to the HANs that utilities hope consumers will eventually embrace.

Gotta HAN It To You

HANs are short-range communications networks that

connect appliances and other devices within a home. By combining HANs with AMI, the networks would empower consumers to track their energy usage through in-home display units, program smart thermostats to respond to price signals or peak alerts from the electric utility, and monitor loads remotely. The utility, meanwhile, gains a pathway for direct load control.

Given these applications, HANs have become integral parts of utility AMI plans. You can find a good summary of the reasons why in Google's recent comments to the California Public Utilities Commission on smart grid policy. Submitted by Bill Coughran, senior vice president of Engineering for Google, Inc., and Dan Reicher, director of climate change and energy initiatives for Google.org, the commentary covers a number of the drivers for HAN plans in smart grid deployments. Among these drivers are the energy conservation effects of consumer education. As the Google team points out, studies have seen consumers cut electricity consumption as much as 15 per cent simply by having access to information that shows electricity consumption in real time.

Combining automation with consumption information ups the conservation payoff. Results from California's 2003/2004 statewide pricing study show that automating demand response - a task that HANs facilitate - reduced demand by as much as 27 per cent on days when critical-peak pricing went into effect.

Such conservation or load shifting delivers cost savings to utilities and consumers alike. In addition, there is an environmental payload. The Googlers told California regulators that, "If just half of U.S. households cut their demand by 10 per cent, the electricity savings avoided would be greater than today's total U.S. wind and solar-power output. The CO_2 emissions avoided would be equal to taking approximately eight million cars off the road."

With benefits like this, it's no small wonder public utilities commissions are looking closely at HAN technology. Texas regulators have mandated that AMI systems be capable of delivering real-time consumption data to consumers and communicating with appliances or other devices within residences. The Lone Star State's policy also says consumers own their energy-use history, and they shouldn't have to pay the utility a fee to see it. Google's Coughran and Reicher asked California regulators to make similar rulings.

Even consumers seem to be ready to jump on board the HAN bandwagon. According to analysts at ABI Research, more than 70 per cent of people who responded to a November 2008 survey expressed an interest in using home automation to "manage consumption of energy" in their homes. Among the 1,010 survey takers, this use of home automation topped uses such as lighting and entertainment equipment control or monitoring family members. Only remote monitoring of the premises for security reasons was more important to the survey respondents, and that nudged out energy management by merely a few percentage points.

The Standard Approach

What kind of technology will consumers be using in their home automation systems and HANs? That's a popular question, says Dr. Kenneth Wacks, a management consultant and member of the GridWise Architecture Council (GWAC). He's working on an answer.

GWAC is a 13-expert panel appointed by the US Department of Energy to provide guidance for the utility industry as it starts to implement smart grids. As part of this work, the council has been asked to help the National Institute of Standards and Technology (NIST) fulfill an obligation to Congress that entails writing a report on the status of standards and specifications related to the smart grid industry. To that end, Wacks was asked to produce a catalog of HAN communications technologies for the report and, so far, he's tallied up about 30 of them [listed in the table below].

"Not all 30 have been used by utilities," he says. "Some are not market winners. This is just a survey of protocols for communications inside a home."

As someone who has sat on a number of standards committees – and run a few, too – Wacks is careful to distinguish between protocols and actual "standards." Protocols can be developed by individual companies or by consortia of companies, such as the ZigBee Alliance, the Z-Wave Alliance, the HomePlug Powerline Alliance and other groups currently vying for the utility industry's nod of favor in HAN technologies.

Standards are specifications "developed under the legal authority of a standards developing organization [SDO]," like the Consumer Electronics Association, Wacks explains. In the U.S., SDOs are accredited by the American National Standards Institute (ANSI). That means the word "standard" is a legal term, referring to specifications created by an SDO that meet ANSI's "essential requirements for openness, balance, consensus and due process." However, this is not the process that

Home Networking Communications Protocols									
Protocol	Communications Domain					Protocol Type			Note
	Gateway	Network Configur-ation	User Interface	Upper OSI Layers	Lower OSI Layers	Standard	Consortium	Proprietary	
CEBus				X	All media	ANSI			
DS2					PLC-BB		Univ. PL Cons.		PLC broadband
Echonet				X	All media	ISO/IEC	Echonet Cons.		
Ethernet					TP	IEEE/ISO			TP = twisted-pair wires
FireWire					TP	IEEE	1394 Trade Assn.		Streaming data - 1394
HomeGate	X					ISO/IEC			Residential gateway
HomePlug					PLC-BB		HomePlug Alliance		PLC broadband
HomePNA					TP		HPNA Alliance		Telephone lines
IEEE 802.15.4					RF	IEEE			Used by ZigBee
IGRS		X				ISO/IEC	IGRS Group		
Insteon				X	PLC, RF			X	
IPv6LoPAN					RF	IETF			
KNX				X	RF, PLC, TP	ISO/IEC	KNX Association		PLC narrowband
LonTalk					RF, PLC, TP	ISO/IEC	LonMark Interop.		PLC narrowband
MoCA					Coax		MoCA		Ethernet on Coax
Panasonic PLC					PLC-BB		HD-PLC		PLC broadband
Product Interop.	X					ISO/IEC			Links applications
Serial master-slave					TP	EIA-485			Driver/receiver spec.
Serial point-point					TP	EIA-232			Driver/receiver spec.
Univ. Remote Control			X			ISO/IEC			UI tailored to customer
UPB					PLC			X	
UPnP		X				ISO/IEC	UPnP Forum		
WiBeem					RF	ISO/IEC			
WiFi					RF	IEEE	WiFi Alliance		
X-10					PLC			X	PLC narrowband
Ytran					PLC		HomePlug Alliance		PLC narrowband
Z-Wave				X	RF		Z-Wave Alliance		
ZigBee				X	RF		ZigBee Alliance		Uses IEEE 802.15.4
NOTES:	This is a preliminary incomplete list of protocols, arranged alphabetically, without regard to market penetration								
	ANSI = American National Standards Institute								
	ISO = International Organization for Standardization								
	IEC = International Electrotechnical Commission								
	EIA = Electronic Industries Alliance (EIA standards are now managed by the CEA, Consumer Electronics Association)								
	IEEE = Institute of Electrical and Electronic Engineers								
	IETF = Internet Engineering Task Force								

