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FEATURE ARTICLE

CASE STUDY: THE UNRULY EMERGENCE OF THE DIGITAL HOME

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Abstract: *Although basic electrical devices like thermostats, phones and radios entered our dwellings many decades ago, the long-awaited vision of the "digital home" is only now becoming a reality. The emergence of the futuristic home, controlled by and for the fulfillment of the comfort, safety and enjoyment of its owners, has become possible only with the development of the hundreds of telecommunications, wireless, data format, networking and other standards that have been created by scores of accredited standards development organizations and unaccredited consortia, some venerable, and others new and created specifically for this purpose. An examination of how this new standards development ecosystem has evolved demonstrates how complex standards infrastructures come into existence through the reordering of relationships among existing, and the formation of new, standard setting organizations. Such a review also illustrates how participants behave when commercial opportunities are great, and the stakes for success (or failure) are high.*

Introduction: Through the coincidental maturation of a variety of technologies, the New Year has brought a rash of news stories and product announcements relating to innovations in digital home technology. All at once, multi-year research, standards development and commercialization efforts in video delivery and storage technology, wireless services (both "last mile" and in-home), multiple types of display technology, and new PC capabilities are converging at roughly the same time, allowing long-anticipated innovations in home services and systems to become available to consumers.

In each case, these new digital goods and services rely on new standards created within a broad variety of standard setting organizations (SSOs) that are both accredited and non-accredited, broadly targeted and narrowly focused, venerable and brand new. Taken together, the scores of SSOs involved, and the hundreds of standards that they have developed to this purpose, provide a vivid example of the degree to which our modern, technology-based society is dependent on the largely unseen operation of the global standards development infrastructure.

At the same time, the news has also been rife with stories describing the emergence of rival factions promoting their favorite standards solutions. Sometimes these battles are being fought within existing SSOs, while in other cases new forums have been created to act as auxiliaries to ongoing efforts within an already existing SSO, and in still other instances totally new SSOs have been formed to develop and promote standards. For better or worse, this behavior is typical of the highly competitive operation of the standards development infrastructure, as the exact parameters of a new standard can have profound economic impacts – both positive and negative – on the vendors that participate heavily in the SSO process.

Where such contests have been waged, the efforts of opposing camps have sometimes been reconciled, resulting in the ultimate release of one standard by a single organization. But in others, the effort has failed, leading to the announcement of two standards, each supported by separate but otherwise often substantially equal product lines – thereby leaving the consumer with two options, and little to inform her choice as between the two. This too is typical of the standards development process. Still, given the high

stakes and the fact that both SSO participation and the implementation of SSO standards is voluntary, it is a testament to the stability of the standards development process that such results are rare rather than common.

Lastly, the example of the emergence of the digital home illustrates the degree to which consortia have been influential in addressing the needs of the information and communications (ITC) technology industry. Perhaps because so many technologies and product opportunities are brand new in the ITC space, consortia have been utilized to a vastly greater extent here than in traditional industries. Similarly, some of the most active and respected accredited SSOs (such as the IEEE) that are nominally accredited in one country have become global, rather than national organizations – in part, because data knows no borders.

In this article, I survey several of the principal areas of innovation and the resulting new product types that are now reaching the market, and the related SSOs and promotional organizations whose usually complimentary, but sometimes conflicting, efforts are enabling the digital home of the future to (finally) emerge into the present.¹

The Technologies: Homes have made increasing use of sophisticated electronic technologies over the last fifty years, and in many cases the areas of greatest innovation today represent efforts to create ever more sophisticated upgrades to the basic products introduced when electronic technology first entered the home. Chief among them are the following:

Environmental controls: The first simple thermostats liberated the homeowner not so long ago from the need to stoke the wood stove or shovel coal into the furnace throughout the day (and night). These controllers, of course, depended on the development of additional technology: the electromechanical means to control and feed coal, oil and gas to furnaces. In the first simple systems, hot air and hot water could literally rise to the occasion, with hot water heat providing manual room by room adjustment through taps placed on individual radiators.

