

# Towards a Common Smart Home Technology

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**Abstract.** While the research field of ubiquitous computing is growing steadily, current solutions outside of laboratories lack many of the essential features. This paper describes the main challenges for the economic success of existing smart home solutions. Based on open standards and protocols product vendors and service providers from different domains have to be enabled to develop solutions which are capable of being easily integrated into existing home environments.

**Keywords:** AAL, smart homes, semantic services, device interconnection

## 1 Introduction

Since Mark Weiser described his vision of ubiquitous computing in 1988 [7], several efforts have been made to realize a smart, all-time available but also for the user's eyes invisible system that recognizes the user's needs and supports him in his everyday life. Smart homes, ambient assisted living and smart products represent concepts leading towards this vision and new markets of connected devices. However, more than 20 years have passed since Weiser initiated the new research field of ubiquitous computing, but so far, none of the efforts that have been made did result in sophisticated solutions. What are the reasons for the inflationary character of smart home projects? Are the available technologies not sufficient? In this paper we analyze current trends and open issues and sketch an approach to open up the new market. The next chapter gives an overview of current trends and existing solutions. In chapter three, existing challenges are analyzed in the form of required enabling technologies. As a conclusion we summarize the challenges and introduce the association Connected Living as a promising solution.

## 2 Common Trends

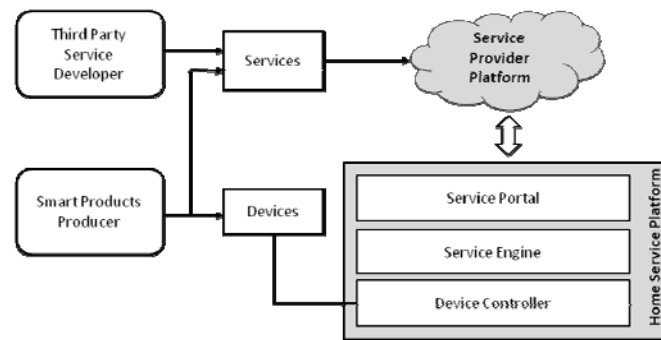
Current trends show that more and more devices become networked. The term Internet of Things summarizes this trend as an umbrella term. The same trend can also be observed within home environments, ranging from PC networks and media sharing to interconnected kitchen appliances like the Miele@Home system (<http://www.miele.de/de/haushalt/produkte/180.htm>). Different standards have been established like Universal Plug and Play (UPnP) and the Digital Living Network Alliance (DLNA) for self organizing media networks or the new Device Profile Web Services (DPWS) and Webservices for Devices (WS4D); European Installation Bus

(EIB), KNX, Digital Addressable Lighting Interface (DALI) or digitalSTROM for home automation; Open Services Gateway initiative (OSGi) or Building Automation and Control Networks (BACnet) as middleware. Additionally, research projects in this area range from controlling home automation via TV sets [4] and prototypical applications to improve everyday life [3] to ambient assisted living projects, supporting the independent living of elderly people [5, 6].

Besides dedicated research projects, there are only little activities that aim at the integration of technologies across application domains and industrial sectors. However, from our perspective it is urgently required to create an integrated and consistent system within future smart homes, which forms a common technological basis for home devices and services. Open interfaces and standardized communication protocols are urgently needed. In the next section we thus identify interdisciplinary enabling technologies as a common basis for interconnected systems. In this way, cooperation between companies (especially from different non-competing sectors) helps reducing investments for the development of smart products.

### 3 Enabling Technologies

From our perspective, the development of smart products requires a common infrastructure, facilitating open standards and interfaces to integrate products across vendors and industrial sectors. This leads to an environment where each developed technology brings additional benefits for other (existing) devices or services. The home itself becomes an integration platform that hosts services, integrates devices and has to be managed and maintained. This point of view generates new technological, economical and interdisciplinary challenges. Some of which have been addressed by the Service Centric Home (SerCHO<sup>1</sup>) project, successfully finished in 2008.



