Les cahiers du numérique, « Ces objets qui communiquent », Hermès-Lavoisier, Vol.3 n°4, 2002, p. 149-171

MultiCom, a Platform for the Design and the Evaluation of Interactive Systems : Application to Residential Gateways and Home Services

Jean Caelen, Evelyne Millien

Laboratoire CLIPS-IMAG, équipe MultiCom
B.P. 53 - 38041 Grenoble cedex 9 – France
Jean.Caelen@imag.fr,Evelyne.Millien@imag.fr

This paper presents a platform, named MultiCom, for the design and the evaluation of user interfaces and more generally of interactive systems or products dedicated to the end user. MultiCom is a kind of "usability lab" which contains various distributed resources on network and dedicated software to capture and analyse the human working with a computer. It can be notice that very few generic usability labs exist now in the world. The methodology of MultiCom is based on the lifecycle *used in software engineering domain, by having multidisciplinary approach, unifying several methods on sociology, ergonomics, and software engineering. The lifecycle starts from the original idea of product or system to need and ends by the evaluation after the complete exploitation by the client. The results show that it is very important to design all innovative product or service by integrating the end user in the "development loop" of the system. This point of view implies that the design process have to start from the situated work where a subject is observed in order to capture is behaviour. The data resulting of the capture stage are analysed in terms of usability factors defined a priori for the diagnostic and evaluation. Then, the results allows the designer to fix the precise system functionality. After the prototype realisation, a lot of users is observed again, and so on, then the prototype is modified until a convergence. The paper describes all the tools needed and used in MultiCom platform to manage a complete design session and their application to design new user interfaces in the home domain. The new growing market of Residential Gateway and Home Services presents some challenges for the design of User Interfaces (UI). The home environment calls for new solutions going beyond conventional GUI. This article describes an exploratory study realized at the early stage of an industrial European project, which aims to better understand the main issues of this specific context. We present the approach that we used, involving the creation of a simulated environment as close as possible to a home where users interact with Home Services through various devices which could constitute a UI to a Residential Gateway. We then present the main results of the study: a) main features of this context; b) main user tasks involved in the use of services and strengths and weaknesses of the tested interaction devices in their aptitude to support these tasks. Finally we present examples of recommendations for the design of the user interfaces of the Residential Gateways.*

KEY WORDS: *Usability/Usage, Home Services, Usability in Home environment, Distributed Interaction Devices, Experimental Platform*

1. Introduction

Bernsen [1] claims : "It is a well-recognised fact that the production of a new software engineering tool or method is difficult and time consuming. The difficulties lie not only in the initial conception of, for instance, a new tool, or in tool drafting and early in-house testing. Even if these stages yield encouraging results, there is a long way to go before the tool can stand on its own and be used as an integral part of best practice in the field. One central reason why this is the case is the problem of *generalisation*. A tool which only works, or is only known to work, on a single system, in a highly restricted domain of application, or in special circumstances, is of little interest to other developers. In-house testing will inevitably be made on a limited number of systems and application domains and often is subject to other limitations of scope as well. To achieve and demonstrate an acceptable degree of generality, the tool must be iteratively developed and tested on systems and application domains, and in circumstances that are significantly different from those available in-house. Achievement of generality therefore requires access to other systems, corpora and/or development processes. Such access is notoriously difficult to obtain for several reasons, including commercial confidentiality, protection of in-house know-how and protection of developers' time. A second reason why software engineering tool or method development is difficult and time consuming is the problem of *objectivity*. It is not sufficient that some method or tool has been trailed on many different cases and in widely different conditions. It must also have been shown that different developers are able to use the new method or tool with approximately the same result on the same corpus, system or development process. The benefits from using a new tool or method should attach to that tool or method rather than to its originators."

Since many years, the designers of interactive systems need tools and methods for the design and the evaluation. This point is crucial in the industrial context where the constraints are hard to satisfy, due to the variety of resources to collect, in the area of human factors (ergonomics and sociology).

The academic research teams are sought frequently by the industry for studies on the user needs, and on the system evaluation with users. It is important to notice this recent evolution : in the past, the evaluation was done at the end of the development cycle, now the usability activities are realised continuously during the lifecycle of the system. So, the industry asks to academic teams about new services or competencies as design studies and usability studies.

It would be more beneficial to create a common platform for both partners [2]. The platform would be defined as a *service centre* devoted to the experimentation . The academic or industrial institutions being clients of this service centre. Based on this definition, the platform must include a complete usability lab : a set of observation rooms and some tools for capturing and analysing the user behaviour. .

The envisioned industrial benefits of this platform are :

- Progress towards the integration of systems best practice into software engineering,
- Improved feasibility assurance of development projects (risk minimisation) and more exact feasibility assessment,
- Improved procedures, methods, concepts and software tools,
- Reduced development costs and time, improved maintenance and reusability,
- Improved product quality and increased flexibility and adaptability,
- Progress towards the establishment of software engineering standards,
- Improved guarantees to end-users that a product has been developed following best software and cognitive engineering practice. Enabling end-users to objectively assess different systems and components technologies against one another and choose the right product according to quality, price and purpose.

