Fridge fridge on the wall: what can I cook for us all?: an HMI study for an intelligent fridge

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Manuela Bucci
Senior Designer of Centrocittà,
via Valtellina 10
20127 Milano, Italy
+39 328.4792487
manu.bucci@gmail.com

Caterina Calefato
University of Turin Department of Computer Science Corso Svizzera 185, 10149, Torino, Italy
+39 0522 52 2663
calefato@ di.unito.it

Sergio Colombetti
University of Modena e Reggio Emilia, HMI Group DISMI, Via Amendola 2,42100, Reggio Emilia Italy
+39 0522 52 2663
sergio.colombetti @unimore.it

Roberto Montanari
Università degli Studi di Modena e Reggio Emilia, HMI Group DISMI, Via Amendola 2,42100 Reggio Emilia Italy
+39 0522 52 2663
roberto.montanari @unimore.it

Monica Milani
Indesit Company Spa Innovation & Digital Design Via L. Corsi,55 60044 Fabriano (AN) Italy
+39 0732 668290
monica.milani@indesit.com

ABSTRACT
New technologies have changed our life, making everyday tasks easier and faster. This new style of living requires a new kind of distribution of cognitive processes, resources and information. Trends in appliance design propose more sophisticated control and networking capabilities. Current white goods may be equipped with complex softwares and GUIs, that may be inputted, by mobile phones. The ZmartFRI project aims at developing a seamless technology with an interactive fridge surface, assuring simplicity and intuitiveness of interaction. The fridge surface equipped with a display and an effective GUI provides more than additional memory device supporting human activities and providing opportunities to reorganize what is known. Thanks to a coupled display system between the fridge and the user mobile device, the fridge is able to alert products expiration date, to suggest recipes, to fill in and send by sms or email the shopping list, to send and post messages for the house residents.

Categories and Subject Descriptors
H.4.3 [**Information Systems Applications**]: Communications Applications – *bulletin boards.*

H 5.2 [**Information Interfaces And Presentation**]: User Interfaces – *Graphical user interfaces (GUI), Interaction styles, Prototyping, Screen design, User-centered design*

J.7 [**Computer applications**]: Computers in Other Systems – *command and control, consumer products*

General Terms
Your general terms must be any of the following 16 designated terms: Algorithms, Management, Measurement, Documentation, Performance, Design, Economics, Reliability, Experimentation, Security, Human Factors, Standardization, Languages, Theory, Legal Aspects, Verification.

Keywords
Coupled Display, Ethnographic Analysis, Household Appliance, Human Machine Interface, Intelligent Fridge, Mobile Phone Nomadic Device, Participatory Design, Ubiquitous Computing,

1. INTRODUCTION
Increasingly people work and live on the move. At the same time, companies are producing various portable and embedded information devices, such as personal digital assistants (PDAs), cellular telephones, pagers and active badges [1] which support this mobile lifestyle, especially as work becomes more intensely information-based. In fact, new technologies have changed our life: they improve our life, making everyday tasks easier and faster; providing enjoyment, playfulness, fun and aesthetics. This new style of living and working requires a new kind of distribution of cognitive processes, resources and information.

The wide availability of digital information and services associated to physical objects reinforces the need for a strong link between the digital and physical spheres, in order to allow users to access useful information anywhere and anytime. On the other hand, the rapid growth of enabling technologies offers concrete opportunities to design on-the-move, fluid interactions with computing devices. In fact, nomadic devices are commonly equipped not only with networking technologies at present, but their processor speeds and storage and display capabilities are rapidly growing, too.

Bridge technologies between the physical and digital worlds (such as wireless sensors, microcontrollers, RFID tags and two-dimensional barcodes) are currently available, as well as standards for the representation and communication of structured data (the most notable example is XML) [2]. Designers should assure that people can interact with computing devices in a fluent and natural way, barely being aware of the underlying technology, even if they are accessing interactive displays that very often are widespread in everyday environments, including our kitchen or any household appliance.

Trends in appliance design are towards more sophisticated control and networking capabilities concerning new innovative domestic technology [3]. Current white goods may be equipped with a quite complex software and graphical user interface (GUI), that may be inputted, for example, by mobile phones, allowing the user at creating, modifying or extending the household appliance scope and use.

