The IBM vision of a smarter home enabled by cloud technology
Goodbye “smart.” hello “smarter.”
A “smarter home” is on the horizon. The increasing number of Web-enabled home appliances and devices, coupled with the widespread availability of broadband communications, are finally enabling new “intelligent” products and services that reach far beyond traditional markets.

Today’s Internet of people is evolving into an “Internet of things,” as soon there will be more than one trillion connected devices. By 2013, 1.2 billion connected consumer electronics devices are expected in the more than 800 million homes with broadband connections.

Compared with previous attempts to enable the “smart home,” where the intelligence was based on centralized control through a home server or gateway, the intelligence and with it the complexity in the new smarter home is moved out from the home onto the network, or more precisely the Internet cloud.

This new paradigm exposes opportunities for innovative services which build on the computational power and scalability of the cloud, along with the collective consumer knowledge. Data which is aggregated then stored within the cloud can provide dramatic new insights about consumer needs and behavior. Ultimately, this paradigm facilitates a host of possibilities, from radically improving the performance of current devices and services, to delivering benefits which have not yet even been considered. The current smarter home services areas showing early adoption are:

- Entertainment and convenience
- Energy management
- Safety and security
- Health and wellness

Many consumers are already using cloud computing and may not realize it. Anyone who has a Web-based e-mail account from Google or Yahoo!—or who has ever used YouTube, Facebook or Twitter—has already interacted with data stored in the cloud. With cloud computing, consumers do not need to have knowledge of, expertise in, or control over the technology infrastructure in the cloud that supports their consumer electronics.

A common services delivery platform based on industry standards supports cooperative interconnection and creation of new services. Implementation inside the cloud delivers quick development of services at lower cost, with shorter time to market, facilitating rapid experimentation and improvement. The emergence of cloud computing, Web services and service-oriented architecture (SOA), together with new standards, is the key that will open up the field for the new smarter home services.

Digital convergence is enabling the smarter home.
The digital revolution has dramatically increased the function and reduced the cost of consumer devices. This has led to an explosion of new smart devices in the home, from digital TVs and game systems to environmental controls, smart appliances, and safety and monitoring devices, along with lifestyle, wellness and medical devices.

The impending almost-universal broadband connectivity for homes represents another major driver for the smarter home. While the physical networks may differ, from DSL and cable modems to fiber-to-the-home and 3G/4G wireless networks, the common use of the Internet Protocol creates universal connectivity. The typical flat rate fee structure for broadband connectivity reduces the marginal network cost of additional services to effectively zero. Compared to earlier times, when any device had to connect to a network service using a chargeable phone call, this is a dramatic cost reduction.
Open source platforms (and open business models such as application stores) are unleashing the creativity of an increasingly large number of application writers, as witnessed by the more than 100,000 applications that are available for the Apple iPhone within a year of system launch.

As the Internet is evolving, consumers of various ages and backgrounds are becoming more receptive to connected products and experiences. At the same time, consumers are demanding more quality and intuitive interfaces with these experiences, offering service providers an opportunity to differentiate with new services and ease of use.

Providers are jumping into this market, looking to increase their revenue through new services and to lower their costs. Cable and telecommunications companies are looking to provide entertainment services. Consumer electronics manufacturers are looking to connect their devices directly to the Internet for new content. Power companies are introducing “smart meters” to reduce their cost and consumers’ energy use. An entirely new class of connected devices has emerged in the area of wellness and convenience, attempting to improve people’s lifestyles.

In the global economy, intense competitive pressure is driving more efficient markets. To stay ahead, businesses must build new models to be the first to create and seize unrealized opportunities for developing innovative products that enable differentiating services. Breakthrough technologies such as cloud computing and Web 2.0 are empowering businesses, driving the convergence of business and IT. Through this process, the distances and costs between companies and their customers are becoming significantly reduced.

The smarter home is instrumented, interconnected and intelligent.

What makes a home smarter, rather than just smart? IBM® has defined three characteristics that distinguish this new generation of household devices.

- **Instrumented** is the ability to sense and monitor changing conditions. Instrumented devices provide increasingly detailed information and control about their own functioning and also provide information about the environment in which they operate. For instance, a clothes washer can report information about the state of its components to support preventive maintenance for avoiding unforeseen outages. At the same time, it can sense its wash load to optimize its operation; it can send usage information to the manufacturer for data driven product innovation and it can be switched on by external signals when the energy cost is lowest.