MultiCom tries to satisfy this needs : MultiCom is a complete platform for the design and the evaluation of the interactive systems, including all the stages of the development cycle and supporting tools for sociologic enquiries and usability testing. MultiCom provides tools and assistance during the different steps of the design in order to :

- identify and diagnose the usage,
- analyse user needs, and define the system functionalities,
- experimente different test scenarios,
- refine the specifications [7],
- validate the formal specifications,
- evaluate the system usability.

2. MultiCom platform

The platform includes :

- An observation laboratoty for capturing the behaviour of human subjects, using the "Wizard of Oz" method or the "Direct Observation" method. These technics allow to make objective measurements such as : sensory tracking, response delay, activity level, task strategy, error measures, etc.
- A numeric usability laboratory which allows to make data analyses based on annotating observations and filtering. Several tools provide some facilities to the expert in order to obtain results concerning the task model or the user model.
- A studio of audio-video recording,
- Dedicated rooms for the experimentation,
- A set of software tool for statistics, virtual reality simulation, networking, etc.
- Hardware and software environment

The observation laboratory is based on a network of several computers (Unix and Windows), where the evaluated system and all the observation material needed (cameras, videos, microphones, and others sensors) are connected together. The Wizards, if needed for the experimentation, are hidden in other rooms than the one used by the subject. Through the network, they receive all data coming from the observed subject room : images, sounds and interactions with the system.

2.1. Observation, Evaluation, Recording and Visualisation Environment :

The platform provides an all-inclusive usability evaluation environment [8]. It consists of a set of tools designed to facilitate and accelerate the usability evaluation process. The tools support the usability specialist by automating a good part of the recording and analysis work.

The tools consist of :

Logging tools to record human-computer interaction. These tools range from event logging to video recording. When multiple recording streams are used, they are automatically synchronised based on their timestamps,

Analysis tools to analyse the recorded interaction. These tools go beyond the traditional statistical analysis by looking at usability evaluation needs and implementing both traditional and innovative usability metrics,

Visualisation tools to display the results of the logs and of the analysis in adequate forms. Our visualisation tools include tools to display analysis results in contextual forms, and tools to combine and synchronise various sets of results and logs to replay or assist the analysis of usability sessions,

The platform is running under Microsoft Windows and X Windows systems. Although not every tool is available for every system, the tools exchange data in the same format. Therefore, you could, for example, record a session on a Macintosh, analyse it on a Unix system, and view the results on a PC running Windows. Our current development effort concentrates on the Microsoft Windows system, in response to our industrial partners request. .

MultiCom is being developed by university researchers in a research environment. We listen to our corporate partners to assess their needs, and then our team of scientists (faculty and graduate students) develop and validate new methods and tools to provide original solutions for our partners. It's a win-win combination: the industrial partners get leading edge tools and methods for usability, and our faculty and students pursue their research interests.

2.2. Modularity and reusability

Based on separate and independent modules, the numeric lab is completely reusable and configurable for all types of applications, in particular for CSCW applications.

3. Methodology

MultiCom methodology is based on the observation of *situated* utilisation. A set of users is observed while they are working and their actions are recorded. The results from the analysed data provides parameters and constraints for the design [4]. We consider the following parameters :

• the value and the sense of usage,

• the usability (more generally ergonomic quality),

• the technological constraints.

“Inspection” is widely believed to be the most cost-effective method for detecting defects in documents produced during the software development lifecycle [6]. However, it is by its very nature a labour intensive process. This has led to work on computer support for the process which should increase the efficiency and effectiveness beyond what is currently possible with a solely manual process, but no single tool available fills all the identified needs of inspection.

MultiCom uses several and complementary methods :

• the *predictive method* which starts from cognitive theories and takes into account the technology feasibility in order to help the designer in the specification step,

• the *simulated method* (by virtual reality or by wizard of Oz technique) which provides data for the specification refinement step,

• the *direct inspection method* on the prototype for the formal validation and the ergonomic evaluation of the system,

• the *indirect method*, as the reverse engineering, which allows to check the system regarding the specifications.

3.1. The design cycle

MultiCom methodology applies during the design cycle of the system in order to integrate as soon as possible the human factors in the design process. The benefit expected is to reduce the development time while reaching a high quality of products. The design cycle runs on three phases [3] :

Information Elicitation and Analysis Phase: involves collecting and analysing device dependant information (in the case of multimodal interface) concerning the user tasks and the positive and negative features of the systems that they currently use. The information is summarised in a device-independent (i.e. high level) task model of the existing system; the system to be designed is modelled at a similar level based on the Statement of Requirements, i.e. the Project Brief.

Design Synthesis Phase: the human factors requirements are established and the semantics of the task domain is recorded. A conceptual design for the target system is produced; this is based on the task model produced earlier, with regards to the information collected about the task domain and the human factors requirements. This design task is then split to separate those sub-tasks that are to be performed using the system under development from those that are performed off-line.

