

# Meeting Household Expectations of a Future Intelligent Home

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## Abstract

Year after year more and more devices are entering modern households. Different types of devices with different and multiple purposes. More often these devices are not just being acquired but interconnected to produce new, small and intelligent home networks. The particular research covers particular aspects of these networks and attempts to analyze users' requirements and expectations of such networking environments. It also attempts to present existing home networking challenges and to provide possible solutions. The final aim of the paper is to bring up particular issues that concern developing of the intelligent home network that would satisfy most of users' needs without complicating their everyday life. It also deals with social impacts of these networks and focuses on their smooth integration into people life.

**KEYWORDS:** Intelligent home, smart home, home networking

## 1 Introduction

Home intelligent networks provide the members of the families with all kind of necessary services participating in their daily life. However, adopting networking technologies to interconnect devices within the home environment is not yet a widespread technique and only a few things about it are well defined so far: neither the way for a successful setting up and maintaining these complex networks nor the consequences of living with them.

More precisely, the aim of this particular research is to determine what users anticipate from such networked environments examining their basic requirements. Referring to related work, the research tries to expose existing difficulties and implications and to suggest what researchers should take into account while modeling products and services for intelligent home networks.

The research starts with a definition of a future intelligent home in section 2. It also provides a list of components of these home networks. Section 3 defines and describes basic user requirements. The study continues referring to related work that has been done so far in the field of home networks. Section 5 presents challenges that modern researches face in their attempt to make homes smarter. Finally, section 6 provides a brief conclusion of the work.

## 2 Definition of the future intelligent home

According to [2], intelligent home is an environment where people are supported and assisted in their everyday activities by information technology that is very different from the computer as we knew it so far. These environments integrate information, communication and sensing technologies into everyday objects.

Intelligent home is considered also to be a domestic environment in which people are surrounded by interconnected technologies that are responsive to people's presence and actions [3]. In fact, people are surrounded by computational devices that varyingly respond, predict, and monitor their activities [5].

According to [4], intelligent home is the one that adjusts its functions to the inhabitants' needs based on the information it collects from the inhabitants, the computational system, and the context. In this kind of environment, information processing and networking technology is hidden away, and interaction between the home and its devices is achieved through advanced user interaction techniques.

In practice, an intelligent home is sometimes considered to be a home network that consists of at least two personal computers connected to the Internet and to each other. In the particular research however, we will consider as an intelligent home and more precisely as an intelligent home network, a network that includes automation devices, entertainment products and home computer appliances with direct interaction between them. Home network is controlled by the inhabitants through particular user interfaces designed to assist and support their decisions.

Let's give however, a brief illustration of the components of an ideal intelligent home network. The intelligent home does not include only the computing elements installed in the home, but also automation as well as Audio/Visual (A/V) devices. The computing part of the network consists of various laptops and personal computers interconnected with each other in wireline or wireless way. These components are usually the basis of the home network to which are connected other home devices and appliances. Automation control devices may control the lightening of the house or the move the curtains. The control of the home is achieved by user-friendly interfaces designed especially for these devices. These interfaces can be installed in familiar to user devices like mobile phones or PDAs or may be installed in particular-purpose multifunction devices which provide control of the whole automated home system. The A/V network may include Televisions, Stereos, DVD players, TiVos,

iPods, digital cameras, home theaters, projectors, surveillance cameras, and many other appliances. Usually the majority of these devices of three subnetworks are interconnected to each other providing intelligent and enjoyable solutions to the inhabitants.

### 3 User requirements

In order to provide the inhabitants of intelligent homes with complete and easy to use network solutions, user requirements have to be determined. User requirements usually vary in scope and have to be defined carefully and sufficiently. Let's examine few of the most important requirements of users.

#### 3.1 Compatibility

Probably the main users' requirement is the compatibility of home devices. Usually, intelligent homes are not built to be intelligent, but are "upgraded" by acquiring devices and home appliances. These devices come to interact with the existing home network in order to provide smart solutions to the inhabitants. An important issue that arises here is that these devices may have been acquired at different times, from different manufacturers and may have been created under different design constraints and considerations. These differences provide significant interoperability, integration and wiring problems. Specifically, what users need is the acquired devices to be explicitly designed to understand every type of device they may encounter. Thus, one of the major user requirements is the compatibility of these physical entities.