- **Interconnected** is the ability to communicate and interact, with people, systems and other objects. Interconnected devices make possible remote access to information about a device and control of the device. This enables services throughout the Internet, removing complexity from the home and lowering costs for the service providers. At the same time, it supports the aggregation of information and control of devices throughout the network. This means that consumers can get a consistent view of their devices, both from home and from mobile devices. For service providers, it provides an aggregate view of customer characteristics according to criteria such as geographic location, consumption patterns, or types of service.

- **Intelligent** is the ability to make decisions based on data, leading to better outcomes. Intelligent devices support the optimization of their use, both for the individual consumer and for the service provider. For instance, a utility can send signals to consumers’ homes to manage discretionary energy use in order to reduce peak loads. By coordinating this process throughout an entire service area, the utility can optimize the peak reduction, while saving the consumers money on their bill.
The IBM vision of a smarter home enabled by cloud technology

Figure 1 illustrates how the home can be connected to a cloud. Instrumented devices in the home are connected to the cloud, enabling data to be aggregated and new intelligence to be created.

The adoption of smarter home devices requires that they also be intuitive. Consumers will adopt new services only if they are easy to use and fit smoothly into their lifestyles. The learning curve for new services must be low to non existent, and the benefits of the services must be immediately apparent. Experience with services on the Web has shown that even minor changes in usability can have tremendous impact on consumer acceptance.

Many current devices and appliances are well positioned to become smarter devices. Many appliances now enjoy an internal CPU, sensors and instrumentation, and I/O ports. Yet the majority of these are accessed by technicians only during manufacturing or emergency repair field service. Adding the capabilities for a more permanent connection to the Internet is relatively easy and low in cost.

**Smarter home capabilities**

The emerging capabilities of the smarter home enable services throughout many consumer industries, making consumers’ lives easier, healthier, more fun and more productive. The four service areas already demonstrating early adoption are:

- **Entertainment and convenience:** The richness of the Internet is now available through the TV, which fundamentally shifts the definition of ‘content.’ Now consumer electronics companies can create open platforms for new lines of flat panel televisions that feature a portal which personalizes entertainment content from numerous broadcasters and movie studios. Over time, such devices might be subsidized by better targeted advertising, with a potential to share profits with other TV manufacturers with similar capabilities. This can lead to a win–win–win situation: reducing the number of commercials viewers have to watch, enabling broadcasters and advertisers to deliver more personalized entertainment options through targeted advertisements and giving TV manufacturers an opportunity to differentiate their products.
The IBM vision of a smarter home enabled by cloud technology

• **Energy management:** Future demands on the electrical grid will encourage minute by minute home appliance management to prioritize energy services while delivering automatic savings to owners. Automatically synchronizing lighting, home appliances, climate control sensors and other home electronics minimizes energy use based on changing exterior conditions and usage patterns in the home. Smarter homes enhance consumers’ access to information, which enables better decision making, while raising overall societal benefit.

• **Safety and security:** Many insurers now offer discounts for existing centralized alarm services using sensors and cameras. The ability to deploy home sensors that can instantly notify the homeowner, selected neighbors, or the police and fire departments can enhance home security and provide peace of mind. These services can also empower family members to remotely check on the safety of children and the well-being of elders.

• **Health and wellness:** A medical device maker designed embedded software that helps healthcare providers continuously monitor patients with implanted or other at-home medical devices without having hospitalization or office visits. Smarter home scales and sensors monitor fitness, well-being and consistent activities. These home health electronic devices can collect evaluative information about current health condition for disease prevention and overall wellness. Such devices may even be reimbursed in part or in full by insurance companies, government, or employers.

Figure 2 provides some examples of how common household devices can become smarter.