Design Specification Phase: a detailed and device-dependent specification of the user interface is produced; this includes description of the screens, widgets and the interaction sequence. The design is then assessed and refined in an iterative process.

The design cycle is is described in more details as follow :

A • Observing the use of current systems and predicting the future use with the system to design,

B • Defining the specifications,

C • Defining some task scenarios and assessing them in real work situations with subjects,

D • Refining the specification from the diagnostic delivered in C,

E • Realise a mock up of the system to design,

F • Testing the mock up,

G • Evaluating the use and the usability of the mock up,

H • Modifying after debriefing , debugging,

I • Developing another version of the mock up, J • Returning at the step F while it is necessary,

K • Evaluating the final mock up,

L • Developing a prototype,

M • Put it on the market,

N • Training end users if needed,

O • Analysing the market returns.

The cycle starts generally from an idea proposed by the marketing team. This idea is relatively imprecise : it does not take into account the usability issues nor the technological limits. Therefore, it is necessary to enrich and concretise the starting idea before developing the first model. SA, B, C are, in this perspective, preliminary steps of the cycle aiming to validate the feasibility of the idea. Then, the steps D to J are the core of the design cycle running under the iterative strategy. The step K is critical because it is the decision point before the market proof.

MultiCom methodology associated to the design cycle, consists in a set of procedures which apply according to the step of the cycle. The procedures provide also different criteria for the ergonomic evaluation or for the formal validation.

The specificity of the MultiCom methodology is based on the fact that all the criteria concerning the human factors (sociological and psychological) are taken into account as soon as possible in the design cycle.

4. A case study in the home domain

This study is taking place at a very early stage of an European project in the domain of Residential Gateways (RG) and Home Services (HS). The residential gateway is a networking device incorporating a set of technical functions. It provides connectivity between different home devices, enabling them to interact with one another, as well as connectivity between internal home networks and external networks. Through RG, a wide set of communication based Home Services can be delivered into the home by service providers.

The European SIRLAN (Secured Infrastructure for Commercial and Residential Local Area Network) project aims to create a Toolkit Platform for the development of RG and HS in a secured communication infrastructure.

Examples of Home Services include: Home security, home medical care, appliance monitoring, energy management, home automation and control, home networking (Internet access sharing, resource sharing), entertainment (Video/Audio convergence, real-time multi-player interaction/gaming), communication (multiple phone lines, messaging), remote monitoring, etc.

The market of RG is a growing market were industrial efforts are intensifying all over the world. Up to now, efforts were largely directed towards technical challenges, but little work has been reported on understanding user needs and behavior in terms of tasks and corresponding UI to support these tasks.

4.1. Objectives

This study aims to better understand future user expectations. We proposed to:

- identify the particular aspects of the RG and HS context that may influence the user interface design
- identify the main tasks that users may execute while using services
- identify the strengths and weaknesses of potentially interesting interaction devices against these tasks

The ultimate goal is to provide the engineers of the project with some directions concerning the design of the future RG user interfaces, and to point out the aspects for which more investigation is needed in the following steps of the project.

4.2. Method

We adopted an exploratory approach in which we created a simulated environment as close as possible to a residential environment and asked some subjects to interact with this environment by executing scenarios covering different HS.

First, we formulated some hypotheses concerning potentially interesting services, typical contexts of use, user tasks, and interaction styles and devices that best support these tasks. Our hypothesis were based on information collected from brainstorming sessions with representatives from following groups: usability and marketing specialists, sociologists, project engineers, and users, as well as external sources :

- Previous research work carried out in the early nineties around scheduling home devices. One realized by HCI Lab at University of Maryland [9] and one realized at INRIA [10].
- Studies about the integration of new devices into the house, for example in the context of the interactive TV and Web TV [11][12], and about Web Tablet [13].
- Sociological study [14], newsgroups, marketing reports.

These hypotheses oriented the elaboration of the experimental environment.

We selected some representative services: home security, remote video surveillance, home automation and control, remote maintenance of home equipment, web information assistant, entertainment, home assistant (agenda and message management, grocery list, etc.).

We supposed that no interaction device could appropriately support all user tasks and contexts of use, and that in consequence several devices would be necessary to constitute the UI to the RG. We choose these devices to cover different interaction styles and different complexity levels of interaction, and to be easily integrated in the home environment.

Among all possible user tasks, we identified the ones being common to all services: selecting and subscribing to a service, follow-up, cancel a service, payment, etc. We made the hypothesis that these tasks could be realized through a unique UI and we elaborated a “generic task” model to serve as the basis for the design of this UI (this model having to be validated by the experiment).