The idea of inputting and interacting with our kitchen households by any personal nomadic device, leaving a public message on an available display surface, i.e. as the fridge surface, will create an interactive ecosystem supported by the coupling of multiple display. In this way home appliance that were in the past considered plain and utilitarian, become entertainment devices or, as in the case of ZmartFRI, become a family information hub. The house inhabitants may send and receive messages and information from the fridge, that play the role of family totem.

In the ZmartFRI (Zigbee sMART FRIdge) project, we aimed at developing a technology that could realize a vision of computation everywhere, where computer technology seamlessly integrates into everyday life, supporting users in their daily tasks. In this way, a common fridge becomes augmented as soft media, therefore it becomes able to enter into dynamic digital relationships with users and with each other, generating novel settings of communication, performance and ownership.

In facts, homes are living spaces that centralize many different activities: housework, entertainment, professional work, information, communication, learning and shopping. The integration of all these activities with the living space model is fundamental to understand how an household appliance as the fridge could become an information hub. The ZmartFRI is designed to play the role of information hub connected to any personal device, making of the fridge the home intersection point of sociology and technology.

Usually fridges aren't of much interest because they are not quite intelligent. In this paper we want to show how it is possible to extend the fridge intelligence, allowing it at becoming a family totem, the preferred place where posting and sending electronic notes [4]. A fridge interactive surfaces offers great potential for social interaction and provides natural ways to directly manipulate virtual objects as electronic post-it, creating a multiple display ecosystems with a combination of small displays belonging to personal mobile devices (i.e. smart phones and mobile phones) coupled with a quite wide public display such as the fridge electronic surface.

The ZmartFRI visual interface lets people maintain existing habits and the desirable characteristics of paper or printed messaging, but also provide easy access to the advantages of the electronic medium. The design of such an interface is part of a longer term research effort to investigate with ethnographic methods applications and interaction techniques about every day home-life and users needs and desires.

Section 2 explains what are the aspects that build in the concept of Intelligent Fridge, starting from some literature considerations and proceeding with the findings of the ethnographic analysis and of the participatory design session. Section 3 shows the ZmartFRI project, its main architecture and its user visual interface. Section 4 reports conclusions and future works.

2. THE 5 W'S OF THE INTELLIGENT FRIDGE

The literature defines the intelligent fridge as follows:

«An "intelligent fridge" could inform its owner when an RFID (Radio Frequency Identification) tagged carton or milk is close to empty or the retailer thereby requesting replenishment» [5]

«The intelligent refrigerator is a relatively new concept. It has the ability to order grocery items that are out of stock or low automatically using RFID technology» [6]. And: «The intelligent fridge that is communicating to the consumer in the supermarket which food is needed to cook a certain dish» [6].

In other words, the intelligent fridge should be able to sense the context and to communicate the user context variations (i.e. approaching expiring dates or close empty cartons) or context implications (i.e. a good recipe to use a product close to expire). Besides these functions, we implemented in ZmartFRI also the ability to automatically fill in a grocery shopping list, that may be communicated to the user via sms or email when s/he is shopping. Moreover it improves its traditional function of showcase for anyone's message with magnets or post-it by sending and posting messages electronically and visualising them on its own display.

In this way context is not only position and identity. The concept of context also incorporates knowledge about time, people's interactions and habits, as well as many other pieces of information often available in our environment. The context is minimally well defined by the "five W's": Who, What, Where, When and Why.

Whereas the connection between computational devices and the physical world is not new, these simple location-aware applications as ZmartFRI are perhaps the first demonstration of linking implicit human activity with computational services that serve to augment general human activity [7]. Context-aware systems and ubiquitous computing promise more than just infrastructure, suggesting indeed new paradigms of interaction inspired by widespread access to information and computational capabilities.

To attain this aim, the driving design principles for our intelligent fridge were the simplicity of the application and intuitiveness of the interaction. To assure an effective and user friendly interaction among a plethora of purpose-specific information functions, interaction design should make it possible that people can discover, and remember, how to use such appliances without any instruction or explanation, as they did with paper messages, photographs, postcards, shopping lists, in order to leave messages to each other, or reminders for themselves.

