User Requirements for Intelligent Home Environments: A Scenario-Driven Approach and Empirical Cross-Cultural Study

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Abstract

This paper presents the results of an empirical cross-cultural study conducted at six different sites in five European countries in the context of the EU IST-IP project Amigo, Ambient Intelligence for the Networked Home Environment [1]. The study employed a scenario-driven approach and used quantitative and qualitative methods to elicit feedback from the target user population on concepts for intelligent home environments. The results are clustered and transformed in prioritized design guidelines.

1. Introduction

The concept of Ambient Intelligence propagates a vision of future environments where people are supported and assisted in their everyday activities by information technology that is very different from the computer as we know it today. The envisioned technologies "will weave themselves into the fabric of everyday life until they are indistinguishable from it." [2]. In this context, we envision the creation of smart environments that integrate information, communication and sensing technologies into everyday objects and distinguish between "system-oriented, importunate smartness and people-oriented, empowering smartness" [3]. To achieve the latter where "smart spaces make people smarter" [3], we have to identify the requirements that potential users have in order to accept and actually live in such intelligent homes. This is especially relevant for systems that provide intelligent user services because the potential benefits are not for "free". These intelligent user services rely for their operation on appropriate and sufficient information from the users. This information may include their identity, usage patterns of systems or services, and preferences, and it might be collected by explicit and implicit means. Hence, the requirements to build trusted platforms that perform exactly as they are expected to do and that protect intimate data while still allowing easy access to it are compelling. For such systems, it is most crucial, to regard and involve the potential users right away from the beginning of system design.

2. Motivation and Goal

Since the target end-user population for the intelligent user services for the different application domains of the Amigo networked home environment comprises citizens from large urban and suburban areas in different parts of Europe, potential cross-cultural differences have to be accounted for. Therefore, we conducted our user studies not only in one country but exploited the situation of having project partners in several European countries. Our goal was to obtain feedback from potential users on the usefulness and appropriateness of applications and services in future networked home environments in order to guide our design.

3. Related Work

Most intelligent user services serve a social purpose, i.e., they aim to support long-term and low-pace communication and interaction between people that have close emotional ties. For example, the *ASTRA* project investigated an asynchronous awareness system that helped related and distributed households to stay in touch with each other [4]. A similar approach was taken in the *interLiving* project [5], which aims at developing technologies that facilitate communication between different generations of family members living in different households. Other projects as, e.g., *EasyLiving* [6] and *Aware Home* [7] address more fundamental challenges of intelligent home environments. A detailed overview of related work can be found in [8].

4. Methodology

To elicit feedback from the target user population a scenario-driven approach was chosen. The user study consisted of three different parts:

- *"Gallery"*, a quantitative evaluation of fictitious scenarios,
- *"MyPlace"*, a structured focus group discussion addressing different scenario topics, and
- *"Ideal Home"*, an open-ended discussion on people's expectations of ambient intelligence technologies in their home and life.

For each part a methodology was designed. The *Gallery* sessions were conducted in exactly the same way for all scenarios at six different sites distributed over five countries (for details see Table 2 below). The focus group discussions conducted in *MyPlace* and *IdealHome* focused on one of the four scenario topics (see below) according to the application domain at the project partner site.

5. Design of the user studies

Four different scenarios consisting of examples of intelligent user services were used. These scenarios provided a view on a day in the life of a fictitious family: Maria, Jerry and their two children Robert and Pablo. The scenarios are futuristic and do not necessarily match people's current experiences

and expectations. Each scenario is grouped around a different theme and consists of several elements (Table 1). Scenario 1 starts with the situation where Maria wakes up in the morning.

Table 1: Overview over scenarios and elements.