We then built an experimental platform as realistic as possible, which would serve to validate the previously enounced hypothesis and to collect new information through exploration of services with users. We proceeded according to the following steps :

- Write scenarios covering the use of the selected services in different contexts (inside the house and from outside through Internet or telephone).
- Select suitable interaction devices available on the market. The resulting set includes: wall mounted button keypads, a 10” touch screen (possibly wall mounted), a remote 5” touch pad, a smart card reader, a microphone and simulation of speech recognition, a telephone, a TV screen, loudspeakers. A standard “screen, mouse, keyboard” interface (simulating office context), and a personal telephone were used for distant interaction.
- Design different mockups supporting the anticipated user tasks and contexts of use through various devices. For example one was dedicated to subscription and payment of some services (remote video surveillance, web information and entertainment). One served for security and home assistance services, others for home automation and control (through touch screen and through remote control device). One supported home equipment programming; another one the distant use of home control service through the web, etc.
- Software, hardware, and home equipment (including lights, heating element, camera, coffee machine, TV, VCR, etc.) were used to simulate a home network (LAN) and the gateway itself. Power line and IR technologies were used for the LAN communication. Wizard of Oz technique served to simulate some unimplemented actions such as automatic motion detection, alarm notification, appointment reminder, or the execution of spoken commands.

Eighteen subjects, chosen to be representative of the future set of users, participated to the experiment: seven men and eleven women from 24 to 73 years old. Two subjects were graduate students, twelve subjects had a professional activity and four subjects were retired. None of the subjects was reluctant to new technologies, but some of them were more interested than others. Most of them already used Internet technology at different levels (occasionally or regularly). Three of them were in wheelchairs.

Sessions (about two hours each) took place in the experimental environment. After having presented the home service and the RG concepts, we ask each subject to execute scenarios covering two different services. During the session, an interviewer stayed with the subjects to observe them and encourage them to explore the use of the service outside the executed scenario and to express their impressions and suggestions.

When appropriate, subjects were encouraged to interact with different devices for executing the same task. For example they were invited to enter an identification code using a touch screen or a wall mounted keypad, or to control home equipment using the touch screen, the touch remote control, physical buttons or voice commands. At the end of the session, they were asked to tell what they liked or did not like in using each device.

After the session, they were asked to fill in a questionnaire about their interests, concerns and expectations concerning HS and RG.

5. Results

5.1. Specific aspects of the context of RG and HS

The first set of results concerns the identification of some aspects specific to the context of RG and HS, asking for corresponding UI design solutions.

Family use of services

One of them is the use of services on a familial base, which has some impacts on the service access and subscription process, the payment, or the service configuration. For example, some users expected to be able to restrict the access to some services for their children, some users required a user identification for each member of the family in order to protect each one own environment. Most users agreed that a user profile for each member of the family would be a useful feature, but only few of them feel at ease with the management process of these profiles.

House environment

The house environment itself presents some challenges for UI design: mobility of users, different vocation for each room, non-traditional physical positions (ex: walking, comfortably seated on a couch), multi-tasking activities (ex: watching TV, cooking). The location of the UI was particularly important. For example the users could use the touch screen, among other things, for activation and deactivation of security system, for equipment control and scheduling, and for home assistant service task (input of appointments, get messages, etc.). There was always a task for which the screen location was not appropriate. For instance if it was located in the kitchen to support the assistant service tasks, it was not useful for accessing the security functions just before leaving the house. The user preference for devices according to his physical position was also clear. For example, when they were seated on the couch watching TV, they preferred to use the remote device, especially to control equipment or for getting information such as home status. In many situations users expressed a need for several UI distributed in the house.

We observed similar distinction between user attitude toward home devices and computer than the ones reported in [3] concerning Interactive TV: in front of a computer, users generally try to learn the system's rules and to comply with environment standards. In house environment, users tend to consider interaction devices like being part of the home accessories and they expect the interaction to be close to real life activities. They also tend to be more sensitive to usability criteria.

Home Service concerns

The notion of HS raised some concerns from users about security, confidentiality, preservation of their private environment, or quality of service. For example, they required some control over access to house information from the outside when the service involves an external person, such as for remote maintenance of home equipment service, or remote video monitoring service. They were also reluctant to send their card number through the network.

Independence of services

In the context of our project, HS or packages of services are expected to come from different providers. For example, when a user subscribes to a service, the necessary applications and UI are downloaded on the RG from a distant server. As a consequence, each service comes with its own separate interface.

However, we observed some situations where users needed to combine functions from different services. For example, defining some "personal commands" such as "I am leaving" that they could launch from a single action, to put the energy management in absent mode, activate the security functions, the voice mail recording or call redirection to an appropriate number etc.

In other situation users need a rapid access to some service functions. For example, during the execution of the scenarios, users had to launch an emergency call, catch an alarm notification, consult messages when they come home, or acknowledge a system reminder concerning an event. In all these cases, they expected to be able to reach the function without having to select the service and navigate through the UI.

Distant use of services

Because the goal of a RG is to provide a communication bridge between the house and the outside world, the interaction from the outside is an important feature to consider.