Over time, each new development in home environment technology gave cause to the design of more sophisticated controllers. First, as better means of distributing heat were developed, localized controls became feasible as well as desirable. When central air conditioning became affordable, more attention was paid to the means (fans) to distribute this new luxury equally where needed, and controllers were needed that could regulate both cooling as well as heating. Humidifiers could also be added to the same system, offering the ability to further influence one's immediate environment – and the need for a device to control that variable as well.

With the increasing price of fuels, programmable controllers became attractive, in order (for example) to automatically lower heat at night to conserve energy. Similarly, as alternative energy sources (e.g., active and passive solar systems) were developed, these technologies needed to be accommodated as well. But control was still exercised in most cases by thermostats that remained in many ways not so different than those in use decades ago. The most significant advance was the addition, either locally or centrally, of a computer chip and related technology.

Today, even more elements of the home environment are becoming centrally controlled, resulting in the design of devices that can locally or remotely make adjustments not only of heat, humidity and cooling, but also control light, yard sprinklers, child monitors, security cameras, and the unlocking of doors. A further area of innovation helps address the needs of the elderly and the disabled.

In the course of this evolution, traditional accredited SSOs have created new electromechanical standards to replace or supplement ones they previously created, while other accredited SSOs that previously had no need to commission information technology oriented working groups have realized the need to do so, creating (for example) standards for wireless solutions that are intended to replace wired

¹ The links in this article lead to SSO descriptions found in the [Consortium and Standards List](#) section of the ConsortiumInfo.org Website. This is the largest and most complete list of accredited and unaccredited standards organizations in existence. Each description includes the purpose and activities of the organization in question, as well as links to its site, and (if publicly available) to its specifications and intellectual property rights policy as well.

or cabled services that conform to standards created by older SSOs. At the same time, new organizations have been created that focus solely on the standards needed to enable the digital home.

One example of such a new organization is the Z-Wave Alliance, which has created both a standard as well as a certification and branding process for controllers that are intended to "deliver increased comfort, convenience, safety and security." Over 100 companies implement Z-Wave compliant products that permit wireless, pre-programmed control not only in traditional areas such as lighting and temperature, but also in more modern applications, such as to control the operation of home theaters, and the heaters and circulators of pools, spas and hot tubs.

Another relatively new consortium (it was formed in 1997) is the Energy Conservation and Home Network Consortium (EchoNet). Its mission is to develop "software and hardware to support a home network that is committed to energy conservation, security, home health care, and other domestic needs" using existing power lines, as well as both radio frequency and infrared devices to enable data transmission without additional wiring.

Entertainment systems: The simple radios of the first half of the last century have given way to sophisticated stereos, while simple black and white televisions have evolved into ever-larger flat screen displays. Similarly, VCRs have given rise to "surround sound" home theaters and Tivo players, while new on-demand video services are transcending the traditional limitations of structured programming. And all of the above are converging with the home computer.

Here again, the standards that are enabling this evolution are being created by a mix of old and new SSOs, with (for example), accredited SSOs continuing to serve the safety compliance and certification needs of home electronics, while other SSOs, both accredited, unaccredited and brand new create the standards needed to meet the unique needs of new products and services. Newer consortia in this domain include the Home Audio Visual Organization (HAVi), which brings together consumer electronics, software, semiconductor and computer manufacturers to promote a network architecture designed to enable home audio-video interoperability at the API and middleware levels to allow "plug and play" performance (i.e., new devices that are added to the network identify themselves and negotiate interoperability with existing devices). HAVi standards are intended to be compatible, and work with those of other consortia with similar goals, such as Jini.org and Universal Plug and Play and Forum (UpnP).

