Free Market Choice for Appliance Physical Layer Communications

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Executive Summary

1. The home energy management market is at an early development stage. Existing technologies are being integrated into innovative new energy management applications, while new technologies are being specifically developed to address this market. The dataset regarding consumer behavior and responses to these new applications is miniscule. While beliefs on how consumers will respond over time continue to be postulated, no one is certain which approach(es) to home energy management will prevail—from a business model, user interface, device, or communications standpoint.

   Accordingly, we believe that it is premature to choose any particular home energy management technologies now, particularly in the area of communication. As an analogy, consider how the use of the Internet developed as technology evolved. Internet access is available via many different MAC/PHY technologies, each of which is appropriate for some applications. Smart Grid-specific technologies will continue to be developed serving various markets. To encourage innovation, physical communications standards should not be mandated, certainly not at too early a stage in the market development process.

2. Selecting a short list of communication transports to be embedded in appliances at this early stage is fraught with unintended risks to consumers. Such risks may include obsolescence and the possibility of unauthorized, remote access to appliances via the embedded communications capability. Industry should focus on developing secure messaging models to ensure standardized messaging delivery in a secure fashion, *regardless* of communications transport.

3. To address the risks identified in #2, we recommend that the NIST H2G DEWG investigate the specifications for a modular socket interface (e.g., USB, PC Card) on appliances. Original equipment manufacturers (OEMs) can then choose to ~~utilize~~ add such a socket interface to the appliance. The customer would subsequently insert a communication module~~s~~ that might support~~ing~~ a variety of communications methods consistent with a service provider's signaling method or the customer's existing home-energy management system. ~~instead of having to embed a specific protocol directly inside the appliance~~. This approach follows proven, best engineering practices to introduce nascent communication methods to existing products. Well defined socket interfaces have proven to be the most durable interface available in consumer goods. By not embedding a specific LAN protocol directly inside the appliance the consumer has ultimate control over access and security by simply removing an inadequately designed communication device. At any time in the future the customer, or their service provider, can replace the existing communication option with a more advanced or simply different communication option. Further, this design relieves the appliance manufacturer for the responsibility of obsolescence, and of designing and warranting a secure LAN method. The responsibility instead shifts to the energy service provider who has an ongoing relationship with the customer and who gains the benefits from energy control.

Introduction

The Energy Independence and Security Act (EISA) of 2007 directed NIST to assess and coordinate the development of interoperability standards that would be required for the realization of electric Smart Grid. NIST is working with many agencies such as DOE, FERC, and NARUC to fulfill this mandate. (Please see the Smart Grid overview at www.nist.gov/smartgrid.)

In residences, Smart Grid communications for energy management between networked appliances and devices is facilitated both by wireless and wired communications protocols that comprise home area networks (HANs). Today, no single HAN protocol dominates the market, or is sufficiently mature enough to be called pervasive. Even widely used technologies like Wi-Fi are only one of multiple wireless options that are available to consumers.

Until sufficient real-world market data exists, it is impossible to forecast accurately which protocols will be cost-effective options for HAN applications beyond Internet access, such as demand response (DR).~~-~~ Also, the industry and regulators must gain extensive field experience about the performance of wireless communications in a wide variety of home construction environments. Furthermore, many networking solutions exist, including Ethernet on twisted-pair wiring, powerline carrier communications, phoneline, coaxial cable, and numerous flavors of wireless. Although many new homes now include wired infrastructure to enable easier deployment of data networks, all these wired technologies combined are a fraction of the installed base of Wi-Fi. The significant economic advantages of the socket approach are detailed in the section titled: Economic Consequences.

Some well organized stakeholders ~~Certain interests~~ are ~~intensely lobbying NIST~~proposing to choose a "preferred" protocol for both wired and wireless networking. This paper presents technical, market, and economic arguments why such a choice of HAN technologies at this early stage would likely be a serious, shortsighted mistake. Instead, we offer specific recommendations to NIST for adopting an alternative approach.

Technical Issues with Selecting a Physical Layer Protocol

What are the Real Requirements for Communications Protocols?