The scenarios covered simulated situations such as communicating from work, from the car, etc. In practice users were in a separate room equipped with a computer and a telephone. They could interact through a "web style" computer UI representing the house or through a simple menu protocol with prerecorded messages for the telephone UI, in order to send commands and receive information. We were interested in finding the situations requiring distant communication and the preferred communication method. The more frequent situations cover:

- being notified of alarms or any unusual events and being able to get home and equipment status (is there someone at home? is everything OK?);
- send commands to equipment, for example cut gas or power, close window blinds, prepare home comeback (heating, lights, etc.), record TV or radio programs, start, stop and program white goods;
- manage agenda, get appointment notifications, take messages, check and get the grocery list (in order to be able to stop at the grocery while going back home from work for instance).

Concerning the devices, users tend to associate telephone to mobile context (in the car or other transport for ex.). Because of the limited interface they used it only for receiving short notifications and home status, not for complex interaction. Because of the voice communication capability, they used it for getting voice mails and send equipment voice commands.

The computer was associated to static context such as the office, secondary residence, hotel, etc. Because of the larger screen and the graphical UI, it was preferred for complex interaction, especially for communicating visual information such as detailed report about home status or managing agenda.

5.2. Generic tasks

The other main result of this study concerns the tasks involved in the use of HS. The first group described here covers the "generic tasks" identified through the hypothesis elaboration process. The experiment allowed us to validate the "generic task" model, leading to the high-level hierarchical model illustrated by Figure 1. More task analysis would be necessary to get a detailed model for some sub-tasks such as user identification, service payment, etc. However interesting information emerged from the exploration of these tasks with the users in the course of the scenario execution. This information will help the project engineers to orient the technical and design choices.

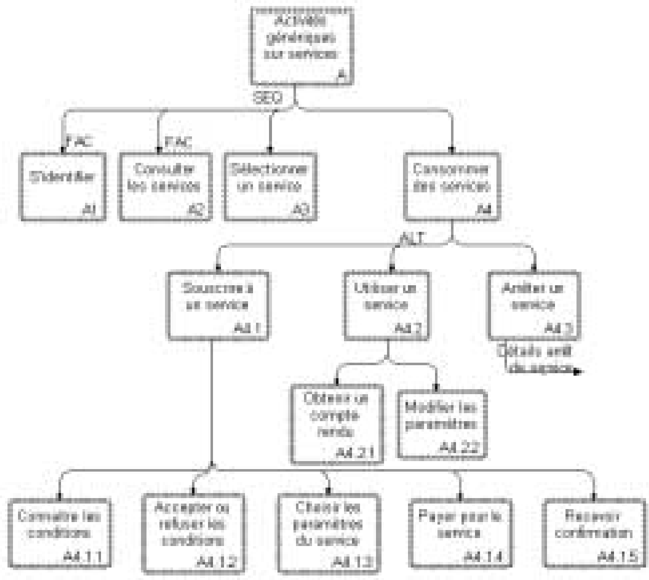

Fig 1: Schematic representation of the hierarchical task model for generic tasks

User identification. User identification for accessing or subscribing to a service can take place in different contexts, calling for different UI technical solutions. For example when users have to identify for security reasons (new subscription to a service, accessing a service from outside, etc.), they prefer methods in which they are confident, such as a personal code and a password. Users mentioned several limitations to the use of a smart card (easy to loose, need of a personal code anyway to be secure, etc.).

In situations where security does not matter, for example within a family context where each member has a free access to his own service, or in case of restricted children access to some information, users require simple and more straightforward methods, especially easy to use by children. They include personal logos or nicknames for free access, and fingerprint or voice recognition for protected access.

Service consultation and selection. The experiment helped us to better understand what information users need when they look for a service and on what criteria they select one. For example, all the users found useful that services to which they already subscribed were clearly identified among proposed services. Some of them also required to be able to identify new offered services, or more widely used (by other customers), as well as being able to search for a service given some keywords.

Service subscription. Information concerning the subscription procedure was also collected such as the key factors influencing user decision, the expected feedback, etc.. For example, some information such as the provider identification and eventually certification is essential for trusting the service. Knowing the price of the service is of course an important issue, but users also need to understand what are the factors influencing the price. One user suggested having a simulation tool to be able to change the parameters and see the according price vary dynamically. The exact terms of the contract, the possible subscription modes, and the renewal or canceling conditions are essential information for users before they subscribe to a service. As a subscription result, users expect to receive at least a summary of the chosen options, the detailed cost of the subscription, or eventually a written quotation in certain cases.

Service payment. Different payment methods were proposed, from classical methods such as check, automatic standing order, banking and credit card, to more innovative methods such as smart card (as a mean to transmit data to the provider or as an electronic money support), or virtual bank account (familial context). Preferred method depends on the context, the kind of service or subscription mode, and the price. For occasional subscriptions and expensive services, most users prefer classic methods, while they opt for automatic standing order in case of services functioning on a monthly-based subscription. In familial context, several users prefer electronic money (smart card or virtual account) because it is an appropriate method for making their children aware of their own service expenses.

