DisQo : A user needs analysis method for smart home

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ABSTRACT
How can people identify the services that they might expect from their smart home when they have little to no knowledge about novel technologies? This paper reports on a user needs analysis method designed to answer this question: DisQo. We have recruited 17 families and used a combination of interviews and playful cultural probes. Results show that families are willing to couple smart objects to improve their lives.

KEYWORDS
End-User composition, smart artifacts coupling, smart home, ubiquitous computing, service-oriented computing.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Ubiquitous computing promises unprecedented empowerment from the flexible and robust combination of software services with the physical world. Software researchers assimilate this promise as system autonomy where users are "conveniently" kept out of the loop. Their hypothesis is that services, such as music playback and calendars, are developed by service providers and pre-assembled by software designers to form new service frontends. Their scientific challenge is then to develop secure, multi-scale, multi-layered, virtualized infrastructures that guarantee service frontend continuity. Although service continuity is desirable in many circumstances, end users, with this interpretation of ubiquitous computing, are doomed to behave as mere consumers, just like with conventional desktop computing.

Our hypothesis is that end users are willing to shape their own interactive spaces by coupling smart artifacts, building imaginative new functionalities that were not anticipated by system designers. A number of tools and techniques have been developed to support this view including the Jigsaw editor [6], CAMP [12], iCAP [3], or Newman's work on end user composition with OSCAR [8]. The major focus of this prior work is on exploring novel interaction techniques and on technical frameworks. In this paper, we are concerned with the fundamental meaning (and human needs) of building confederation of interoperating smart artifacts.

In ubiquitous computing, we are unable to predict which artifacts of everyday life end users would be willing to couple (and decouple) to obtain new services. In addition, would such coupling be commutative, associative, distributive over some other operation? In other words, is it possible to define an algebra over smart artifacts so that we can generalize the problem and reason at a high level of abstraction in a rigorous manner?

Human sciences offer tools and methods for exploring human needs and behavior. However, the novelty of our problem requires to solicit participants imagination while at the same time controlling the experimentation and respecting the privacy of their intimate home. In this paper, we analyze representative methods that have been developed for analyzing domestic activities. Based on these previous experiences, we propose our own improvement followed by the detailed presentation of the experimental material. Our findings are discussed in the last section.

EXISTING NEEDS ANALYSIS METHOD FOR HOME
Analyzing domestic needs requires to respect people privacy and to avoid overloading inhabitants with temporal and cognitive constraints, all of this within the context of an uncontrolled field study. Interviews [3, 4], journal studies [10] and playful cultural probes [1] are unable, used in isolation, to respond to all of these requirements. In addition, they do not trigger subjects' imagination, and they are prone to observers' bias and to social conformity. To avoid these limitations, multiple techniques must be combined in a complementary way.

Rode et al [9] use a three-step method. The first step consists of dining with the inhabitants. The goal is to turn the observers into guests in order to promote convivial mood and free talk. The second step consists of visiting the home with the inhabitants. The observers ask inhabitants

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about their use of the technological equipments and electrical appliances. Last, inhabitants are invited to place pieces (representing rooms, peoples, artifacts and activities) on a board. This method satisfies all our requirements but privacy: observers somehow impose themselves to the inhabitants' intimacy.

Similarly, Davidoff et al. [2] propose that observers visit the appliances of the home with the inhabitants. However, observers have to focus their questions on the key moments of the day such as "morning" and "come back home" times. At the end of the visit, a cultural probe [5] is left to the family for collecting complementary data. Privacy is respected, but the temporal constraint imposed to the family spans from one to two weeks.

THE STUDY

Our method, DisQo, includes a pre-study of industrial solutions proposed on the market in relation to technology acceptability. In short, this study has permitted to measure the gap between the industrial point of view and that of users, and has helped us to identify the "right" questions for the interview phase of DisQo.

Participants

Drawing on Davidoff's et al. method and conclusions (i.e. "families want more control of their lives" [3]), we focused on "busy" families. The participants have been solicited through bulletin board advertisements, email, as well as from personal relationships.

We have recruited 17 families representing a total of 40 persons (35 adults and 5 children), all living in the area of Grenoble (France). Of the 17 families, 12 were dual income families, 1 was single parent, 2 were house mates, and 2 were retired couples. All families were well educated with medium to high standard of living.