Scenario 1: "Being Followed by Content"	**Scenario 2: "Playing Games"**
1. It plays Maria's favorite song when she wakes up in the morning. 2. The song follows her through the house. 3. At the same time it shows Jerry's favorite news in another room. 4. If she starts singing her own song, the system starts playing it. 5. If she meets Jerry in another room, the system stops playing. 6. If Maria or Jerry leave the room, the system starts playing again. 7. The TV shows summaries of their favorite news. 8. The news is downloaded on a portable device to take along.	1. It asks for parental permission. 2. It downloads and shows game play lists. 3. It adapts the lights and the sounds of the home to the environment of the game. 4. It displays a video wall to show the game and other players. 5. It lets the game player interact with body movements. 6. It recognizes friends at the front door and lets them join in the game. 7. It recognizes and integrates the game devices of the friend. 8. It downloads the profile of the friend.
Scenario 3: "Home Caring"	**Scenario 4: "Sharing Ambiance"**
1. It has an intelligent door that recognizes family and friends. 2. It has a vestibule display showing who is home. 3. It downloads recipes in the kitchen. 4. It shows recipes and the whereabouts of the persons in the house. 5. It detects problematic items in the washing machine and warns. 6. It starts the dishwasher when it is full. 7. It sets up the living room for film watching, adjusts lights and curtains.	1. It shows her father at his home and Maria in her home. 2. They see each other and it lets them engage in a chat. 3. It interrupts the chat if other persons enter the room. 4. It knows the privacy preferences of both Maria and her father.

The scenarios are used to explain the innovative concepts to potential target users. The feedback from target users was structured using different variables for quantitative and qualitative responses and then compared across the different project sites.

5.1. Gallery

The goal of the *Gallery* session was to collect quantitative feedback from the participants on the different scenarios. The scenarios were visualized and shown in a *Gallery*-like setup. The participants were asked to rate the scenario elements and to list advantages as well as disadvantages of the elements.
The stimulus material consisted of visualizations of the scenarios. The elements of each scenario were visualized in two variants and presented in frames with different colors. The scenarios were presented on four different walls so that the participants could walk around, like people do at an exhibition. The text of the scenarios was used as an introduction and translated in the native language of each site. Two neighboring rooms were furnished as a reception room with a large table and chairs, refreshments, paper, pencils and as an exhibition room showing the visualization of the scenarios. In the reception room, the participants received a general introduction and a short instruction on the tasks that they had to perform in the exhibition room.

Figure 1: Exhibition rooms at different partner sites.

The participants were instructed to form small groups with 2 to 4 people. When they entered the exhibition room, each group was assigned to one wall and instructed to assess the scenario and its elements. After fulfilling these tasks the group moved to the next scenario. The participants were requested to follow the natural order of the scenarios; e.g. morning, afternoon, evening; afternoon, evening, morning; or evening, morning, afternoon. All tasks were performed individually. The participants were asked to rank the elements for each scenario according to their perceived usefulness and to list advantages and disadvantages of the elements.

5.2. MyPlace

The goal of the *MyPlace* focus group sessions was to get qualitative feedback on the concepts described in the scenarios and to position them with respect to their relevance to meet the needs of users, their family situation and household practices. All focus groups started with stimulus material in the form of a story, which first introduced the idea of ambient intelligence and then focused on one of the scenario topics (e.g., "Playing Games" or "Home Caring") to introduce innovative features and services. While reading the story, the moderator positions keywords on a poster-sized abstract visualization (Figure 2).

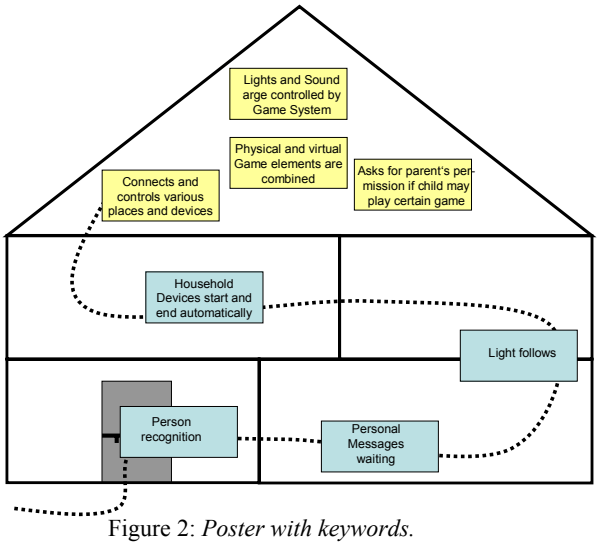

Figure 2: *Poster with keywords.*

The focus group discussion was guided by structured questions focusing on the specific issues of the scenarios. Keywords were collected and clustered by the participants.