A similar effort was launched by the Universal Home API Forum (UHAPI Forum), which also focuses on making home entertainment systems more attractive purchases for homebuyers. The ultimate goal of the UHAPI Forum is to standardize a complete set of open APIs for a variety of appliances such as analog and digital televisions, set-top boxes, DVD players and recorders, printers, personal video recorders, home servers and other consumer audio and video devices.

Communication: While the telephone has been present in households for over a hundred years, only in the last thirty has it become revolutionized, first by the development of switching and long distance transmission technologies that have nearly eliminated the need for human operators, and (through deregulation and the breakdown of monopolies) decreased long distance costs. In the same time period, the humble rotary-dial phone finally gave way first to the push-button phone, then to mobile and wireless base station phones, and now to multi-purpose and multi-service wireless devices that incorporate computer, telephone, video, text messaging, Web access, and other functions, and which are already eliminating the need for land-line accounts for many customers.

The standards used to enable these upgrades range from those regulated through the International Telecommunication Union (ITU) globally and the Federal Communications Commission (FCC) in the United States, to those created by literally scores of accredited SSOs and unaccredited consortia, in the case of multi-function hand held devices.

Data formats: Traditional color television is giving way to High Definition television, even as existing DVD players are about to be replaced by two competing standards-based high definition technologies. At the same time, digital radio transmission and reception is just entering the marketplace.

The efforts of regulators (in the case of broadcast frequencies) as well as accredited and unaccredited SSOs are involved in these developments (upon which more later).

Transmission modes: But the greatest revolution of all unquestionably lies in the means by which these various new devices communicate with each other and are controlled by their owners, as well as the means by which services are delivered to, and by them. The methods being employed to accomplish these goals are diverse, and in each case, are standards based. The categories of progress in this category include the following:

Connecting to the Network: The so-called "last mile" constraint to delivering broadband data to the home from the high-capacity fiber optic cable infrastructure that has already been widely deployed has challenged the industry for years. That constraint arises from the limited capacity of existing pole-to-home "twisted pair" copper wire to deliver data at robust speeds. With the cabling of more and more households to allow the purchase of expanded cable television services, however, a new route became available to provide broadband data services: the **cable** infrastructure already largely in place.

The increasing availability of such services, in turn, provided the competitive challenge to the TelCos to finally accelerate the rollout of the infrastructure needed to deliver their own solution: **DSL** coverage. However, just as the TelCos were slow in offering the original DSL service, their reception to the next-generation standard DSL standard ("Very-High-Bit-Rate Digital Subscriber Line 2", or **VDSL2**), approved by the ITU last summer, has been lukewarm, despite the fact that VDSL2 might allow the delivery of such services as pay-per-view video.

Other alternatives include **satellite**, **WiMax** (a long distance microwave frequency analog version of WiFi), and delivery of internet over existing **Powerline** networks, each of which can be useful to serve sparsely populated areas. WiMax and Powerline services may also come to be economically competitive in urban settings as well. And while satellite has been available for some time, fixed-station WiMax is only just now being launched commercially, based on the development work of the IEEE in creating the standard itself, and the certification and promotional work of the supporting WiMax Alliance, which has created the means to test and certify WiMax compliant equipment.

Integrating data sources, networks and devices: While it's good news that consumers may now gain access to the Internet via multiple means, this reality presents other challenges, as does the rapidly escalating number of types of devices that consumers would like to use, and the proliferation of Internet-based services they wish to enjoy. These challenges have been met by another crop of new organizations, each of which is dedicated to resolving some subset of these issues.

One example is the Home Gateway Initiative (HGI), which was launched by telecommunications providers in December of 2004 to develop and promote standards to guide manufacturers of the "gateways" that homeowners may need to ensure interoperability among home network(s) and home-based devices, on the one hand, and the wide area network represented by the external Web – and thereby create a greater market for TelCo-provided services.