<table>
<thead>
<tr>
<th>Household device</th>
<th>How smarter?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator</td>
<td>Adjusts cooling temperature based on volume of items it contains; cooperates with washer and dryer and with HVAC cycles.</td>
</tr>
<tr>
<td>Thermostat / HVAC</td>
<td>Changes target temperature based on current and coming weather conditions, sensors watching household activity; takes into account cost of power and load conditions as communicated by utility.</td>
</tr>
<tr>
<td>Television</td>
<td>Recommends television shows based on past selections of each viewer, advertisements reach more intended audiences; uses Web browser and dynamic interface to other connected devices like thermostat or environmental controls for lighting and distributed audio.</td>
</tr>
<tr>
<td>Washer and dryer</td>
<td>Determines water temperature and wash/rinse/dry time needed based on load volume, dirt level and time-of-day energy rates; cooperates with other power demanding devices.</td>
</tr>
<tr>
<td>Pool equipment</td>
<td>Determines contamination levels and automatically dispenses correct amount of chemicals; adapts operation of circulation pump and chlorine feed to time of day and weather conditions.</td>
</tr>
</tbody>
</table>

Figure 2: Examples of smarter household devices
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Smarter home services in the network cloud
Over the years, there have been attempts to create a smart home by bringing servers or data appliances into the home that consolidate the home information and control. However, the need to manage, even if done remotely, very complex IT devices in the home has prevented this approach from being widely adopted.

A more effective approach is to connect the devices throughout the Internet to services in the network cloud, which enables centralized services. Many of the devices in the home today can already connect individually to services in the Internet, even though each may use different application protocols and APIs. Putting the intelligence into services in the network cloud reduces the complexity of managing software in the home devices and simplifies the interoperability of devices. This is accomplished by bridging the services throughout the network through Web services interfaces, translating the different device protocols to a common platform, then connecting the devices through the network cloud. This is a far less expensive and more flexible way to aggregate services and compose new services from existing devices than past attempts. It also removes a major barrier to adoption, which has been the significant complexity in the home as a result of all the connected devices. Now the consumer moves from being the IT manager of their home to a consumer of services through their connected devices.

A local services “clone” or services cache in the home can safeguard the availability of the services against network problems and guarantee continuous high quality, all with simple control by the consumer.

With new cloud services, new possibilities exist for an appliance as simple as a pool pump or refrigerator when it has the ability to sense and respond to changing conditions, to communicate with other systems and to inform decision-making.

Figure 3 shows some of the average yearly costs of everyday appliances, but certainly not all. Typically air conditioning, heating and hot water heaters use even more energy than pool pumps and refrigerators, so it’s obvious that making these devices smart has benefits. Having better information about where energy is being used can help consumers save money and energy, all while reducing their carbon footprint. This is an affordable way to increase consumer comfort without increased complexity for the consumer.

"Smarter" everything causes shifts in the value chain.
Digital convergence—that is, the transformation of content into digital content—and the near universal availability of IP connectivity have changed the consumer electronics landscape forever.

Earlier, products were isolated, and there was little contact with consumers after the sale. Entertainment content was broadcast, without direct connection between the content provider and the consumer. The ability to associate services with a device was very limited.
Now, devices are network connected, creating the possibility of one-on-one relationships between the consumers, service providers and device manufacturers. This new capability of one-on-one, two-way interactions combined with the vast expansion of device functions is leading to an explosion of services and devices. Using independent appliance monitors and control equipment enables the integration of more traditional appliances that don’t have the “smarts” built in.

A particularly important development is the transition of devices from single function platforms, such as music players or mobile phones, to application platforms which enable a vast array of new services.

As a consequence of this development, the growth of the service portion of the value chain is far outpacing the growth of the device sector. At the same time, traditional consumer electronic devices such as televisions are under intense manufacturing costs and retail margin pressure.

Forming an open ecosystem that supports applications and services from a wide variety of providers opens up the possibility of a broad range of business models with varying degrees of control of the ecosystem.

These approaches to benefiting from the expansion of services value require a services business model, which is typically unfamiliar to electronics manufacturers—and consequently, they are shy to adopt. These manufacturers have the option to add features to their products that make them friendly for services providers, such as software and content security for licensed content, secure device authentication, support for an application platform, and differentiators such as additional storage or advanced user interaction devices (e.g., remote controls). These features can be monetized by larger sales due to the increased attractiveness of the devices and the associated services, or through licensing of features to content service providers.

Economic drivers for “smarter” devices and services

Insurers can lower the risk and offer lower, more competitive premiums to their customers. Broadcasters and other content owners can expand their offerings by making back catalog (so-called “long-tail”) content available. They can further increase their revenue through improved business intelligence and targeted advertising. Hospitals and private practitioners can extend health care services to patients’ homes, lowering the health care cost and freeing up facilities. Energy utilities can help their consumers manage their energy use, lowering overall consumption and peak loads with the potential to not have to construct new power plants or import electricity.