**Figure 1: The SerCHO service concept allows (third party) service developers to supply their services on a Service Provider Platform. Services are running on a service engine and are using devices with the help of a device controller.**

Figure 1 illustrates the main concept of the SerCHO service technology. The Home Service Platform (HSP) integrates numerous devices with different technologies (standards and protocols) and supports the hosting of additional services. Devices are abstracted via UPnP, supporting discovery and control. OWL-S descriptions

<sup>1</sup> Funded by the BMWi from 2005-2008, [www.sercho.de](http://www.sercho.de)

semantically describe the offered services and functions. Thus, hosted services on the HSP do not need to communicate with the devices in a network by proprietary communication standards. This enables third party developers to supply new services independently, which can be hosted on the Service Provider Platform (SPP) or downloaded into the home.

However, based on this understanding we can identify four main challenges, which have to be addressed in order to realize sophisticated solutions in the future. We define these challenges as required enabling technologies, forming the common basis across domains and vendors.

**Common dynamic infrastructure:** Intelligence of a smart home might be central on a single device or distributed over a network of various devices. Which solution is preferred depends on the network infrastructure and the problems to be addressed. Setting up a smart home network starts with one initial product, extended with additional devices and services step by step. This requires a dynamic infrastructure that grows and allows distinguishing three roles of devices. *Connected Appliances* provide services and can be controlled. They might act smart and integrate additional devices, e.g. available sensors. However, they work on a peer-to-peer basis and provide what they are designed for. More advanced *Control Appliances* are able to host services and thus directly control the connected appliances to realize more sophisticated scenarios. Additionally, *Interaction Devices* provide the interface to the user and allow interacting with the smart home system. Aiming at such a common dynamic infrastructure allows the step by step expansion of the home network if the involved companies are willing to cooperate.

**Semantic Descriptions:** Developing smart products means more than developing a couple of devices that are able to communicate with each other. A fitting definition of smart products (or objects) is given by Kawsar [2]. One of the main challenges in smart environments is to enable the user to become a system integrator himself. By using semantic descriptions of services and functionalities of devices it becomes easier to integrate new devices and connect services for enhanced benefits. While existing standards like UPnP, DLNA and DPWS already support inter-communication of different devices and self organization of networked consumer electronics products, semantically enhanced versions of these standards are needed as part of the enabling technologies

**Common User Interfaces:** To enable the user to benefit from the smart home network, flexible and adaptive interaction is required. Natural, multimodal interaction, dynamically involving various devices is the ideal here. In any case, interaction has to be managed at runtime, facilitating the integration of different interaction resources as discussed e.g. in [1]. To support a consistent look and feel, common interaction concepts for smart homes have to be defined. Model-based approaches provide some flexibility here by describing the interaction on more abstract levels instead of directly implementing a specific user interface style. Based on the user interface model, the system supports multiple user interface variations and delivers partial user interface artifacts to different devices supporting different interaction modalities. Addressing multiple users, multiple interaction resources and handling multiple user interfaces is a crucial issue for smart home interaction.

**Deployment and maintenance:** Current approaches usually require a lot of initial configuration and technical support of experts. This is one of the main barriers which

have to be overcome. Therefore remote maintenance is a major issue in a future smart home environment in order to keep the system up to date, prevent security leaks and enable new functionalities. An automated, self organizing system will prevent the user from having to call experts when adapting the system to new requirements or integrating a new device.

The described challenges have been identified based on several years of work in the area of smart home systems. From our perspective, there is a strong need for vast cooperation to settle on open approaches beyond the boundaries of single products.

#### **4 Conclusion**

One of the main challenges of establishing smart homes in the future is a consistent development of products and services in the home environment based on common standards and protocols. Different domains, like consumer electronics, energy efficiency, home automation and healthcare have to be taken into account. However, the cooperation of various companies and the achievement of a critical mass of compatible devices and services are heavily required. A promising approach is the new founded association Connected Living (<http://www.connected-living.org>), whose members span from industrial partners to research laboratories and share the same vision. Specific problems are solved by initiating research and development projects with partners from at least two different domains based on enabling technologies. Giving third party developers the chance to implement additional services by referring to common interfaces and protocols the benefits will be increased even more. Finally, concrete market entering strategies and public relations prepare the future market. This provides a strong partnership to address the described challenges and develop integrated products.

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