5.3. Task categories involved in service use

A wide range of user tasks is involved in the use of HS. In order to select the right interface devices to support adequately these tasks, we have analyzed and classified these tasks on the basis of:

- the task complexity (type and number of actions);
- the nature and quantity of the information exchanged;
- the direction of the information (coming from, or going to the user).

We have then identified each device strength and weakness compared to these categories.

Direct control. This includes straightforward user actions (direct commands to equipment, or function calls), leading to an immediate action from the equipment or function. Some examples of these actions are: control of lights and window blinds, activate the function to listen to voice messages, launch a predefined function such as “Good night”. Because in these cases the interaction level is low, users prefer simple devices. Because the intended action is immediate, they tend to use the device the most “at hand” according to their position (the remote control, the button keypad, or voice control for commands to equipment in the same room). They use the touch screen mainly when visual feedback is needed (mainly for command applying to other rooms such as turning all lights off).

Command with a short dialog. This includes commands requiring a short dialog with the user before their execution. It could be that user has to choose between different options, has to modify some parameters on the fly, provide a confirmation, etc. For example, while launching the “I am leaving” command”, users had to set an option to redirect the phone calls (instead of leaving the default option which was to record the messages). In that case, the device location was important (here close to the door), but also the device ability to support the dialog, mainly providing appropriate feedback (for instance here the chosen option).

Postponed command. This includes commands executed after a given time period or at a given time of the day. For example to schedule the VCR for recording a given TV program users preferred the touch panel, mainly because they could “drag and drop” the TV program to the VCR image. However, to set the washing machine to be started at night, most users mentioned that they would prefer to program the execution directly on the washing machine. A touch panel (preferably located in the kitchen) would be used if they had to set several appliances at the same time.

Function and equipment programming. This includes programming and configuration of service functions and home equipment. It may consist in scheduling equipment, such as heating, based on time constraints or external events, or defining actions to execute on different equipment. For example, users were invited to define a macro command “Wake up” by defining actions on house devices such as window blind, radio, coffee machine, etc. at different times on weekday and weekend. Programming is not a task performed very often, but it generally takes time. For this reason, the position of the device, more than the location, is an important issue. Only the touch panel was proposed for this task, but we collected user comments concerning their experience with other devices to realize similar tasks (heating system programming for instance). Most of the reported problems concern time/day setting, poor feedback and lack of global view of resulting schedule. Most users appreciated the direct manipulation style and the visual feedback of the touch screen.

Notification to the user. This includes information communicated to the user spontaneously from an application service. For example: alarm conditions detected (equipment fault, water leek, intrusion, etc.), anomaly (unlocked door), appointments or things to do, important event, etc. The goal of the notification is to reach the user wherever he is at the right time and to ensure that he has been notified. In case of alarms for example, both visual and auditory signals, sent together, seem necessary to capture user attention. In case of less urgent situations such as reminder function, less intrusive methods are preferred (vocal messages or a blinker placed on the device, giving access to a vocal or written message on demand). When away from home, email and telephone are the preferred methods. For this task category mainly, the distributed aspect of the UI is important.

Information consultation. This includes all the tasks the users execute to get some information from a given service or function. For example, consulting home status report or cultural events schedule, getting new messages when coming home, monitoring a children room, etc. The nature of the information conditions the form under which it is presented (text, tables, graphics, images, video, sound, spoken message, etc.) and the output device (some being more adapted than others). For example users like the TV screen for video monitoring. Users also tend to replicate the use of familiar devices such as answering machine for getting voice mail, wall calendar for family time schedule, or agenda for personal appointments, etc.

Input of data. This includes the tasks that the users execute to provide data to a service. As for output, the nature of the data conditions the possible input format (voice, written text, numeric values, etc.) but the user behavior also plays an important role. They usually adopt the least effort strategy. For example, when invited to add an appointment to their agenda, most of them prefer recording a vocal message than using a touch pad with a virtual keyboard. Some specific devices such as camera, scanner, smart card, etc. may also be adopted. For example, a bar code reader would be used to add items to the grocery list.

Data manipulation and transactions. This includes all user interaction involving an elaborated dialog with the service, such as selecting CDs in a database and downloading them, transaction leading to a concert reservation, etc. These tasks generally include several of the previous categories (particularly commands, input and output of data). When involved in such dialogs, users are very sensitive to mechanisms, objects and metaphors familiar to their real environment. For example, they favored the direct manipulation of objects every time it was possible.

Communication. This includes all real time or recorded communication. Generally, users are very interested in using the RG as a communication tool between members of the family: for example leaving messages to each other (spoken or written messages, short videos) on the principle of the post-it, or communicate through intercom facility, etc. In that case users prefer devices distributed through the house and supporting “natural” communication (voice, handwriting, etc.), such as microphones, loudspeakers, camera or electronic notepad incorporated in home equipment.

6. Challenges and directions for UI design

At the light of the previous results we provide some recommendations and solutions in order to orient the design choices for the future RG interfaces.