In fact, resources and information have three interesting features [8], to be taken into account designing smart or proactive appliances:

1. They are distributed across the members of a social group (i.e message or reminders);
2. They may involve coordination between internal and external material or environmental structure (i.e. the shopping list);
3. They may be distributed through time in such a way that the products of earlier events can transform the nature of later events (i.e. products approaching expiry date may became ingredients for cooking a certain dish).

In this way the fridge surface equipped with a display and an effective GUI provides more than additional memory device and affordance to support human activities. It also provides opportunities to reorganize what is known using a different set of internal and external processes [8]. Users are expected to benefit from a continuous access to the information and from the

possibility to be informed and/or warned everywhere (i.e. at work or at the supermarket).

ZmartFRI is able at receiving and sending messages to house inhabitants. In order to develop an interaction concept effectively supporting people's needs, we followed three main scenarios, derived from the ethnographic analysis:

- Cooking assistant suggesting useful receipts (see Figure 2)
- Shopping assistant suggesting (and sending) the grocery/shopping list (see Figure 3)
- Family totem receiving and sending messages from an to family members (see Figure 4 e 5)

2.1 The ethnographic analysis

The real expectations and needs of people concerning intelligent home devices are multifaceted and should be carefully researched. To understand in details which functions the user may desire about an intelligent fridge, field methods have been conducted to gather typical users' ideas, expectations, and concerns. The specific goals of this investigation were [6]:

- Define a targeted set of users
- Define features desirable to a user
- Determine the ordering processes surrounding an intelligent fridge
- Determine potential negative issues surrounding the product
- Determine if there is a market for this product

In order to achieve our objectives we set up a short ethnographic research, involving 8 users, which had been requested to fill in a questionnaire about the way they i) leave messages to others residents, ii) check products expiry date, ii) compile the shopping list. We observed the way they write and hang messages up the fridge surface, documenting it with pictures (see Figure 1).

What come out was that a mere surface become an intelligent infrastructure, able to monitor, look and act assuring an appropriate smart home experience, without any high technology.

Figure 1 A and B Some picture of intelligent infrastructure based on fridge surface set up by an end-user.

The findings of the ethnographic study allowed us at designing ZmartFRI for specific needs, but starting from a particular point of view: home is already smart, smart not in terms of technology, but in terms of how people conduct their lives at home. This consideration is also present in human factors literature [10], confirming the approach to augment and support these existing practices, learning from the ways in which people already menage their activities, choosing the most proper device.

We are, of course, not the first to focus on surfaces in the home nor on the potential of digitally augmenting them [10][11], but we paid attention on the implications of human machine interface in a multiple coupled displays eco-system. In fact surfaces are places in which digital capabilities may appear, but they are also part of an ecology within a household, where the placement of information acts as memory aids. The fridge provides a surface which is "public". The physical form of fridges and the way in which we use it are embedded into a home social organisation. Surfaces on fridges become intelligent surfaces not in what they do, but in the ways they are used.

What makes homes intelligent is how surfaces are used to display material in particular ways. The ZmartFRI aim is to improve what people usually do with particular surfaces, using "low tech" and non-computational artefacts (i.e. paper notes and calendars) [10]. In fact, as our study showed, a note placed on the refrigerator door has implications for who will see it and how it will be used. Further, people make particular decisions about where best to leave a note for someone else. Thus, they are "pushed" to people's attention, confirming that the pervasive computing paradigm has a "technology push" vision and primarily deals with basic next generation computing technologies, differently from emails, sms or phone calls, that are often "pull" rather than "push" methods of communication.

Starting from these considerations we sketched two of the three scenarios presented in the previous paragraph. The use cases we followed took into consideration specific user profiles: young house inhabitants confident with technology or people who usually follow new technology trends and are skilled in using advanced personal devices.

Particularly, the scenarios depicted in Figure and Figure are expression of the "A3 paradigm" which states that information will be available Anytime, Anywhere, and with Any-device [9].

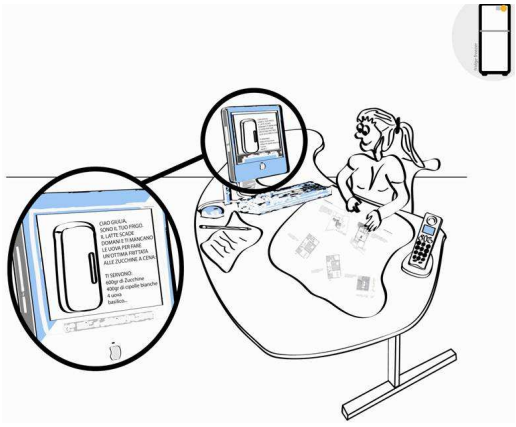

Figure 2 In this scenario the user receives a mail message on her laptop from her fridge, that is suggesting that the milk expiring date is tomorrow and that to cook an omelette for the dinner, eggs are missing.