For device manufacturers, the incremental cost to connect devices that already have substantial intelligence in them is easily offset by a number of benefits. Fewer truck rolls to consumers’ homes reduce the repair and warranty costs and increase the consumer satisfaction for both the manufacturer and the retailer. The potential for product registration increases exponentially. Consumers are willing to pay a little extra for the assurance that their appliance will not fail at a time when it is most inconvenient. Other benefits such as access to more information, advice and the ability to control devices remotely are additional incentives.

Economic indicators from throughout the target markets show that the opportunities for smarter home devices and services will experience explosive growth in the coming years. Forrester Research reports that a third of the U.S. households surveyed are interested in being able to remotely monitor conditions in the home, and forecasts that U.S. home broadband will grow to 75% penetration by 2012.
Meanwhile, Parks Associates have estimated that by 2012:

- **Entertainment:** 450 million worldwide connected entertainment devices in the living room
- **Energy management:** 45 million U.S. households with smart meters that measure household energy usage and send this information back to the energy grid
- **Health and wellness:** Nearly $2.5 billion of revenue in the U.S. for health and fitness monitoring devices and services

Polycom is looking to create a high-definition media conferencing system for consumers, with high quality audio and video from every room of the house. Connecting media devices through the Internet, this creates an innovative communication experience from a simple phone call to a shared media presence in the living room. Managing this innovative service in the cloud assures a high-quality experience for consumers with minimum complexity.

General Electric and Whirlpool have both publicly announced that soon their products will be built to connect to the intelligent grid. Emerson Technology’s smart thermostats will enable consumers to have more control over their home energy usage than ever before. Residents will be able to control the air conditioning/heat intensity and temperature of their home remotely, through computers and mobile phones, resulting in significant savings on heating and cooling bills.

Vignet is providing mobile and fixed broadband infrastructure for healthcare and life sciences. Their “person-centered” Connected Health Services platform lets users capture, aggregate, analyze and share data with their mobile devices and PCs. The Vignet platform enables connecting of devices throughout the entire healthcare continuum and provides cloud based solutions for wellness, fitness, nutrition, chronic disease management, home care, body-area networks, remote patient monitoring and independent living. Vignet, like IBM, is part of the Continua Health Alliance, whose goal it is to enable end-to-end interoperability for connected health solutions. By providing a framework of standards-based interfaces, Continua is spurring innovation while removing barriers to global implementation and adoption.

Using Webcams and remotely controlled locks for the front door and the garage door, it is possible to always ensure the security of a home. The Shaspa smart building automation plug makes possible the network integration of devices that were not originally designed for remote monitoring and operation.

“Envisioneering surveyed consumers throughout America’s largest coastal cities, where 78% now enjoy WiFi broadband at home. Most consumers enjoy six or more networked consumer electronics products (primarily PCs, video and handheld games, cell phones, media players, Webcams and Internet phones) and a growing assortment of fitness, wellness and remote healthcare monitoring devices.”

– Richard Doherty, Research Director, The Envisioneering Group
The smarter home is enabled in the cloud.
Cloud computing technology creates an ideal environment for an intelligent, highly efficient and highly flexible utility approach to services in the network. At the hardware infrastructure level, it enables the flexible, dynamic and low-touch provisioning of resources to applications. The creation of virtual service images supports the easy life cycle management and deployment of services. Finally, standardized Web services interfaces to the services enable the dynamic composition of individual services into flexible solutions in a plug-and-play mode.

The cloud for managing the consumer services can extend directly into the home. A services “clone” can directly interact with services in the network, in effect becoming part of the cloud. This clone can function as a limited local replica of some services, delivering control even in the case of a network failure. It can also ease the connection of home devices to the network by translating protocols and acting as traffic concentrator. The ability to adapt any type of network and application protocols increases the choice of devices and services for consumers.

Cloud technology, whether in the form of “software as a service” (SaaS) or “infrastructure as a service” (IaaS), improves service management by speeding up the time to market and lowering the management cost for service management, resource management and life cycle management. It reduces the resources cost by enabling more efficient allocation of fractional hardware resources to virtual service images.