#### 3.2 User interface

The system that comprises the intelligent home must also be easy to use and to configure, to be simple and intuitive. Familiar information appliances can be used as user interfaces to home functions in order to achieve broader user experience. User interfaces which mediate between the inhabitants and the physical network of the intelligent home must be friendly, efficient and with respect to different nature of the inhabitants. Issues that are to be considered when designing these interfaces is the age difference, experience and background difference as well as knowledge level difference of the users. Technology must simplify users' life and not stress them.

#### 3.3 Customizable products and services

Another important issue is customizable products and services. Products and services created for intelligent homes must be manufactured and designed in such a way to support different needs of users. They have to be customizable to the preferences of each user and adapted to factors like country, culture, year, season and even time of the day. Intelligent home is a general phenomenon regardless of particular users and states conditions.

#### 3.4 Security, safety, privacy

Another basic users' requirement is security, safety and protection of their privacy. According to users, intelligent home is to be adopted and accepted only with respect to their privacy. Usually, there is a fear related to the loss of control by the inhabitants and the threat it imposes to their privacy. Users don't want to be monitored by a system. They perceive it as a major threat to their privacy. Protection of the data integrity and provision of confidentiality are basic security requirements. Users demand that their home system has to be well protected against intrusion and loss of data. Home data must not be accessed by outside entities due to the risk of expose of sensitive and private information. Furthermore, security is also a global concern that includes physical security at home. For example, no family member should be hurt or harmed because of the existence of intelligent home system.

#### 3.5 Network smartness and robustness

Intelligent home has to contain smart technologies. Their smartness is usually determined in terms of efficiency and convenience provided to users. Intelligent home networks have to be context-aware and include applications which require almost no user input. The least effort has to be provided from the inhabitants to interact with the intelligent home. Network must support users' preferences and choices and provide intelligent solutions for the home. However, it has to be always under user's control and never act as an independent entity. The network also has to be flexible and to consist of multifunctional but robust devices. No robustness should be sacrificed for smartness. Network devices have to be stable and to perform explicitly defined functions.

#### 3.6 Smooth integration into users' life

The more devices are acquired and interconnected in modern homes, the more intelligent these homes become. The intelligence of the home incurs many changes into people's life. This intelligence however, has to fit harmoniously into users' everyday activities without reducing for example family members impersonal contacts. The affect of smart technologies to inhabitants' relationships is an important social issue. Personal relationships have to remain inviolate and maiden. Users' life may become more convenient due to smart home technologies nevertheless special attention has to be paid to avoid excess and exaggeration. As mentioned before, privacy has to be respected in such intelligent environments.

Concluding, I would like to refer to the requirements in general and from different point of view. The important thing in defining user requirements is to address them correctly. User requirements are often resembled to research challenges which will be presented later. This overlapping may look rational however, requirements has to be clearly distinguished form research challenges. Particular needs for users are interpreted in a different way from research and design point of view. For example, user's requirement of customizable product for different family members is a

challenge of designing a particular flexible interface for researchers and manufacturers. User's need for compatible products is a challenge to design a model of connectivity and interoperability for the researchers. User's need for network smartness is interpreted as a challenge to create context-aware and multifunction applications.

## 4 Related work

A lot of studies have been carried out in order to describe, research and evaluate potential or already existing, intelligent home environments. Some of them were based on empirical user-case studies and others were based on monitoring inhabitants' life in real intelligent homes. Three of them are presented below.

### 4.1 Amigo project

This study [2] presents an empirical cross-cultural study conducted at six different sites in five European countries. The study employed a scenario-driven approach to elicit feedback from the target user population (potential intelligent home inhabitants) on concepts for intelligent home environments. The user study consisted of a quantitative evaluation of fictitious scenarios, a discussion addressing different scenario topics and an open-ended discussion on people's expectations of intelligent technologies in their home and life.