6.1. RG and HS context

To address the familial use of services we suggest that user profiles could be defined and managed within the family context. Each user profile defines some general RG parameters such as access rights and user preferences, as well as service parameters. For example it serves to determine the preferred payment methods so that only applicable methods are proposed at the payment step (check or banking card options do not apply to children). Mechanisms to define and manage these profiles have to be easy to use for non-expert users.

6.2. Distributed UI

To address the house environment issues, we suggest that the RG interface be made up of several interaction devices distributed through the house, communicating together and with the RG central processor. This brings solution to user mobility in the home environment and contributes to support activities where they generally take place. For example, it would be useful to integrate a UI to each main home appliance (white goods, heating system, etc.) even if a "central UI" exists.

The UI design should also take into account user everyday references. For example in most families, the kitchen, and especially the fridge, is used to leave post-it, messages, grocery list, etc. This suggest that these locations are good candidates for a UI dedicated to "home assistance" and "family messaging" tasks.

A distributed UI, already "networked" in the house, also facilitates the integration of personal devices that the users are already familiar with (PDA, personal computers, personal phones, etc.) by allowing these devices to easily connect to the existing network.

Needs and preferences in terms of UI vary from one user to another, but may also evolve in time for a given user. It could be because he subscribes to new services, because his physical environment changes, because he wants new interaction capabilities, etc. To meet this demand, we suggested that the design of the RG support this possible evolution. For example, a RG "package" includes a basic core and optional UI elements that the user can progressively integrate as his needs evolve.

6.3. Service independence challenge

To meet the constraint of keeping each UI service independent while addressing the problems related to this constraint (see section 5), we suggest that a mechanism enables the user to define and configure some "personal commands" ("Good night", "I am leaving", etc.), independent from any service. A similar mechanism also enables the user to define shortcuts to some service functions ("Emergency call" function). The user can decide how the command is launched (automatically according to time constraints or external event, or on a given user action such as voice command, push button, etc.). We suggest that for all devices, a dedicated zone independent from any service serves for accessing these "personal commands" and shortcuts. Figure 2 illustrates one solution proposed for a 10" touch panel.

Example of design solution for a touch panel.

In this example, services are accessible from the buttons on the left. The center of the screen is dedicated to the specific UI of each service, but also to personal commands defined by the user when the "Home" screen is selected (like illustrated). The bottom zone is dedicated to the shortcuts for frequently accessed functions. The red points on the "Messages" and "Mémo" buttons blink when a new message is available or when the user is reminded of some event

6.4. Consistency challenge

This constraint of having independent services, in addition to a large variety of interaction devices, brings another challenge in the HS context: maintain UI consistency.

As a first step towards this goal, we identify the most important UI elements for which a coherent aspect and behavior is necessary:

- Terminology used (function names, terms to designate objects, instructions, etc.)
- Graphical elements and illustrations, especially those representing home environment
- General procedures (and corresponding objects) such as selection, confirmation, cancellation, navigation, saving, scrolling, etc.
- Virtual objects and metaphors, especially objects for data input such as keyboard, keypad, calculator, voice recorder, etc.
- Control elements such as time and date setting, intensity level setting, ON/OFF Start/Stop setting, etc.
- Coding elements such as of color coding, blinking, sound, etc.
- Prompting, feedback, notification procedures
- Function activation or deactivation procedures

A further step toward this direction would be to write a style guide defining the design principles for the UI of all services provided in the SIRLAN environment.

6.5. Choice of UI according to supported tasks

In order to orient the choice of interaction devices constituting the UI, we analyzed each device or interaction style in term of strengths and weaknesses against user tasks and contexts of use. The analysis covers the following devices: 10” touch panel, small touch panel (about 5”), remote touch control, electronic notepad, TV screen, telephone, voice (I/O), button keypad and other physical controls (buttons, sliders, dimmers, etc.).

No device was identified as satisfying to all tasks and situations, but we showed how interface weakness may be compensated by combining it with others or by adding some external functionality. For example, one major drawback of a wall mounted touch panel is its fixed position so that it may not be within reach when necessary. A remote touch control (for direct control) or an electronic notepad (for communication) compensates for this drawback. Accessories such as smart card reader, code bar reader, scanner, finger print reader, or camera were for example suggested to extend data input capabilities.

7. Conclusion and future work

One of the major advantages of having a usability laboratory as MultiCom, is that the incremental hurdle for user testing of a new product becomes fairly small since all the equipment is already in place in a dedicated room that is available for testing. This effect is important because of the compressed development schedules that often leave little time for delay. Thus, if usability testing can be done now and with minimal overhead, it will get done. Similarly, usability may get left out of a project if there is too much delay or effort involved before results become available. Because of this phenomenon, the support staff form a very important part of a usability laboratory in terms of keeping it up and running, stocked with supplies, and taking care of the practical details of recruiting and scheduling test users.

To summarize, MultiCom is a consulting and research platform specialised in human factors, usability and safety in product and system design. The following is a listing of service areas provided :

User Research : User research is conducted to support system design specifications to assure optimal interaction between user and system. User research includes user surveys, job and task analyses, human factors profiling of user populations, function allocation and other analyses.