Limitations of Advanced Metering Infrastructure (AMI)

AMI networks have been proposed for demand response. However, the following issues may challenge an AMI network:

- When large quantities of customers participate in DR using synchronized rate designs like time of use (TOU) and critical peak pricing (CPP), the rebound in demand when high-price periods end may create load problems.[1]

[1] The rebound problem from large direct load control programs is well known empirically with many credible references published by EPRI and IEEE. A methods to alleviate the problem, such as randomizing restart after a curtailment event, ~~is~~ was described by Burke and Auslander, *Modular and Extensible Systemic Simulation of Demand Response Networks* at the Conference on Power Systems in Winnipeg October 2008. http://billstron.com/documents/SystemicControlModel_cigreCanada.pdf.

~~-~~There are no large implementations of CPP in the US; consequently there is no experience with rebound. In many technology enabled pilots, CPP has the effect of implanting a significant curtailment as in direct load control. However unlike direct load control programs where the utility can control the rebound through the techniques described above, utilities are at the mercy of appropriate rebound control strategies by third parties.

- If short duration (e.g., five-minute) real time prices are the solution, the combination of limited available bandwidth today, asymmetric loading, and long latency of AMI networks may not be appropriate to convey[2] real time price signals to one billion[3] home appliances.
- Latency and signaling requirements for ancillary services may stress AMI networks.[4]
- Network requirements for sending phasor information that keeps millions of roof top solar units on-line during grid transients may not align with AMI networks.

Clearly we need flexibility in communication protocols to enable the more demanding grid applications anticipated.

Are Current Utility Requirements Realistic?

Some industry stakeholders have recently commented that certain use cases requiring feedback from appliances may not be accurate or realistic. Specifically, Google has recommended relying upon meter data for statistical analysis rather than state information from appliances, such as customer override of a control signal. The Google approach[5] is to consider home energy consumption from a macro level, through the use of meter data. There is a real risk that However, appliance manufacturers and most home energy-management system providers will take the OpenHAN requirements and expend unnecessary time and money are drilling down to focus at the micro level, attempting to gather as much granular information as possible implementing use cases that don't have

[2] The author has direct personal experience with the operation of more than one radio-based AMI systems installed at Portland General Electric. AMI systems were not designed to send recurring commands or messages to a significant percentage of the communication nodes over a short period, or even hourly. There is enough bandwidth however, to achieve this type of messaging with group broadcast techniques. However these group broadcast techniques may expose undesirable security problems. Even if the broadcasts are secure, frequent repetitive messaging will likely interfere with robust collection of meter data.

[3] One billion appliances assume a future state with most significant appliances receiving control or price signals. This is based on growth from today's 110 million households in 2010 with an average of 5 five loads worthy appropriate for of control. Refrigerators, freezers, window air-conditioning A/C units, dehumidifiers, dishwashers, water heaters, electric dryers, electric space heating, central air-conditioning A/C, pool pumps, electric spas, and others are could all be cost effective control points

[4] Certain appliances like such as electric water heaters are ideal for providing ancillary services or absorbing unexpected production from wind generation plants. Frequency regulation signals can changes as often as every minute and as described above the AMI networks are not design to send messages every minute. Even a broadcast of such a command every minute will compromise system performance for meter reading. Thus frequency regulation must be implemented for autonomous, local control. However the control algorithms could be driven by settings that can be updated via the Network, and the performance of the appliance under these algorithms could be collected daily. But use cases to modify control algorithms and to collect performances metrics have not been developed.

[5] The Google's approach is in the record of comments regarding the development of OpenHAN 2.0 during in April of 2010.

proven value when they could be starting with a much simpler set of uses cases and commands~~.~~

The ~~relevance~~ importance of ~~to~~ the recommended "socket" approach is that the initial standard at the socket could define a short list of messages with desired, but optional, behavior when the appliance receives them. For example a message that represents "price is higher than average" could be associated with the desired behavior of "cut back average power level or defer operation." The communication module has responsibility to translate the current and any future complex use cases to the relevant command set available at the appliance. Under this approach there is no need to second guess whether the OpenHAN requirements are correct or incorrect. The communication module plugged in by the consumer will implement OpenHAN requirements.