Using particular scenarios and according to the results of the study, few design guidelines were proposed during the Amigo project. According to the results of the evaluation, foremost priority for creating an intelligent environment, according to participants' suggestions, should be the continuous control of the system by user and never vice versa. Security, safety and privacy requirements have also to be met in such environment. Another priority should be the reduction of information overload and the load of housekeeping chores. Participants also states that the system should provide assistance to users, organizing their home environment. The importance of the project is the big number of suggestions and ideas provided by the participants. Few of them were mentioned above. These ideas may eventually be the main elements to build future intelligent environments.

### 4.2 Empirical evaluation of three UIs

The particular research was based on The Smart Home Usability and Living Experience project [6] that was carried out in 2002-2003 at Tampere Institute of Technology in an eHome, a two-room apartment with basic infrastructure for an intelligent environment. The purpose of T. Koskela et al [4] research however, was to evaluate three user interfaces (UIs) - PC, media terminal and mobile phone - for smart home environments. More particularly, the research evaluated the usability and acceptability of the three device/UI entities. The tenants of eHome for the six month trial period were a 26-year-old woman (historian) and a 27-year-old man (biologist).

The study consisted of the definition phase-during which the researchers collected the basic UI requirements, the design phase-during which they tested and iterated the UI pro-

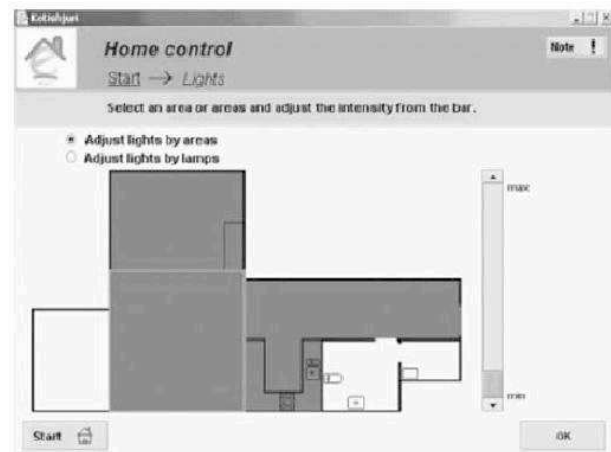


Figure 1: Example of a GUI on a PC



Figure 2: Example of a mobile phone UI

totypes and the evaluation phase-during which they gathered and analyzed data on user experience. After these six months, researchers came to a number of conclusions concerning couple's life assisted by the three UIs. For example, the couple liked the controlled automation in the apartment but had sometimes problems with the invisibility of automation. The couple was quite skeptical in the beginning about using the mobile phone UI at home but after a short period of time, mobile phone became their primary and most frequently UI. Examples of PC and mobile phone UIs are shown in Fig.1 and Fig.2

The final conclusion and the aim of the research is that the subjects welcomed the smartness that was added to their home and enjoyed the interaction with the UIs. However, there are still many obstacles that are to be overcome in order to provide flexible and trusted UIs.

For example, couple's trust on the surrounding devices and interfaces was not complete and absolute but varied from day to day. The particular interfaces were used by the couple only when they could confirm visually that the results of their actions were exactly the expectable ones. In the beginning they were less confident about controlling home appliances from distance and more concerned about leaving devices active for extended periods. With time however, they became more confident in performing these kind of tasks. Generally, the couple's trust to the devices and interfaces of eHome as well as their experience evolved stepwise.

### 4.3 The work to make a home network work

The particular research [5] reports findings from an empirical study of households containing complex networks of computer and A/V technologies. The study begins by reviewing domestic collaboration, which is domestic routines, everyday activities and technologies that coexist in such environment. It also reviews the role of computing in this collaboration. Particular methods and participants are enrolled to derive information about these networked households.

The findings of the study contribute in understanding and distinction of number of networks that exist in the households. The household tensions that emerge because of individuality and collectivity overlapping are also reported. One dominant theme in all the households seemed to be the challenge of setting up, administrating and troubleshooting the network. Furthermore, the research proposes and suggests how much collaborative work has to be done to make the home network work and provides invisibility and comprehensibility of the network as desirable aspects. Finally, it presents and analyzes the integration paradox.