The open platform environment permits devices to be connected, enabling interoperation and remote access of services. This will create an ecosystem based on industry standards, driven by industry leaders. Using service-oriented architectures, services with different protocols and data types can be easily connected. The application services can also take advantage of common infrastructure services, such as customer relationship management (CRM) or billing.

The benefits of a cloud-enabled smarter home are many and distinct for each participant, including:

- **Consumer benefits**: Consumers will find these new devices and services far easier to use, as the complexity and management has been moved into the cloud; no additional IT device is needed in the home with the attendant management headaches. The open nature of the ecosystem increases the choice—and reach—of devices, services and service providers. Connecting disparate devices in the network is simply a matter of software adapters at the service provider site. This interconnection and interoperation can give home owners a common view and provide mobile access to monitor their devices. The robustness and extensibility of networked services, along with the ability to link both existing and newly optimized devices, provide reliable performance and superior consumer customization whose value will increase through services innovation.

- **Consumer electronics manufacturer benefits**: The development of industry standards for services and the ability by service providers to create innovative service models increases the market size for devices while reducing the business risk for device manufacturers. Previous “walled gardens” yield to an open ecosystem. This reduces the risk of being locked out from markets through exclusive contracts by some device manufacturers. The cloud is the platform. The manufacturing company can concentrate on the function and the service and can be confident that its devices can “talk” to the cloud over any infrastructure.

Implementing the bulk of the intelligence in software over the network minimizes the technical limitations placed on devices during design and manufacture. Open standards and the ability to take advantage of existing service components in the network reduce the development cost and the time to market. Monitoring devices remotely to detect impending failures, and to understand usage patterns, reduces warranty cost and increases business intelligence for data driven product innovation.
The IBM vision of a smarter home enabled by cloud technology

- **Service provider benefits:** Many of the benefits for device manufacturers also apply to service providers, such as a shorter time to market and the open ecosystem. The shared, low-cost infrastructure of a cloud solution reduces the capital expenditures for bringing a solution to market. A common view by the service provider of the devices yields a vast amount of data for new business intelligence. In addition to lower CRM cost, these insights can yield substantial improvements in services, or create the opportunity for entirely new services. With a cloud solution, a service provider can focus on its particular value add and obtain additional business and operational support services from utilities in the network.

**The Service Delivery Platform Makes it Possible.**

A service delivery platform (SDP) enables the integration and management of large and complex sets of services (see Figure 4). The SDP concept has been developed in the telecommunications system environment to manage the integration of the many different types of telecommunications services, from standard wired phones to analog and digital mobile services to Internet services and IPTV.

The SDP provides an SOA-based framework to link modular component services, including third-party services, to manage the different types of service exposure and to use common back end components such as business support systems (BSS) and operational support systems (OSS). In addition, the SDP provides service life cycle management from the creation of new services, to bringing them online in a controlled way for selected customer sets, to actual operation, bundling with other services and finally termination of services to make way for alternatives. The IBM SDP has been deployed successfully in many telecommunications environments.

Important benefits of the SDP are:

- Managing the complexity of service deployments means that third party service providers can focus on their specific value add, without having to acquire the skill or expend the capital to build a full function service infrastructure.
- Using services oriented architecture and Web 2.0 technologies, the SDP enables collaboration for a more agile service creation.
- Common storefront technology enables service providers to integrate their business processes and store fronts for monetizing their services more efficiently.

As the next step of the evolution of the SDP, it is being ported into the cloud. At the same time, the benefits of the proven concepts of service managements are extended beyond the telecommunications environment to any type of complex services involving large numbers of components and market players.

Implementing the SDP concept in the cloud can revolutionize the ecosystem for the smarter home. The SDP is a platform to easily integrate component services, whether they are implemented with cloud technology or as conventional Web services. It makes possible the balancing of centralized and decentralized services and the use of existing back-end systems for functions such as customer relations management or billing.
The IBM vision of a smarter home enabled by cloud technology

An SDP in the cloud supports the expansion of the services scope by enabling new services in existing markets and by expanding existing services into new markets with minimum risk. By exposing standard service interfaces in the network, it enables third parties to integrate their services quickly, or to build new services based on the service components provided in the SDP. This creates the opportunity for new business models, for instance, for media distribution and advertising throughout multiple delivery scenarios.