Each cluster was labeled by an appropriate title. The participants rated the importance of each cluster.

Figure 3: Setting for *MyPlace* focus group.

5.3. IdealHome

The goal of the *IdealHome* sessions was to generate qualitative feedback from people with regard to expectations and needs for an ideal home. The *Gallery* material was used as the stimulus material because it covered various aspects of ambient intelligence. The *IdealHome* focus groups were conducted in the same way for all scenario topics. The results were collected and clustered in the same way as the results of the *MyPlace* focus group.

5.4. Participants and Schedule

Altogether, 55 people were participating at different sites. Table 2 shows the composition of the user population at each participating site. Each site used the same profile for selecting the subjects. This profile represented different classes of family conditions, i.e., single – married or living together; at home – away from home; single house – flat; working – not-working; children – no children; male – female. All participants had a higher education and could be classified as upper-middle class. A strict condition for the participants was that they were not employed at any of the organizations participating in the project. The focus groups were conducted at the sites of 6 project partners in 5 different countries.

Table 2: Distribution of participants over countries.

Partner Site	Participants	Age
Fagor (Spain)	11 (5 ♀, 6 ♂)	22 – 47
France Telecom (France)	9 (4 ♀, 5 ♂)	27 – 45
Italdesign-Giugiaro (Italy)	7 (2 ♀, 5 ♂)	21 – 40
IPSI (Germany)	10 (5 ♀, 5 ♂)	15 – 45
Philips (Netherlands):	11 (5 ♀, 6 ♂)	22 – 52
Telefonica I+D (Spain)	7 (5 ♀, 2 ♂)	25 – 58

The overall schedule for the quantitative and qualitative evaluation session is shown in Table 3. This schedule was used at all 6 participating partner sites.

Table 3: Schedule for the evaluation (4 hours).

Duration	Activity
5 min	Arrival, introduction and explanation
10 min	Warming up
45 min.	"MyPlace"
10 min	Coffee Break
15 min	Clustering and Rating of the "MyPlace" results
45 min	Lunch Break
30 min.	"Gallery"
15 min	Questionnaires
10 min	Coffee Break
30 min	" IdealHome"
15 min	Clustering and Rating of the "IdealHome" results
10 min	Unwinding, cooling down, debriefing

6. Results

Our systematic approach based on experimental design techniques and structured ethnographic methods made it possible to integrate the feedback from a large sample of users for different intelligent user services and different application domains. We generated and prioritized user requirements in major categories.

6.1. Quantitative Results (Gallery)

The results of the *Gallery* session provided two categories of data: the ranking of the elements that constituted the scenarios, the lists of advantages and disadvantages, and general feedback. The agreement among judges was high at all sites (χ^2= 76.5 – 95.8, df=26, p< .001). The data from one site could not be used.
Table 4 shows the results on the ranking tasks of 5 sites for all 4 scenes for a total of 45 participants. The calculations are based on the top 3 rankings for each participant for each site (n=45, Kendall's W(a)= .252, χ^2=295.036, df=26, p<.001).

Table 4: Mean scores for the scenario elements ordered from most preferred to least preferred within each scenario.

Description of scenario elements	Mean Score
Scene 1: Being followed by content (max. score = 8)	
▪ The TV shows summaries of their favorite news.	7
▪ At the same time it shows Jerry's favorite news in another room.	6
▪ It plays her favorite song when she wakes up in the morning. ▪ The song follows her through the house. ▪ The news is downloaded on a portable device to take along.	5
Scene 2: Playing games (max. score = 8)	
▪ It asks for parental permission.	8
▪ It downloads and shows game play lists. ▪ It adapts the lights and the sounds of the home to the environment of the game. ▪ It displays a video wall to show the game and other players. ▪ It lets the game player interact with body movements.	5
▪ It recognizes and integrates the game devices of the friend. ▪ It downloads the profile of the friend.	4
Scene 3: Home caring (max. score = 7)	
▪ It detects problematic items in the washing machine and warns.	6
▪ It starts the dishwasher when it is full.	5
▪ It has an intelligent door that recognizes family and friends. ▪ It downloads recipes in the kitchen. ▪ It sets up the living room for film watching, adjusts lights and curtains.	4
Scene 4: Sharing ambiance (max. score = 4)	
▪ They see each other and it lets them engage in a chat.	4
▪ It shows her father at his home and Maria in her home. ▪ It interrupts the chat if other persons enter the room. ▪ It knows the privacy preferences of both Maria and her father.	2