The special contribution of the particular work into complex home networks studies could be the attempt to explore the question of what it means to set up, to maintain and to live in complex home networks. It also addresses issues of how these home networking environments effect inhabitants' everyday routine activities.

## 5 Challenges with home networking

While it's easy to set up and to determine user requirements, it's quite difficult to meet them. There are a lot of challenges [3] that have to be overcome before the concept of the smart home becomes an everyday reality. These challenges arise from the attempt to meet users' expectations and are related not only to technical issues but also to the social and ethical impact of these technologies to the inhabitants' life.

According to recent researches, one of the most challenging issues in the field of intelligent environments is the so-called "*accidentally*" smart home. As the existing homes are not built with the purpose to support intelligent networks, they are usually "upgraded" by acquiring products, interconnecting them, and finally creating these smart environments. Thus, these smart homes are called "accidentally" smart due to the lack of infrastructure for such smart application, but smart due to intelligent networks residing in them. The problem with these homes is that they may suddenly start to live a life of their own performing actions uncontrolled and unpredictable by users. So the question is how the inhabitants will adapt to the idea that their, dumb so far, home has reached a complexity and an intelligence of performing unpredictable actions and moreover how the inhabitants will manage to control these intelligent environments. While it can be stated that every undesired unpredictable action may occur due to bad design issues, it is proved that the very modern smart homes can reach an "intelligence" of their own.

Another challenge for the modern researchers, as the previously mentioned study showed [5], is the *lack of administration* in intelligent home networks. As more and more devices enter the home and home networks become big-

ger, administration skills become necessary to manage these complex home networks. While early computer users could control their networks having limited administrative skills, nowadays network and security administration tasks are everyday need. Fortunately, there are some models that support administration-free use of complex home networks. Particular appliances for example have been developed to provide home users with control and management capabilities. These devices are connected to the home network and provide a centralized control of its functions. When such a device breaks, an expert is needed to repair it. The question however, is how these devices can provide control of the complex and continuously expanding home network without losing their simplicity.

As previously stated, one of the main user requirements concerning advanced home technologies is the respect of their privacy and a smooth integration of these technologies into their life without any implication. However, there are few *social implications* of intelligent home networks. These implications determine a major challenge for moving towards intelligent home solutions. Lack of privacy is considered as the main social implication that smart homes have. Studies however, illustrate another consequence of domestic networks: the "labor saving". While it is believed that new technologies will provide users with labor saving devices, there is always a risk that these devices may turn to labor changing devices. It's not well defined yet whether the future home devices will integrate into inhabitants' life without changing their social beliefs. Even simple devices of past like washing machines is proved to have affected people's beliefs and have changed the society itself.

## 6 Conclusion

The current research included the study of intelligent home networks. It presented basic user requirements as well as what has been done so far in the still infant field of intelligent home networks. It also came up with existing difficulties and challenges in the way towards smart homes as well as with few suggestions and ideas.

In particular, the aim of the research is to find out what do users anticipate from intelligent home networks and to suggest what researchers should take into account while modeling infrastructure for such environments. According to the research, users demand features like compatibility of home devices, easy-to-use user interfaces and customizable products and services. They are absolutely concerned about security, safety and privacy. Users also envision a smooth integration of intelligent homes into their life.

Referring to three different projects, the research shows that intelligent networks are evolving stepwise and gain inhabitants' trust incrementally. In an experimental project [6] of couple leaving for a period of time in an eHome, it was inferred that the subjects welcomed the smartness of the new networked environment. However, there are still some challenges that have to be overcome in order to make intelligent environments widely available. Lack of administration makes smart home appliances as well as the whole network difficult to be managed by the inhabitants. Another rising issue is the social implication of such environments. Are users

ready to accept something like that? How it will affect their everyday life?

Despite however, all the seemingly insuperable obstacles, the work towards intelligent home networks moves quite fast. Lots of households nowadays, interconnect their appliances creating small networks. These networks vary from simple ones with just few computers to more complicated where the networks include almost every electronic device of the house. The impacts of living in such environment are not yet well known. However, if the smart networks are built in smart way, they could provide countless solutions simplifying users' life.

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