Voice over IP: Just as wireless telephony is challenging landline service, "**VoIP**" technology has become sufficiently sophisticated to provide a real alternative to traditional telephone service. Although this type of service may soon become taken for granted by the user while speaking, its impact on pricing and service models may be profound, driven by freely downloaded (thus far, by more than 262 million people) software such as Skype. Using VoIP, a user can add a handset to a broadband connection, and eliminate her normal phone service entirely, and take advantage of additional features (such as video) as well. The development of the underlying standards for this new service again brings together the old and the new – in this case, the venerable International Telecommunications Union (ITU) and the nouveau Internet Society (ISOC) and the Internet Engineering Task Force (IETF) among other organizations.

Wireless: For some time, the IEEE has been the crucible within which most of the wireless activity has occurred that is relevant to the home. That work is identified by a series of numerically designated standards that all begin with "802," to which various numerical and alphabetic suffixes are added to distinguish each tailored application from the next.

While these names may suffice for the engineers that create these standards, the marketing departments of IEEE corporate members have seen fit to attach more accessible names to the technology in order to sell products that rely on these standards. The result has been the popularization of names such as "Wi-Fi" (based on 802.11a, b, and g, to date) and "WiMax" (which utilizes 802.16).

Wi-Fi standards have been extremely useful for enabling the small, localized networks used by homeowners, coffee shops and small businesses, and may in the future be used in broader applications involving "mesh" networks that link multitudes of home and business Wi-Fi routers, each allowing a signal to be handed off to the next. A proposal for the standard to accomplish this result – to be developed by the IEEE as 802.11s – is supported by the Wi-Mesh Alliance

But there are also many additional standards that operate at shorter ranges – some being used at a range of only a few centimeters, and others at a few feet or yards. The best known of these standards is Bluetooth, which was originally developed by Nokia, and is now supported by the Bluetooth SIG. A newer specification is the Near Field Communications standard developed by the Near Field Communications Forum, which operates at a distance of only one or two centimeters, and can be used (for example) to set up the transfer of pictures from a camera to a printer.

Making life easy: Just as HAVI and the UHAPI Forum (discussed above) are each seeking to make it more attractive for homeowners to buy audio and video consumer products by enabling cross-vendor "plug and play" performance, other SSOs are making the purchasing of their members' products more tempting by resolving other barriers to realizing the digital home.

One such focus is avoiding the need to install new wiring in order to enjoy the benefits of a home network. While wireless-enabled products are one solution, there are others as well, such as that offered by the Home Phoneline Networking Alliance (or HomePNA, founded in 1998), the mission of which is to ensure adoption of a single standard for utilizing already existing home telephone wiring to permit sharing of a single external Internet connection by multiple computers in a home. Like many other consortia that create standards intended to drive consumer buying behavior, HomePNA also provides a certification testing and branding program.

A similar goal, but a different conduit, is the focus of the HomePlug Powerline Alliance. As this organization's name indicates, the standards, certification program and branding that it offers repurposes existing home electrical wiring to create a home network.

Not all such efforts have been successful, however, as the marketplace has favored some solutions but not others. The HomeRF Working Group, for example, was founded in 1998 to create a home wireless standard optimized for handling voice, data and entertainment applications. The early success of Wi-Fi, and the early focus on lower-density data, rather than voice or entertainment, however, led to its dissolution in 2003. The solutions of other organizations (such as those that repurpose in-home telephone wiring) may prove to be transitional, as other technologies – and in particular wireless solutions that have fewer problems dealing with electromagnetic interference – leapfrog them.

Getting to yes (but not always): As noted in the introduction to this article, not all efforts to achieve consensus have been successful, and the points of fracture can vary widely.

For example, as described in the April 2005 issue of the CSB, China continues to push a number of its own home-grown standards, including several wireless specifications. One is called WAPI (for Wired Authentication and Privacy Infrastructure), while another (called TD-SCMA) has been developed as an alternative to two other 3G telephone standards, WCDMA and CDMA2000. China is also active in developing its own RFID standards. In each case, a major motivation is to avoid the expensive patent royalties that Chinese manufacturers would need to pay in order to build to non-Chinese standards.