The discussion of advantages and disadvantages of the various elements of the Amigo scenario supports the results from the ranking tasks. People were very outspoken in their desire to maintain control over their environment and to have well defined responsibilities. They wanted to be responsible for their children and to control and protect them from inappropriate entertainment and information. But, they also respected the privacy of their children and parents, i.e., no video monitoring on their whereabouts at home. Reducing interpersonal contact is a very sensitive issue. Participants preferred telling their family if they are leaving a room or the house and thus talking to each other more often. The element "asking for parental permission" (Scenario 2) scored very high, while the elements that concerned the starting and stopping of playing a song or presenting content scored low when it was triggered by their behavior or that of other people (Scenario 1). Furthermore, the elements that concerned showing who is at home and what their whereabouts are (Scenario 3 and Scenario 4) scored relatively low. The integration of profiles and devices of other people in their systems was observed with reservation. Clearly "maintaining and respecting control and privacy" are very important and might be the determining factors for the acceptance of intelligent user services. The potential loss of direct contact with friends and family was a very serious threat for our participants.

People ranked reducing the information overload and the burden of searching for entertainment and information items high. Providing "summaries of the favorite news" to each person at the same time was ranked high as well as the follow-me content, the downloading of play lists and the downloading to portable devices. People were very appreciative with regard to solutions for perceived practical problems with home care, i.e., automation of household chores, like "helping with routine household chores and preventing annoying accidents" (Scenario 3), "adjusting lights and curtains to the desired ambiance" (Scenario 2 and Scenario 3), and a "door that recognizes them". Some of the elements in the scenarios elicited worries with regard to "becoming too dependent" on the system, "inducing a lack of physical and mental exercise". This was also reflected in the preference scores, except for the possibilities of interacting by means of body movements and gestures for the children's games in Scenario 2.

With regard to the elements in Scenario 4, people liked the possibility to "see each other and engage in a chat" very much. They did not appreciate the other elements because they worried about impolite and intruding behaviors and in general a lack of privacy. People were positive about the possibilities for conducting spontaneous conversations with far-away family members and friends: it brings them closer together and creates intimacy. The possibility for taking care of family and friends by means of always-on video communication was an advantage. However, loss of privacy, loss of intimacy, and impolite and intrusive behavior were listed as disadvantages. People also recognized the potential for conflicts when their requirements for privacy, security and intimacy did not coincide with those of their family and household friends. They were also concerned about loss of spontaneity in their relations with others. In general, having focus groups listing disadvantages seems to be a good strategy for designing intelligent user services because it emphasizes the need for protecting security and privacy, the relevance of social communication and polite and expected behavior for a given context. Table 5 summarizes the overall trend in peoples preferences considered over all the scenarios and ordered in 6 clusters from most important to least important according to the rankings of the participants.

Table 5: Scenario elements clustered according to ranking preferences.

Cluster	Scenario elements
1. Maintaining control and responsibility	Asking for parental permission re. entertainment, games and information for kids
2. Reducing information overload and search burden	Providing personalized information summaries to different people, at the same time, and at different locations in the home
3. Preventing household accidents	Detecting and warning for faulty objects
4. Assisting with organizing the personal home environment (individual focus)	Selecting favorite songs, inducing follow-me of content, downloading of music, information, and play lists.
5. Assisting with organizing the home environment (group focus)	Recognizing profiles of family and friends, at the entrance door to let them in, downloading profiles of visitors, downloading recipes to the kitchen, adapting lights and windows to the appropriate activities in a room.
6. Caring for others and staying in touch	Peeking into each other's home, reacting towards events in one of the homes (like another person) and being knowledgeable about privacy preferences while conducting video chats.