User Interface Design : User interface design includes the design of input devices as well the design of screen layout and control elements. Design services include the functional specification of the user interface as well as control and screen layouts.

Usability Inspections : Usability inspections are conducted on a user interface to assure compliance of the interface with existing design guidelines, standards and practices. Inspections can be conducted throughout the development process from initial specification to working prototype.

Usability Testing : Usability testing is conducted on the product or system with representative end-users engaged in representative tasks. Testing is conducted in the laboratory or the work setting of the end-user.

Safety Reviews and Inspections : Safety reviews and inspections of products and systems are conducted by certified human factors and ergonomics professionals in accordance with national and international standards and practices.

Seminars in User-Centred Design and Evaluation : Seminars in the user-centred design process and evaluation methods as well fundamentals of human factors in product design are provided to assist clients in improving product usability and safety.

Human Factors Research : Ongoing human factors research is conducted to determine the nature and extent of the interactive effects of interface design, user, and task characteristics on overall system performance. The research is both externally and internally funded.

As application of MultiCom concept, we have reported the results of a study realized at a very early stage of a project. This includes the specific aspects of the RG and HS context, the main user tasks involved and some recommendations for the UI design of the future RG.

The study on home domain also pointed some challenges to address in order to meet user needs for the introduction of RG in the house. Beside next steps in the project which include the validation of the proposed UI solutions, further work includes:

- Defining new standards for HS in order to address the problem of UI consistency between services.
- Go further into usability testing of new interaction styles and devices in order to validate the solutions addressing the features of the house environment: mobility, various physical positions, and multi-tasking activities, while integrating as far as possible the interaction devices in the house environment.
- Explore technical solutions to address the challenges presented by the communication and synchronization between all UI devices of the RG, as well as the connection with external personal devices.

The existence of multiple devices brings some challenge for the service designer because the UI for a service must adapt to different devices. For example, information will be presented differently on a TV screen, a wall mounted touch panel, or a PDA. This problem calls for solutions such as automatic adaptation techniques that would enable the service content (mainly information presented to the user) to adapt to the various devices. Some research work carried on in the IIHM group of CLIPS laboratory on "Plasticity of User Interfaces" goes in this direction[15].

8. References

1 N.O. Bernsen, H. Dybkjær. and L. Dybkjær, Designing Interactive Speech Systems. From First Ideas to User Testing. Springer Verlag, 1997.
2 R.G. Bias. and D.J. Mayhew (Eds.), Cost-Justifying Usability, Academic Press, Boston, MA, 1994.
3 D. Browne, STUDIO Structured User-Interface Design for Interaction Optimisation, Prentice Hall, 1994.
4 B. Catterall, Three approaches to the input of human factors in IT systems design: DIADEM, The HUFIT Toolset and the MOD/DTI Human Factors Guidelines, Behaviour & Information Technology, 10(5):359-371, 1991.
5 B. Curtis and B. Hefle, A WIMP No More - The Maturing of User Interface Engineering, ACM Interactions, pp.22-34, January 1994.
6 D. Hix and H. R. Hartson, Developing User Interfaces: Ensuring Usability Through Product and Process, Wiley, New York, 1993.
7 L. Macaulay, C. Fowler, M. Kirby and A. Hutt, USTM: A New Approach to Requirements Specification, Interacting with Computers, (2)1:92-118, 1990.
8 J. Nielsen, Heuristic evaluation, in Nielsen, J., and Mack, R. L. (Eds.), Usability Inspection Methods (John Wiley & Sons, New York, NY), 25-6.C., 1994.
9 B. Plaisant, J. Shneiderman, J. Battaglia, Scheduling home-control devices: a case study of the transition from the research project to a product, Human Factors in Practice, Computer Systems Technical Group, Human Factors Society, Santa Monica, CA, 7-13, December 1990.
10 S. Sebillotte. Les actions et les concepts généraux d'activités dans l'utilisation d'appareils domestiques. Rapport de recherche no 1181, Programme 8, Communication Homme-Machine, Mars 1990.
11 S. Turcotte, S. Tellier. Rapport de veille stratégique: La Télévision Interactive et la Convergence Télévision-Internet, Technologies, expérimentations, facteurs de succès et milieu. Centre de Recherche Informatique de Montréal, 1999.
12 J. Nielsen. WebTV Usability Review. Alertbox, February 97 http://www.useit.com/alertbox/
13 McClard, P. Somers, Unleashed: Web Tablet Integration into the Home, in CHI'2000 1-6, April 2000
14 Dard, C. Laumonier, P. Mallein et Y. Toussaint. Réseaux de communication et services résidentiels, Cahiers du CSTB, cahier 2869, Mars 1996.
15 G. Calvary, J. Coutaz, D. Thevenin, A Unifying Reference Framework for the Development of Plastic User Interfaces. Engineering Human Computer Interaction, EHCI2001, 2001.