predominates in the development of specifications for HANs and AMI today.

Rather, Wacks notes, the communications specifications being developed and touted in the HAN and AMI space today mostly are being championed by individual companies or a consortia made up of several corporations. "How do we extend utility networks from the utility back office to substations to meters to in-home devices in order to implement demand response? What technologies do we use?" he asks. According to him, the GridWise Architecture Council has "come to the conclusion that we're going to have many technologies. It will be nearly impossible to get the industry to coalesce around one set of specifications."

This could be troublesome. According to the 2008 Demand Response and Advanced Metering Assessment published this past December by the Federal Energy Regulatory Commission (FERC): "General uncertainty over the development and evolution of standards and how they will impact networking technology, especially as regards HAN integration, has some state regulators reluctant to proceed with AMI specifications, because they may discover a year or two later that they chose an inferior or unsupported technology."

As a case in point, the FERC report points to the New York Public Service Commission's decision to not authorize full-scale AMI deployments by Consolidated Edison in 2008. According to unofficial transcripts of a Commission meeting on January 16, 2008, there was concern because, "Many parties express caution that HANs and similar home appliance control systems are quite new, involve several competing designs and currently lack standardization of design or cross-compatibility."

Homeward Bound

More than a year later, the same situation remains: There is no clear winner on HAN or AMI network specifications. According to Wacks and others, that means the focus needs to be on interoperability, "so that we can get messages from end to end, even though the messages may be translated between different communications technologies along the way."

This means, he continues, that there will be a need for gateways, or devices that translate between two different

communications protocols. Where will those gateways reside? Some utilities are pushing for them to be located within the meters themselves, although Wacks doesn't think that's the way to go.

"Meters are designed to be in the field for years, if not decades," he says. "The HAN hardware that's going inside meters will be obsolete in five years." It's a fundamental problem, in his view.

Another problem: HANs may start with connections to smart thermostats provided to consumers by utilities but, ultimately, the networks will link to a variety of consumer electronics. Have utilities included the consumer electronics industry in HAN discussions? Not so much.

"There probably ought to be a lot more dialogue between what we call our 'tech home' community – companies who install or build equipment for home systems – and utilities," says Brian Markwalter, vice president of technology and standards for the Consumer Electronics Association. He recognizes utilities using HAN technology for load shedding have a need to verify that signals get through to the targeted appliances and load has, indeed, been curtailed. "We need to balance that with the rest of the consumers' home systems, where things may be items consumers bought themselves and consider their own."

Markwalter also thinks consumers themselves should be brought into the planning. "Be careful of treating this as something pushed out to consumers," he says.

Finding Your One and Only

Given these issues, how should utility managers plan the HAN part of an AMI deployment? Try before you buy, says Wacks. According to him, "Now is not the time to start mandating what works and what doesn't work. Now is the time for utilities to trial many different solutions."

Wacks also thinks utilities should take the same approach consumer electronics manufacturers take: Put the products out on the market, and let the market pick the winners.

CEA's Markwalter says, "That's a nice success story toward the end, but I'm not sure it will work at first" with HANs. "Home systems tend to be complicated," and he's not sure they're do-it-yourself technologies. Still, he sees merit in Wacks' market-based trials of HAN devices. "If we don't allow that, I don't think we will have succeeded. Volume won't be there. Prices won't be great. It will remain a niche market. That's not successful for anybody."

Until devices do hit the market, utilities planning for AMI with HAN applications have some resources to examine for ideas on specifications that promote interoperability. One is a set of general, high-level requirements created by a group called UtilityAMI. The suggestions are designed to be of value in a variety of deployment situations.

In addition, the Electric Power Research Institute (EPRI) is gearing up to launch a multi-utility study of radio-frequency and powerline communications protocols used for HANs. After a year of utility-based technology trials, EPRI intends to consolidate findings into a report that outlines performance related to transmission range, data throughput and electromagnetic interference between advanced meters and appliances in a variety of residential settings. EPRI scientists also intend to evaluate network security issues. Research begins this spring. A report should be forthcoming in spring of 2010.

Other groups also are investigating HAN and AMI network options. These include the Association of Home Appliance Manufacturers (AHAM) and the National Electrical Manufacturers Association (NEMA). Internationally, the U.S. is leading an ISO/IEC project to write world standards for gateways and product interoperability that apply to home networks. ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) issue standards that promote trade and commerce. ANSI votes U.S. positions on ISO/IEC standards and appoints delegates to meetings. Ultimately, the product interoperability standard under development will include a system model of an energy management system that can support demand response.

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.