6.2. Qualitative results

6.2.1. MyPlace

The purpose of the *MyPlace* focus group session was to explore and generate feedback from people about the concepts that are proposed by the scenarios. Although different aspects of home life such as information, automation, entertainment (games) and extended home environments were addressed and the studies were conducted in different countries, no cultural differences were identified. Many common topics could be identified from the results. At first sight, ambient intelligent systems at home seem to highlight more fears then benefits. Fears concern: lack of control, lack of security, increasing isolation, favoring laziness (sometimes even an extreme decrease in responsibility). In other words, ambient intelligent systems might present risks that people may be afraid of. Two particular risks that were identified at all participating sites concerned: the loss of control by the users and the threat they impose to their security. The participants also proposed some guidelines for designers on these matters:

- First and foremost, users must stay in control of what is happening. They must never have the impression that things are happening that they do not want.
- Account for pre-existing social rules: for example, when someone enters the room where two people are already chatting, they all know what to do without having a system interfering.
- The system must not replace direct interaction between people.

With regard to security, fear of pirating constitutes in general the most severe reservation of people, especially, when it concerns a network and remote servers. A vital factor for gaining support from users is the perceived security of the system. For example,

- The system should be as well protected against intrusions as it is against the loss of data.
- Household data must not be accessible from the outside and there must not be any risk of pirating or viruses.
- System security also includes controlled access, particularly for children. Due to the centralization and sharing of data in the home, users need to be able to place access restrictions on functions and content, based on the user profile.

Furthermore, security is also a global concern that includes physical security at home, for example, preventing domestic accidents and protecting children. Home automation in general is more perceived as a kind of ideal: having no more household chores to do and expecting "intelligent" devices that act as assistants. Linking household devices, such as, cupboard and refrigerator to the Internet to get ideas for new recipes is another example. Other functions in the domestic environment were envisaged such as monitoring the level of dust mites or the ambient atmosphere. With regard to the entertainment domain, people were very positive about all features that could improve their experience: sound, special effects and adaptation of the environment to the game or the movie. With regard to communication, people were very positive about the possibilities for sharing emotional information with distant friends and to be able to stay in touch with several persons in several different ways.

6.2.2. IdealHome

The focus group sessions on *IdealHome* were conducted after the *MyPlace* focus group and the *Gallery* session. Although all sites followed the same procedure, the participants were already tuned to the different scenario topics.
The agreement amongst participants from all focus groups was large. First of all, all participants agreed that the system must be easy to use and to configure, to be simple and intuitive and customizable to the preferences of each user, as well as enabling natural interaction. The strongest worries of people refer to expected security and privacy problems with the system. They do not want to be monitored by a system, as they perceive this as threatening to their privacy. People also worry about the lack of control of the system. Furthermore, people worried about the protection of their intimate data.
Another aspect concerned the effects that this system could have on people, i.e., they can become lazy because they do not have to do anything, or incompetent because they forget how things are done, or they get isolated due to the loss of direct personal communication. Furthermore, people don't want the system to mediate communication and relation between people when they have the possibility to interact directly. For example, the system shall not show which person is in which room, as people could go there and see themselves who is there. All participants were enthusiastic about home automation functionalities (household tasks, cleaning, recipe suggestions, etc.). They all agreed that more autonomous and intelligent household appliances could improve the quality of life by increasing people's free time. People also observed that it should be easy to move the system to another home.
Despite all these convergences, within the groups disagreement existed on several topics. For example, a news summary service appeared to be attractive for some but undesirable for others (because they think that some important news may be filtered). Therefore the system should be flexible enough so that all these different points of view of the system could exist together by allowing, for example, profiling in these functions.