Similarly, regional standards strategies (particularly in the EU, but also in other areas, such as Southeast Asia), may lead to competing standards initiatives.

The greatest divergences, of course, are among vendors, and the strategies that they adopt in a given instance or market vary. At one extreme, there are individual patent owners that unabashedly work to promote a standard that will reap the greatest royalties, and seek to gather companies around them to

support their cause. At the other, there are companies that work within existing organizations to promote their cause, but sometimes break away when they are unsuccessful in achieving their goals.

An example of the first tactic that has had an impact on home products is the long and bitter series of struggles between the proponents of competing specifications for each generation of home DVD players. The first, and most notorious conflict, was the VHS – Betamax format war of the 1970s and 1980s, which doomed content owners to support, and video rental stores to stock, both formats, and ultimately left millions of Betamax owners marooned with players that were compatible only with a format that content owners and video stores eventually abandoned. The sides engaged again with the first generation of home DVD players, until one side gave in to the other – but only for a share of the royalty income from the winning format.

Now, the same industry is at it once again, as it seeks to introduce next generation technology in order to reinvigorate sales to an already saturated market. One group supports a specification called HD-DVD, while another champions a format it calls Blu-ray, each of which has distinct, but not overwhelmingly superior characteristics relative to the other. The battle has been waging for years, and each camp has at one time or another seemed to hold the edge over the other. Until recently, the Blu-Ray group seemed destined to prevail – until Microsoft announced that it would support the HD-DVD standard rather than the Blu-ray format, which led to Hewlett Packard and others switching their support.

Along the way, each of these camps formed its own support group to further develop and promote its specification, and, sadly, neither side has given in. This spring, home video players will reach the stores from each camp, to the distress, once again, of content owners, video rental stores, and confused buyers.

An example of the second type is the struggle that has been ongoing for some time within the IEEE task force that has been seeking to create an Ultra Wide Band (UWB) wireless standard with high enough data transmission rates to permit (for example) the sale of wireless video displays. The task force developing the new standard was successful in winnowing 23 technical submissions down to two, but then stalled. This was in part because the proponents of the two final contenders had each formed their own independent supporting organization and sought to rally as many interested companies to its cause as possible. As a result, neither group could achieve the support of the required majority within the IEEE task force to secure final adoption of its proposal.

When a final effort to reconcile the two competing standards failed, the task force decided to abandon the effort, and let the marketplace decide which of the two alternatives it would finally support. Once again, incompatible competing products will enter the marketplace.

In the middle is a third approach that some SSO members have taken: the creation of new working groups within multiple existing SSOs to address the same problem, and/or the founding of a new consortium (or multiple consortia) to advance favorite approaches. This occurred broadly in the case of early wireless applications, giving rise to multiple specifications, (e.g., Wi-Fi, Bluetooth and HomeRF), all of which were originally claimed by their respective proponents to be suitable for many of the same purposes. Over time, two out of three of the three standards just noted (Wi-Fi and Bluetooth) found their own niches, where the strengths of the particular specification were found to be the most suitable. The third entrant failed.

Notwithstanding the often over-promising claims of those that promote new specifications, the first standards to enter the field do not necessarily address all needs. As a result, later standards (such as the Near Field Communications standard) are often developed to fill in the gaps where none of the earlier standards prove to be appropriate. In the case of NFC-enabled devices, the full power (and cost) of implementations of earlier standards are not necessary to achieve the results needed.

Second generation standards often follow as well, sometimes promoted by new organizations. For example, the Zigbee Alliance was launched to promote the use of yet another IEEE 802 family standard (802.15.4), just as the Wi-Fi Alliance was formed to promote, brand and certify 802.11a, b and later Wi-Fi standards. But in this case, the new standard was not an upgrade of an earlier IEEE standard, but rather a specification intended to provide a superior, less expensive alternative to Bluetooth-enabled devices. The Zigbee Alliance, in turn, promotes this standard for the particular uses for which it has been optimized, which principally focus on controlling many types of home devices.