Smarter TV: A key example of a smarter home service
Smarter TVs are leading the way for broadly accepted smarter home devices, promising a complete entertainment revolution. Through their broadband connections, they provide consumers with on-demand access to an unlimited array of entertainment options throughout the Internet. In addition to standard, linear TV, they provide two-way interaction, personalized content, games and a wide range of personal and social communications, from instant messaging to social network applications. Televisions are about to become the next open application platform, similar to the application platforms on mobile devices.

Smarter TV creates an ongoing connection for device manufacturers and content owners with their consumers, where up to now mainly discrete sales opportunities existed. This creates the opportunity for new business models through services. The intelligence of the new infrastructure, both at the device and in the network, enables consumers to achieve the personalization needed to navigate the large amounts of content now available. It provides the device manufacturers with the opportunity for user-driven product innovation. It also creates the opportunity for entirely new types of content for programmers, distributors and content owners.

Case example: Philips Net TV
Philips Net TV is a leading example of this development (see Figure 5). When a consumer brings the TV home, the TV connects itself to the WiFi network. Upon pressing the Net TV button, the user is connected to the services portal which presents a localized start screen in the user’s own language. The services range from simple information services like weather and news, to games, commerce, social networks, personal media and user generated videos.

In the near future, premium services such as movies and “catch-up TV” will be added as well. Selecting from this wide array of Net TV services, the user can customize his start-up screen to put his favorites at his fingertips. A second button on the remote control brings the user to a program guide screen that provides detailed information about the broadcast programs available to the user and lets him tune directly to a program.
The Net TV services portal brings together local and international content and services and lets consumers navigate and select with the click of one button on the remote control on Philips’ simple user interface. Net TV’s personalization features enable consumers to select their favorites and their preferred language and country. The individual connection between the consumers and the Net TV Portal creates an improved ability to use interactive advertising.

The Net TV services portal manages the television’s access to content, and Net TV content partners can easily add to their diverse Internet service offerings. By controlling the services portal, Philips can assure the quality of the content and the branding of the service, while leaving each content provider freedom to pursue his own business model, be it advertising supported, transaction based or subscription based. The operation of the services portal is supported by advertising and click-through fees, to assure a continuous revenue base without having to place a surcharge on the TV devices. IBM collaborated with Philips to design and develop the new services portal and is operating the portal on behalf of Philips.

Standard Web technology addresses the challenge of making a large array of content quickly and easily available. A browser in the TV displays the content and supports the user interactions. Using widely accepted Web standards such as HTML, JavaScript and Ajax for the content format makes it easy for content service providers to prepare broad entertainment content suitable for the TV, all while leveraging the content base they created for the Web. A special HTML extension, the CE HTML standard, supports the navigation of the TV Web pages with a standard remote control without the need of a mouse and a keyboard. Within the HTML framework, the TV can present standards-based media types such as h.264 video, AAC audio and JPEG images.

A look into the future: Intuitive virtual 3D user interface

Intuitive user interfaces are a key acceptance factor for smarter homes. Many devices that exist on the market today are overloaded with features and difficult to configure. Offloading the configuration to a cloud and designing devices for ease of use like the Philips Net TV or the Apple iPhone can stimulate the demand for home automation. Existing non-IP based systems can be connected to a cloud with products such as the Shaspa Bridge.

Due to their increased function and impact on consumers’ lives, smart systems require more sophisticated human environment interfaces. A blend of technologies from wireless sensors, mobile access and virtual worlds, to social networking technology forms an innovative service framework that puts the control of their homes at consumers’ fingertips, wherever they are.

Figure 6 shows a cloud-based IBM prototype of how a simple interface (here the Shaspa interface) may look to control the various aspects of a smarter home. Also important is a simple means of displaying energy consumption. Tests with volunteers show a potential of reducing peak energy consumption by up to 30% through identifying and replacing inefficient devices and user behavior. Figure 7 shows how energy consumption data can be displayed so the user can quickly see patterns and adjust usage if needed.
The IBM vision of a smarter home enabled by cloud technology

The smarter home, instrumented with sensors and actuators to control and optimize usage, can be controlled with a simple interface.

Taking advantage of Web standards and ubiquitous technology, it becomes possible to access information from the smarter home anywhere, even with smart mobile devices. Figure 9 shows an example of a readout from a health monitoring device on an Android-based device.