If the early attempts reveal flaws, then the requirements are easily repaired. In the ~~, and~~ worst case, the consumer will be sent a new communication module but the appliance will be as reliable and functional as the day it was purchased. Some appliances may be able to accept the more complex use cases directly without translation, but the benefit of starting simple is that a basic command set could be implemented sooner. This has large economic benefits. Appliance OEMs don't have to wait for the complex use~~s~~ cases to be vetted by the utility industry. Also ~~and~~ there is no risk of incorrectly embedding the interpretation of the more complex use case in the appliance firmware.

A question to be answered ~~The challenge~~ is whether the breadth and depth of current use cases burden appliance OEMs with too much cost for communication. For this reason, we think it is premature to mandate full-stack communications and transport protocols for appliance interfaces. Instead, we should start with the essential and basic requirements, and let market experience guide revisions and protocol extensions. ~~The OSI reference model promotes modularity at each layer of the stack; the Smart Grid industry should embrace a similar approach, enabling modularity from the physical interface all the way up to the application layer.~~ Starting with a simple but extensible socket interface ~~Only this approach~~ will ensure an innovative, cost-competitive market delivering benefits for consumers, utilities, and regulators.

The approach described above is consistent with the reasoning provided by AHAM (Association of Home Appliance Manufacturers) at an April 2010 meeting sponsored by EPRI where AHAM ~~they~~ suggested the use of an embedded "light" communication protocol. The AHAM model moves most of the security problems and translation of OpenHAN messaging to a hub or gateway in the home but external to the appliance. ~~It is not clear whether the~~ If this light communication protocol ~~will~~ follows an open protocol common to all OEMs, ~~this~~ it would help minimize obsolescence. However, ~~but~~ there is still the risks that the selected physical link may not operate in some home, multifamily, or farm settings. If the appliances OEMs do not converge on a single open protocol from the appliance to the hub, ~~then~~ obsolesce of the appliance~~'s~~ communications protocol is certainly an issue.

Beyond the Smart Grid and Energy Management: the Inter-connected Home

Energy Management is only a subset of home communication applications. Home entertainment systems, such as video gaming systems, TVs, set-top boxes, computer systems, and smart appliances will be interconnected to enable services we cannot even imagine today. These use cases are not yet well-understood. In order to enable this capability, a communication protocol embedded in smart appliances needs to be flexible in order to adapt to the marketplace by offering solutions customers can afford and understand.

Firmware Upgrade Limitations with Embedded Communications

Appliance firmware upgrades in the field must be considered for those devices that participate in DR. However, this is a challenge for appliances because some communication systems to the home may be one-way or relatively slow. Also, the additional cost and complexity for appliance makers may be difficult to justify—a truck roll every four or five years adds cost that OEMs, utilities, and consumers will be unwilling to bear. The alternative for consumers to bring their appliance to a repair center for upgrade is unreasonable. The socket approach means the repair option ~~is~~ for the service provider is to send the customer a new communication module.

Standardized Socket for Communication Interface

One solution to these technical problems might be the incorporation of a modular, standard socket that would allow smart appliances to work with a variety of communications devices. A new communications protocol would then be customer-installable via a plug-in communication device costing $5 to $10. For example, RS-232, USB, a proposal by EPRI, and U-SNAP are all possible options for a universal hardware interface. The EPRI project aims to create an interface specification after soliciting interface requirements from utilities, appliance OEMs, and communication device manufacturers. At this price point, the consumer can readily adopt new communication methods to meet value propositions of tomorrow—not so with embedded appliance communications designed for the needs of today. Obviously, the port technology would need to be carefully chosen to support anticipated communications requirements.

Communication Solution

There is no optimum single choice of access networks (e.g., xDSL, cable, satellite, fiber, GSM/CDMA, WiMAX) to deliver energy management data and/or control messages to the consumer premises—if there were, utilities would be using it by now.[6] Instead,

[6] For the advantages of different physical layer protocols see the references.