Over time, not only does the full set of needed standards tend to evolve as the market matures and purchaser needs become more clearly defined, but the SSOs that were created in a new field often consolidate as well. The Open Mobile Alliance, for example, is the coalescence of many of the early mobile wireless groups that sprang up like mushrooms in the early days of the nascent industry, but later merged into one.

Summary: While the names of few standards ever become household words (Wi-Fi being one of the rare exceptions), the emergence of the digital home as a reality provides an excellent example of the little-noticed process whereby large numbers of standards are developed by many old and new SSOs to enable long-awaited visions to become productized. The enormity of the home market for consumer goods and telecommunication-delivered services has also inspired activity that illustrates the types of competitive posturing, alliance-building and other behaviors that often emerge in rapidly evolving market niches where the stakes are high. Finally, the rapid evolution of new technologies to make possible the digital home demonstrates how a mature ecosystem of SSOs – some old, some new – and successive waves of increasingly finely targeted standards (most obviously in this case, wireless standards of multiple types to serve various discrete needs) evolve to provide the interoperability and other standards tools needed to exploit the new commercial opportunity.

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For a selection of recent stories on digital home standards and wireless standards wars, see this month's <Rest of the News>

Appendix: Other Relevant SSOs. The SSOs mentioned in this article are only a fraction of those that are active in the digitization of the home. The following are some of the other organizations that focus most directly on home applications, but scores of additional SSOs set standards that enable electrical, electronic and digital home services, products and infrastructure as well:

Application Home Initiative, The (TAHI): Develops solutions for issues surrounding connected homes

Association of Home Appliance Manufacturers (AHAM): Represents home appliance manufacturers

Asymmetric Digital Subscriber Line Forum (DSL Forum): Promotes DSL broadband adoption

Audio Engineering Society (AES): Professional society devoted to audio technology

Broadband Content Delivery Forum (BCD Forum): Promotes adoption of broadband networks

Cable Laboratories: Research and development consortium pursuing new cable telecommunications technologies and facilitating interoperability

CDMA Development Group: Promotes development, adoption and standardization of CDMA wireless systems

Consumer Electronics Association (CEA): Promotes the consumer electronics industry

Digital Display Working Group, The (DDWG): Develops industry specifications based on Open IP

Digital Enhanced Cordless Telecommunications Forum (DECT): Promotes digitally enhanced cordless technology

Digital Living Network Alliance (DLNA): Promotes the development of a home wireless interoperable network

Digital Video Broadcasting Project (DVB): Develops standards for the digital television and data services industry

DSL Forum (DSLIF): Promotes the development of broadband DSL

DVD Copy Control Association, The (DVD CCA): Licenses the Content Scramble System (CSS) to manufacturers of DVD hardware, discs and related products

DVD Rewritable Alliance (DVD+RW): Develops and promotes a universal rewritable DVD format

Multiband OFDM Alliance (MBOA): Develops specifications based on ultrawideband-based technology

National Electrical Manufacturers Association (NEMA): Promotes the electrical industry

Printer Working Group, The (PWG): Promotes printer interoperability

Telework Consortium: Evaluates telecommunication technologies

TV Anytime Forum: Develops audio-visual specifications

UPnP Implementers Corporation (UIC): Promotes interconnectivity standards and testing

UWB Forum: Promotes Common Signaling Mode (CSM) and Direct Sequence Ultra-Wideband (DS-UWB)

Video Electronics Standards Association (VESA): Promotes and develops display and display interface standards

Voice over IP Security Association (VOIPSA): Addresses VoIP and Information Security issues and concerns

WiMedia Alliance: Promotes wireless connectivity and interoperability