Method

DisQo was designed to reconcile the following requirements: to collect meaningful data in a minimum of time while respecting privacy. As presented above, we are interested in determining how far people are ready to envision the interconnection of everyday devices to improve their lives, and to which extent coupling objects is commutative, associative and distributive. For so doing, we have used a combination of interview [11] (good for clarification), playful cultural probe (appropriate for respecting privacy and for improving subjects involvement [1]). The presence of the experimental team (ourselves, from 1 to 3 persons) was limited to 1h30 per family home. Fieldwork was structured as a four-step process: photographing, interview, game, and debriefing.

Step 1: Photographing. Using digital cameras provided by the experimental team, two volunteer family members were asked to take pictures of 10 objects at the rate of 2 objects per room. For each of the 5 rooms of their choice, they were asked to take a picture of one object that they considered to be necessary in their everyday life or that would help them in organizing their lives, as well as a picture of one object that they considered to be superfluous but valuable (typically, a painting). The volunteers (in general, the parents) were not supposed to be in the same room at the same time so that they would not know which pictures the other member had taken. Meanwhile, the experimental team would wait sitting at a place indicated by the parents (typically, the living room where they usually meet with friends and visitors).

Step 2: Interview. We then conducted an interview with all the family members, using the pictures as input material. (Pictures have been quickly transferred from the cameras to a tablet PC by one of the observers.) Questions were directed at understanding the reasons for their choices, the value attached to the objects or the services provided in daily use. Special attention was given to the (many) remote controller(s) typically found in the household environment. We progressively oriented our questions towards novel uses of smart artifacts. In particular, we asked which objects of the house (including those on the pictures) they would qualify as "programmable" (e.g., TV's, washing machines, alarm clocks), "communicating" (e.g., computers, mobile phones), or emotional (i.e. carrying intimate value). This was used as a means to elicit routines and exceptional needs as well as to prepare the game developed in Step 3.

Figure 1: An example of 2 play cards association presenedtd on the tablet PC and its related question: "What services, whether it be useful or not, could result from a communication/cooperation between your washing machine and your TV ?"

Step 3: Association game. The association game drew on people creativity using the pictures as play cards. Pictures were sorted randomly and presented two at a time (then, three at a time) on the tablet PC. Family members were asked to imagine which service(s) and value(s) these two (or three) objects coupled together would provide them with (*figure 1*). Random coupling was designed to solicit imagination in unexpected ways as solutions creativity grows with the semantic distance between elements [7]. Another reason for this random coupling is to get hints about the existence of a "natural" algebra over smart artifacts.

Step 4. Debriefing and informal discussion. The last stage was dedicated to debriefing, including opened friendly discussions.

Overall, we have collected comments and objective data for 349 couplings for a total duration of 25 hours of our presence in the 17 family homes.

Data Analysis

Interviews and debriefings helped us to identify recurring facts between home families such as key moments during weekdays for which families would expect support from a smart home, or attitudes with regard to "programming the home". Data from the association game as well as from the interviews were used to find answers to our theoretical questions. More specifically, we classified the objects that have been photographed into four categories: objects that have been denoted as "programmable" by the subjects, objects that have been declared as "communicating", objects that support both capabilities, and objects that have none of these two properties. Using the Chi-square test, we have been able to find strong significance between the abilities of the subjects to envision (or not) services depending on the capabilities of the assembled objects. In particular, the communication capability allows people to more easily imagine new services from the assembled object.

FINDINGS

Our study has led to three types of results: recurring facts across families, early answers to our theoretical questions, as well as insights about our method.

Recurring Facts

We found a number of facts that are quite consistent with the results reported in prior literature:

1. "Wake-up" time, "on-the-way-to-home" and "arriving-home" times are key moments to people. To save time and improve efficiency, activities are organized into well-polished procedures. As a result, exceptions to these routine tasks are sources of stress. Support for avoiding or for solving exceptions is one class of services expected from a smart home. This includes the management of possessions (laundry to be launched because of a business trip planned in a couple of days, food on the point to be missing, medicine close to expiration date), decision-making (what to buy, what to wear today), reminders (doctor appointment), security (door properly locked), resources consumption and resource sharing among family members (typically, hot water and bathroom occupation in the morning), etc.