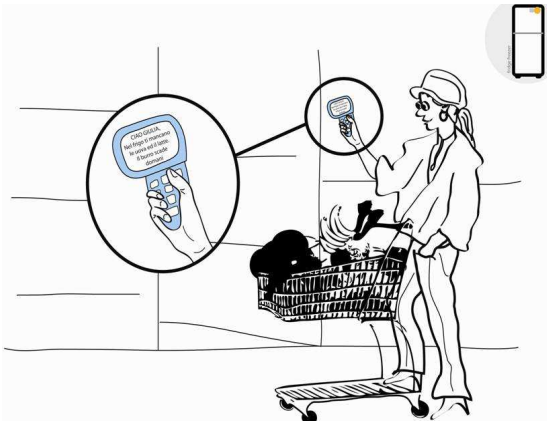

Figure 3 In this scenario the user is at the supermarket but she forgot the shopping list. She requested a real-time updated list to her fridge and received it by an sms on her mobile.

2.2 The participatory design

In order to design a user-friendly and effective HMI (Human Machine Interface) we set up a participatory design session, with a facilitator, four experts (an ergonomist, a designer, an engineering developer, an user-experience designer) and four target users. The design session took place during evening, at 7 o'clock pm. After the presentation of the meeting aims, a dinner was offered in order to promote the socialization among participants and to create a relaxed and familiar atmosphere. The design session ended at about 11 o'clock pm.

The most important features for an intelligent fridge that come out thanks the facilitator interventions, the participants' open discussion and the hand-made draft of the outcoming ideas were:

1. expiration date alert
2. ability to print the grocery list and sent it by sms or email
3. make remote questions about an item through a touch screen display
4. Write, send and post messages for the house residents (i.e. "I'm coming, put the pasta on")

The design session was really crucial in defining ZmartFRI concept in order to offer a new way to inform house residents about someone's whereabouts or needs.

3. THE ZmartFRI architecture

The ZmartFRI has a RFID antenna and a reader inside to read the goods stored in it. Each product has got a smart label attached to it. The overall architecture works in the following way:

- The fridge communicates via zigbee with the router server of the home
- The house resident register themselves and the fridge to an on-line messaging service
- Anyone can send a message to the on-line service that post it to the home server which sent it to the fridge, in order to be displayed on the TFT display.

The TFT display features are:

- Size 4.7 inch
- Resolution 480(RGB) x 272
- Interface RGB 24 bits
- Color Depth 16.7M
- Measures (W x H x D) (mm) 114.3x72.5x5.0

3.1 The innovative HMI

Thanks to the interaction between the display of a personal device and the fridge display, several actions are possible: i) checking the goods in the fridge, ii) creating a shopping list, iii) sending to a personal device the shopping list if requested iv) being guided on how to prepare a recipe, v) writing and delivering messages, vi) creating, rearranging and deleting notes, vii) mailing a note to one of the family members whose portrait is decorated with a cover icon (see Figure 4 and Figure 5 A and B).

Figure 4 An example of a message sent to the fridge from a personal mobile device ("Hi Mum, put the pasta on, 'cause I'm arriving)

Figure 5 A and B On the left the user interface to add items to the shopping list, that may be updated also by the ZmartFRI. On the right the user interface to write a message for an house resident.

4. CONCLUSIONS AND FUTURE WORKS

The presented ZmartFRI project follow a main design principle: this is the "just use it" requirement. The fridge prototype is still virtual, but it represents a promising start, which we plan to pursue further, implementing a mock up that will be used for usability tests with users. With the adequate improvements we

intend to test its use in a real context, by installing it in the residence of our subjects, and testing its uptake as part of their daily life over some prolonged period, according to the ethnographic approach we undertook. A future challenge will be the design of a wider display that will open new interaction concept and modalities between the family totem (the fridge) and the personal portable devices.

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