ITU-T, G.995.1 (02/01) Overview of digital subscriber line (DSL) Recommendations [ITU-T standards are called "recommendations." ITU, the International Telecommunications Union, is part of the United Nations.]

utilities deploy various methods today, and will continue to do so in the future. One-way VHF and one-way pager actually top the list of the most commonly used communication methods based on the volume of points that have been deployed. Rural utilities have used low speed power line communication techniques for decades to read meters because of the value proposition. Recently, some utilities have proposed reaching homes using one network technology for access, then continuing into the home with other networks such as LonWorks, BACNet, ZigBee, IEEE P1901, or ITU G.hn.

The key motivator for choosing a utility access network is low cost and reliability. One-way, FM/RDS is another method gaining traction in some areas of California and Canada because it meets the needs of simple implementation, low cost, and reliability.

Basic two-way communications enhances reliability by acknowledging the transmitted packet. A notable example of an acknowledged protocol for DR has been deployed by Florida Power & Light (FPL) Company to more than a million points. The technology chosen was *Two-Way Automatic Communications System* (TWACS® from Aclara). Non-communicating meters are used in this particular program. The return communications channel acknowledges the receipt of a utility control signal for appliance operation, allowing FPL to verify that the control signal has reached the controlled point. Ironically, with AMI, the interval data can be used to validate load response; consequently, communications to the appliance with a response from the application rather than just an acknowledgement is not needed to validate that the direct load control signal has reached the premises. Under time-varying pricing, customers will be responsible (as in any other retail market) for observing and responding to price signals.

In the present heterogeneous utility environment, no single protocol is likely to be best for a specific home and application. Of greater concern is the fact that the industry, comprised of utilities, appliance makers, and DR providers, has had experience with only a few thousand homes. These customers opted into boutique pilots based on more

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"Design Review of Satellite Telemetry based on CCSDS standards and Proposed Hardware Implementation of CanSat," by Waqas Afzal and Adnan Mahmood, *Proceedings of the International MultiConference of Engineers and Computer Scientists* 2008 Volume II IMECS 2008, 19-21 March, 2008, Hong Kong.

"Residential Fiber Optic Subscriber Loops: Information Pipeline or Technology Pipedream?" by B. Mullinix, *IEEE Journal on Selected Areas in Communications*, December 1986.

"Digital cellular telecommunications system (Phase 2+); Specification of the Subscriber Identity Module - Mobile Equipment (SIM - ME) interface, (GSM 11.11)," ETSI (European Telecommunications Standards Institute).

TIA-95-B (October 2004), *Mobile Station-Base-Base Station Compatibility Standard for Wideband Spread Spectrum Cellular Systems* [CDMA].

IEEE Standard 802.16-2001, *IEEE Standard for Local and metropolitan area networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems* [WiMAX].

IEEE Std 802.16e-2005 *Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems - Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands.*

robust two-way communication technologies. Under the circumstances, our proposition is that simply not enough evidence of market experience exists to pick protocol winners.

Obsolescence

Typically, home appliances can be expected to last twenty years or more; significant changes occur in the communications industry in such a timeframe. For example, twenty years ago home PC ownership was 19%, with almost none connected to the Internet. As technology evolved, so too have network protocols, with some becoming obsolete in as few as five years. The Internet began using packet-switching networks, then evolved to embrace a wide range of physical media, such as fiber optics, coaxial cable, twisted pair, and many wireless protocols. The Internet incorporates myriad networking technologies including Ethernet, Wi-Fi, cellular, WiMAX, powerline, and more. Each solution was developed in order to meet the constraints of the operating environment and the needs of the applications.

A similar type of environment is envisioned for the Smart Grid, one that will require a range of flexible connectivity options. Thus, based on current limited evidence, it would be too risky a proposition to propose HAN communication standards based on the existing suite of protocols, some of which could very well be obsolete in five years or less.