7. Design Guidelines

Using three complimentary methods resulted in confirming evidence with regard to perceived user goals and needs and the match or mismatch of the proposed scenario solutions. Note, that a perceived mismatch can be reformulated as a requirement, condition or constraint for the system requirements.
The results from the *Gallery* evaluation could be summarized and prioritized in user requirements that are generic for multiple intelligent user services. First and foremost, maintaining control and responsibility for how they organize and maintain their physical and social household is a top priority for people. This is made explicit by the elements that show the role of the system in asking for parental permission with regard to content and games for their children (highest preference judgment over all sites). The qualitative results from *MyPlace* and *IdealHome* support this user requirement fully for all scenario topics. The following requirements are always subsumed in all other requirements and have the **foremost priority** for all people:

1. The user must always remain in control of the system and never the other way around.
2. The system must be secure, safe and protect the privacy of all users.
3. The system must provide an added value over existing systems.
4. The system should never unnecessarily replace direct interaction between people.
5. The home comfort should always be maintained and not be subversive to the system.

Second in priority is the need to reduce the overload of information and the burden of search. This was made explicit by the scenario elements providing information summaries, personalized to different people, provided at different locations in the home, and dependent on context. The qualitative results from *MyPlace* and *IdealHome* did not show this priority since the structured questions did not address this topic. Although ranked very high, the different elements elicited mixed feedback. The feedback with regard to the control of the system can be summarized as:

6. The system should provide concurrently the appropriate information to the right persons for the appropriate occasion at different locations, i.e., filter information, provide resumes, according to user preferences (note that people refer to existing services that they know).

Third in priority is to reduce the load of housekeeping chores and to prevent all kinds of household accidents. This was made explicit by the scenario elements that detected

problematic items in the laundry and automatically started appliances. The qualitative results from *MyPlace* and *IdealHome* support this user requirement fully for all scenario topics, but especially by the "Home Caring" scenario. Clearly with regard to home care and safety, people have great expectations.

7. The system should reduce the time needed for household chores and where possible do most of the cleaning jobs.
8. The system should integrate and combine functionality of appliances.
9. The system should be energy saving.
10. The system should be cost saving.

Fourth in priority is to have assistance with organizing their personal environment at home and between home and the office. This was made explicit by the scenario elements that selected favorite songs, induced a follow-me of content, and downloaded content and play lists to different devices. The qualitative results from *MyPlace* and *IdealHome* support this user requirement, especially for the "Being followed by Content" and "Playing Games" scenarios.

11. The system should support the activities organizing and planning for multiple persons at home, between homes and between home and work.
12. The system should protect against abuse, intrusions, loss of data, house system hackers.
13. The system should provide controllable access and respect individual preferences and authorities.

Fifth in priority for people is to have assistance with organizing their home environment. This was made explicit by the scenario elements that adapted the ambiance, i.e., lights, windows, etc. to the appropriate activities in a family or game room and the recognition of people at the main entrance. The qualitative results from *MyPlace* and *IdealHome* support this user requirement.

14. The system should take context/environment conditions into account and be aware at any time of the local situation.

Sixth in priority for people is to be supported with the care for others and to stay in touch with others. This was made explicit by the scenario elements that addressed user modeling and profiling, awareness and notification, and security and privacy. To see each other while talking or being involved in joint activities from different locations was the preferred example. The qualitative results from *MyPlace* and *IdealHome* support this user requirement.

15. The system should take implicit social rules of behavior into account.
16. The system should protect people's privacy at all times.

8. Conclusion

The participants generated a wealth of suggestions and ideas for usage and services. They were also very determined about the ideas that they at face value did not appreciate at all. Most pertinent for people are the requirements that we might call 'hygienic', such as, easy to use, nice looking, no programming, no extra effort, affordable, and functional. In summary, one can conclude that the studies showed confirming evidence with regard to general user requirements including the very obvious, like the system should be easy to use and to configure. There should be no need for programming by the user and, of course, it should be maintenance free, i.e., no need for maintenance by the user. It should be modular, enable individual settings and preferences and be configurable by the user or service provider.
Participants were unanimous in their desire to protect their privacy (no surveillance), their mistrust of a system invading their personal life, and their dislike of being too dependent on an ambient intelligent system for social communication or even replacing the face-to-face interaction.
Having collected and investigated this wide range of user requirements, it is now our task in the Amigo project to have them inform our design and transform them into design specifications guiding our development of intelligent user services for future smart home environments.

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