2. With regard to programming, attitudes range from "I do not want to be assisted" to "It will work 99% of the time, but it will be hell for the other 1%". Motivation for programming is systematically grounded on a clear straight forward observable benefit. Next section presents results obtained about the coupling of everyday life objects. We believe that these results are original with respect to prior literature.

About Coupling

Our data from the association game shows two important results: (1) Family members are prone to envision new services when coupling involves one "communicating" object, or one "programmable" object, at least. (2) The "communicating" capability has more impact than "programmability" on the capacity of family members to imagine new services. However, 78 of the 349 couplings resulted in service finding although none of the objects were programmable or communicating. For example, the couple "bed-shower", whose objects had not been classified as programmable nor communicating, suggested that "getting up from the bed in the morning would turn the shower on in order to provide water at the right temperature when coming back from the toilet". This means that there is a large body of potentiality for novel services based on mundane everyday objects.

The services suggested by our family members fall into four categories. We illustrate them with the most typical examples drawn from our fieldwork.

Service substitution. People have observed that, for the same (sport) events, commentaries on radio broadcasts are richer than those provided by TV. As a result, they would like to replace the TV sound service with that of the radio to improve the overall quality of the informational experience. Another example is user interface substitution: some people are quite skilled at setting up alarms on their mobile phone, but they do not know how to do this for their physical home alarm clock. As a consequence, they would find it quite convenient to replace the user interface of their alarm clock with that of their phone thanks to a convenient opportunistic coupling of the phone with the alarm clock.

Service improvement. Some household appliances such as washing machines and storage areas, do not provide any convenient way to control and monitor their current internal state. Appliances than are not sufficiently equipped could be improved by coupling them with additional input and output facilities such as those of the TV set.

Service chaining. Service chaining is intended to improve comfort, wellbeing as well as resources for the routine, but hectic, activities. For example, "picking up the towel after the shower would trigger the coffee machine so that coffee would be ready just in time, at the right temperature, along with the radio turned on in the kitchen broadcasting the news using the appropriate sound level".

Service "starter". We have observed that some appliances serve as triggers for services that are expected to be pre-composed to support routine activities. The towel and the bed mentioned above, play this role, implicitly. Not surprisingly, people also want to have an explicit and reliable control over the home (cf. the worry that 1% of the time, the house would turn into hell). Some people came up

with the "*morning starter push button*" conveniently located close to the bed that would gently "wake up" the house when pushed.

We found some results about algebra's properties of couplings. The need for chains of services underpins some form of *associativity*. For example, one family qualified the "towel-coffee machine" coupling as a "morning package". During the discussion, our family members thought of adding the "morning starter push button" to get a controllable chain.

Coupling for service improvement entails some form of *distributivity*. Typically, the TV has often been mentioned as a way to observe and control the state of a number of appliances such as the washing machine or the oven.

Commutativity between two coupled artifacts has generally been satisfied with notable exceptions when there is a causality relationship between the artifacts.

About the Method

The "Snapshots taking" of our fieldwork has multiple advantages: (1) It serves as an ice breaking between the family members and the experimental team; (2) Family members "reveal their house" naturally while we, the experimenters, do not intrude their private spots. (3) Family members get truly involved (and intrigued by what will come next). (4) As opposed to playful probing proposed by R. Bernhaupt [1], our game uses images of intimate objects, not that of generic entities. This increases the interest and imagination of the participants while improving the meaningfulness of the data collected. In future work we will explore the benefits of providing them with a journal for a duration of two weeks in order to test whether their creativity can be increased after the interview [4].

CONCLUSION

We have presented DisQo, a method for investigating the fundamental meaning of building confederation of interoperating artifacts for future smart homes. DisQo combines several techniques to reach a satisfying balance between experimental control, privacy issues, and ecological validity. The key element of the method is for observers to be able to "visit" people homes through the pictures of intimate objects taken by the participants themselves and to use these pictures as playful cultural probes to envision future use.

DisQo has provided us with preliminary answers to our problem of finding an algebra for coupled artifacts. Although additional investigations are necessary, early results from our fieldwork support our hypothesis.

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