Best Engineering Practices

The communication modularity in personal computers (PC), now a household commodity, provides an excellent example for the Smart Grid industry. The life of a PC is typically only three to five years, and yet, manufacturers were so concerned about obsolescence and lack of interoperability that they developed modular standardized physical interfaces—enabling them to adapt and support newer communications technologies. These interfaces were based on socket architectures for service offerings such as wireless connectivity to hedge against obsolescence risks. Example of such sockets included the serial port, the ISA slot, the PCI slot, and the PCMCIA socket (which accommodated plug-in Ethernet and Wi-Fi modules, storage, and other technologies). By the year 2000, PC manufacturers had enough experience to determine that Wi-Fi capabilities could be built into the PC itself. However, the dependence on sockets was a wise decision because LAN cards then were not interoperable.

The moral of the story gathered through this PC experience has been that embedded communication technologies should be considered only after 1) a standard has been accepted by the market, and 2) shortcomings found in a sufficiently large (e.g., the first 10 million) number of units have been resolved, and 3) best design practices are understood by most manufacturers.

Appliance Makers not Motivated to Collaborate on a Communications Protocol

Currently, the largest appliance OEMs do not have the motivation to collaborate on a common communications protocol. Rather, these OEMs prefer to maintain a proprietary machine-local protocol used for inter-module communications within a single appliance and not open the possibility of interoperable communication with their competitors. These local protocols could easily communicate with a small transceiver embedded in the appliance for communication with the Smart Grid. However, with the diversity of proprietary protocols used, this transceiver module would also be proprietary and specific to the appliance manufacturer. Without evidence of a significant market advantage of providing a smart-grid appliance, the OEMs are not willing to move towards a common local protocol to interface with a smart-grid transceiver. Considerable value would be gained by adopting a best-practices approach through research, field trials, and learning from market failures and successes.

Market Issues with Selecting a Physical Layer Protocol

Customer Experience with Two-Way Control Protocols for Demand Response

As mentioned above, customer experience with communication embedded in appliances is practically non-existent; thus, we don't have convincing answers to the following questions:

- What are the market acceptance barriers to two-way communication technologies (versus one-way communication technologies)? How much DR market opportunity will be lost if those customers who prefer to participate only anonymously under a one-way signaling process opt out? (Market tests have revealed some consumer resistance to two-way communications, particularly due to privacy concerns.)
- Will manufacturers and customers prefer energy management embedded in existing network electronics, such as cable/DSL modems, VoIP answering machines, Internet connected TVs, and home media centers? Communication technologies embedded in these relatively short life span devices will change over the life of these appliances—to the consumer's detriment or benefit?
- What business entity is suited to provide service for in-home energy management: store staffs (e.g., Geek Squad), HVAC technicians, utilities themselves, or new Internet-based businesses? Won't these entities have preferences for the communications method to reach the appliances?

Unintended Market Outcomes

By mandating appliance manufacturers to embed "standardized" communications protocols into their appliances with all the attendant business risks highlighted above, we may also inadvertently stifle innovative appliance design. For example, the cost of embedding communications could instead be utilized towards more creative design of "DR-ready" appliances with sophisticated operational flexibility that can be invoked when necessary.

Embedding communication protocols in appliances may impose security and obsolescence risks on the appliance OEM, the customer, or both, but likely not upon the utility that holds the value proposition for smart appliances in the first place.

Risks of Selecting a Physical Layer Protocol

Selecting Specific Protocols Now Imposes Unnecessary Risk

Recommending a small list of protocols now creates the following risks:

- The wrong protocols are picked based on politics and/or incomplete market experience.
- Once selected, the pressure to deliver smart appliances with these protocols could short-change complete and thorough development leading to:
  - Permanent security threats in home appliances, or costly fixes.
  - Appliances with use cases based on immature communication protocols that will quickly become obsolete.
  - Appliances that are incapable of much greater operational flexibility than could possibly be invoked through these communication protocols and associated information models.
- Cessation of innovation in alternative communication methods.
- Privacy concerns are of paramount importance to customers. Two-way communication protocols that send information from inside the home to third parties could be deemed an unconstitutional invasion of privacy on the basis that customers must sacrifice privacy in order to lower their electric bills.[7]
- Hacker conferences (e.g., Black Hat) are featuring the ability to modify firmware in immature protocols to create worms that could take advantage of the two-way feature and infect nearby "wireless" devices, which in turn infect more devices within their reach. This is a good reason not to eschew one-way technologies or to limit the consumer options such as upgrading existing communication devices.