The adoptions of open standards for the involved systems can simplify the planning, installation, usage and maintenance of the systems. For example, the CAD drawings that an architect creates can be converted to a virtual representation of the building that makes possible remote control of the lights, heating and window shutters. The white goods that are installed later can be added to the virtual world representation and also monitored and controlled from within a virtual world (here Second Life). The benefit of virtual worlds is that a person that does not know the building very well gets a very realistic impression of it and can, for example, monitor the house when you are on vacation (see Figure 8).
The emerging technology standards
One challenge to the realization of the cloud-based smarter home vision is the need to integrate a large number of device interfaces, networking protocols and technologies and a variety of applications and services already deployed in the home today. The IBM vision of a smarter home requires bi-directional communication between home devices (appliances and automation systems) and the cloud, a communication that can use any hardware and networking technology. Today, there is a confusing set of choices and a complex hierarchy of standards from low-level specification of data formats to system level application interoperability standards. Figure 10 shows some of the more important access technologies and standards, including:

- Systems at the level of application interoperability: OSGi, TAHI, TEAHA
- High level protocols: UPnP, IGRS
- Low level protocols: DLNA, Zigbee, HomePlug, Wifi
- Specifications: HGI, ITU-T SG15, ITU-T IPTV-GSI
- More specifications: IEC TC100 gateway

This pattern of multi-technology adoption is not likely to change any time soon. Depending on the specific service requirements for controlling and interfacing to various types of devices (e.g., entertainment, information, medical, remotely managed appliances, safety and security), cost and convenience will dictate what wired or wireless interface technologies will be most appropriate. In the home today, most devices and applications from different manufacturers do not share a common technology base and their applications generally do not interoperate.

Implementing the smarter home in the cloud, however, helps to overcome the interoperability obstacles presented by this diversity of standards in home devices by adopting a common interoperability framework for home devices and Web-based services. Now, devices communicate with the services in the cloud using Web-based standards, regardless of the access networking technology or other standards used, and different services can interoperate in the cloud using Web services standards.

Services interfaces
The services interfaces for devices are not standardized in today’s practice, but are generally device-specific. For example, mobile phone and intelligent home appliances have their own unique interfaces. The direction for standardization in this space is to encourage the creation of device-specific interfaces and gradually identify cross-device interfaces to support the convergence of home appliances, mobile devices and net appliances.
There is a growing need to get different kinds of devices to communicate with services. Especially, key functions in devices need to be exposed as services so other services can access and make the most of those exposed functions. Open Service Gateway Initiative technology (OSGi) provides a service-oriented platform for developers to design and implement embedded systems. It also offers standardized ways to manage the component-based environment in software life cycle. This specification enables all OSGi compatible computing devices such as computers, home devices and mobile phones to communicate with each other.

**Communication protocols**

There are two types of communication protocols. The first one is “LAN”-like protocols to enable devices to communicate with each other. For example, Bluetooth and WiFi are wireless protocols devices the home can use to exchange data. The second type of communication protocol is a “WAN”-like standard such as Internet protocol. In this case, each home device can take advantage of the home router to connect directly to service in the network.

Once more and more devices use Web services to define their interfaces, SOAP (Simple Object Access Protocol) can be used to enable message exchanges over various communication channels such as HTTP and MQ. The message formats can make the most of XML to enable devices to carry information for exchange. A standards group in ISO/IEC 18012-1 offers a guideline for product interoperability for home electronic systems.

**The future is in the cloud.**

There is more to the smarter home than installation of smarter devices. Device manufacturers and service providers must focus on creating instrumented, interconnected and intelligent devices that users find intuitive to use.

In this vision of the smarter home, one that is enabled by cloud technology, partnerships among ecosystem players will be vital as new business models emerge around service offerings. Consumer electronics companies turn to IBM to help extract significantly more value from a world in which the number of IP-enabled devices is exploding. When these devices are connected in the cloud, they get the integration and affordability they need to drive maximum success.

A service delivery platform in the cloud lets them move forward quickly and with confidence and lets their organization take immediate action in a cost-effective manner. Therefore, it is important to seek out a partner with proven capabilities, rich industry knowledge and creative expertise. The right solution provider can help them focus their energies, make the right choices and turn economic drivers into economic opportunities.

IBM is that partner with proven capabilities and experience building service delivery platforms and delivering services from the cloud.

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