Economic Consequences from Selecting Physical Layer "Winners"

Interoperability is a challenge even with proven protocols. In the Pacific Northwest GridWise Demonstration Project, collection of data from the demand response nodes

[7] See legal precedents described by Lisovich and Wicker, *Privacy Concerns in Upcoming Residential and Commercial Demand Response Systems*, IEEE Proceedings on Power Systems, Vol.1 No.1 March 2008

was a problem.[8] Cable and DSL Internet services were sufficiently ~~enough~~ different that only one of them could be used. The lessons learned from this project resulted in a published paper for the 2007 Grid--Interop conference on the definition and advantages of the socket approach.[9] This paper documents that implementing a standardized appliance socket creates a present value of benefit greater than $50 billion ~~of dollars~~. The critical assumption to capturing this wealth is that the socket should be universally added to all appropriate appliances over a ~~5~~ five-year development period. Once a socket has been added ~~After added~~ to a ~~given~~ product line, ~~then~~ all appliances produced in that line would be sold as demand response-ready. Because of the long life of appliances, adding the socket captures what would otherwise be a lost opportunity when a late-adopter customer is finally sold on the idea and adds the communications device 10 years later.

In 2009 Portland General Electric did additional analysis with the model built for the 2007 paper cited above. The analysis demonstrated that even a one--year delay in developing the standardized socket would reduce the present value benefits by $6 billion dollars. They submitted a summary of these results to encourage an effort to fill the gap caused by the lack of a standard appliance interface.[10]

The large economic consequence of delay explains why the socket approach is superior to the AHAM light embedded communication approach. The AHAM approach will be either slower, or riskier, than the "socket approach." Thise approach will ~~be slower ifor interoperability. T~~ hinder interoperability and cost society billions of dollars,

These following bullets summarize the disadvantages of embedding communication in the appliance:~~appliance.~~

- The probability of substantial negative economic consequences of prematurely selecting a winning technology is quite high given the immature state of the market and nearly total absence of material experience with two-way communication protocols.
- With communication protocols embedded prematurely, smart appliance consumers bear a high risk of unexpectedly buying a capability that is prematurely obsolete, or worse, for becoming a victim of cyber crimes.
- Best business practices demonstrate that success in new endeavors is enhanced when the business parties focus on their core competencies. For DR, this means that:
  - The utility role will be limited to sending basic and reliable communication signals.

[8] See page 5.9, *Pacific Northwest GridWise Test Bed Demonstration Projects Part II Grid Friendly Appliance Project*, October 2007, Hammerstrom, Principal Investigator. http://gridwise.pnl.gov/docs/gfa_project_final_report_pnnl17079.pdf

[9] Eustis, Horst, and Hammerstrom, *Appliance Interface for Grid Responses*, October 2007, http://www.gridwiseac.org/pdfs/forum_papers/103_106_paper_final.pdf

[10] Portland General Electric comments on the Draft Interoperability Standards Release1.0 filed November 9, 2009.

- The appliance OEM role will be limited to modifying appliance controls to accept basic signals and re-engineering the appliance controls and user interface to be receptive.
- Communication OEMs will have a role to innovate communications methods to bridge signals between the utility and the appliance.

Deviating from such a proven and successful market paradigm, or worse, imposing a barrier to this model is likely to introduce unnecessary costs to the consumer.

- For good reasons, appliance OEMs and utilities both practice conservative, risk-averse design principles. To maximize economic benefits, the architecture of the DR infrastructure should allow business entities with experience in communications and information technology to play an active role in innovation. A facilitation of this principle would be a standardized communication interface on the appliance, rather than limiting utilities in the communication options they might choose to invoke in reaching an appliance.

Recommendations to NIST on Facilitating HAN Communication Standards

1. Until the evolving DR use cases have been practiced in millions of households, encourage implementation of a wide variety of wired, wireless, and power line carrier technologies to encourage markets that cater to different needs and acceptance levels.
2. The NIST H2G DEWG should investigate the specifications for a standardized, USB-like socket interface that appliances OEMs can choose to adopt instead of embedding a specific protocol. If technical issues need to be investigated in depth, the H2G DEWG may recommend the creation of a PAP to assess the alternatives.
3. Gather extensive field experience by deploying various protocols in a variety of homes with various building materials, infrastructures, and climates; rather than declaring a winning technology or choosing a standard. If a solution presents itself head and shoulders above the competition, NIST could consider a recommendation. However, NIST should keep in mind that innovation occurs in leapfrog phases, and that any winner NIST declares now (at a peak) may fall out of favor in as little as 12 to 24 months (in a valley).
4. Allow utilities and third-party developers of energy management services time to determine what kinds of programs are successful in the marketplace, and allow consumers the time to acclimatize to new energy programs (possibly many years).
5. Avoid embedding short-lived communications technologies in long-lived appliances without a plan to accommodate upgrades; most communications

products (e.g., home routers, cable/DSL modems) have maximum five to seven year lifecycles, whereas appliances have life spans two to three times as long.

6. Focus on the energy services interface (also called the residential gateway or customer services interface) between the energy management service provider (outside the house) and the home network (inside the house).
7. Leave the interface on individual home appliances open to investigation, field trials, and market testing. NIST could provide a forum to compare results, encourage cooperation, and eventually focus on a limited set of choices. Currently, it is too soon to mandate one appliance interface because we do not know what works in the widest set of environments and cost-sensitive appliances.
8. Leave the communication system architecture open to investigation. One should not assume that a meter will serve as the communication gateway to a residence, nor should one assume that a HAN is required for DR purposes, as opposed to a wide-area communication signal direct to end devices.
9. Solicit the inputs of a diverse cross-section of the appliance industry, including manufacturers of white goods (large kitchen and laundry appliances), consumer electronics, and small appliances that consume significant energy (such as portable heaters, fans, window air conditioners, and de-humidifiers). Specifically, we recommend that NIST facilitate large-scale participation and contributions in various domain expert working groups (DEWG) and priority action plans (PAP) that NIST manages as part of the Smart Grid program.
10. Educate the appliance and consumer electronics industry about the value of an interface to a home network for energy management and other services. Urge product designers to include such interfaces in future product and application designs.
11. Defend consumer freedom to mix and match appliances, water-heaters, entertainment devices, and networking gear from multiple vendors.
12. Allow for options both with and without in-home energy management systems, and let the free market decide on their value.

In summary, choosing a preferred solution(s) now for wired or wireless technologies will stifle innovation among appliance and vehicle manufacturers and their suppliers, while limiting consumer choice. The consequences are potentially higher prices for white goods due to a lack of market-driven efficiencies. Today, certain interest groups are urging NIST, FERC, and the Executive Office to make a decision with significant impact on U.S. consumers—despite the fact that no knowledge base exists on how consumers will utilize smart appliances. No single HAN protocol choice can cover all applications.

As a useful analogy, we can see the benefits of market development and choice in mobile devices. If the federal government had mandated a standard mobile operating system four years ago, consumers would not have benefited from the introduction of the Apple iPhone, which has led to a healthy and competitive marketplace, one that has prompted worldwide innovation by Google, Microsoft, Palm, and others.

If the Executive Office and NIST feel compelled to choose a “preferred” solution for wireless or wired home area network communications, they should announce a competition to put each solution through a rigorous interoperability compliance and testing regimen to prove its suitability for Smart Grid applications. This competition would be similar to the evaluation currently undertaken by the Society of Automotive Engineers to determine the most appropriate solution for communications between an electric vehicle and its charging equipment.

Market-driven economies are very efficient. The market should decide the winner over a period of time, not an ill-informed pronouncement of a so-called “preferred” solution now. Allowing any mechanism other than the market to decide is not only ill advised, it is anti-competitive.