Universidade do Minho

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iiD: Interactive Informative Display

Tese de Mestrado
Mestrado em Informática

Trabalho efectuado sob a orientação de
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Abstract

The use of small displays at Home is not new and has mainly been explored in the context of specific services, such as Home automation or energy meters. The interactive informative display described in this work differs from previous approaches in its use of off-the-shelf photo frames as generic displays for accessing a broad range of interactive services.

This dissertation describes and evaluates a service for supporting generic interactive content on standard photo frames. The proposed service enables photo frames to present content from several information services such as, the user favorite online newspaper, the ambient assisted living system of the house or dedicated applications. Interaction is based only the standard photo frame controls, but by decoupling interaction events from specific actions, the system enables those basic controls to be used to support a broad range of interaction situations. Evaluation results have shown that the proposed approach is able to support the multiple interaction modes, but has also highlighted some technical challenges associated with cache management in some photo frame models.

This work is a contribution towards enabling digital photo frames to become generic interaction device for the Home. Their off-the-shelf nature and the simplicity of their interaction model means that there is a great application potential to explore this possibilities.

Resumo

A ideia de um pequeno ecrã ser usado na vida diária em casa não é uma novidade, e já é bastante explorada em vários serviços com utilidade muito especifica. Este serviços encontram-se na área da medidores de energia e automatização da casa, ou como recentemente se tem sido apelidado, domótica. O *interactive informative display* é um pouco diferente. Este projecto usa molduras digitais como ecrãs interactivos para acesso a serviços genéricos de informação.

Esta dissertação explora uma abordagem que possibilita utilizar molduras digitais como dispositivos de interacção para o ambiente caseiro. Este serviço permite o uso das molduras digitais para apresentação de conteúdo proveniente de diversas fontes de informação, tais como um jornal online, o sistema de vida assistida da casa ou aplicações dedicadas. A interacção com o serviço e feita a partir da moldura digital, e usa apenas os seu controlos. O sistema funciona ao utilizar estas simples acções de interacção dando-lhes um novo significado permitindo assim um amplo leque de interacções com o conteúdo por parte do utilizador. Os resultados da avaliação mostraram que esta proposta permite a utilização de vários modos de interacção, mas também permitiu detectar varias dificuldades técnicas associadas a gestão da cache de algumas molduras digitais.

Este trabalho é uma contribuição para o esforço desenvolvido no sentido de permitir que as molduras digitais se tornem no dispositivo de informação genérico para a casa. A natureza genérica destas molduras digitais e a simplicidade do modo de interacção resulta num grande potencial para possíveis novas aplicações para este tipos de dispositivos.

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Nomenclature

AAL - Ambient Assisted Living

CSCC - Computer-Supported Coordinated Care

DPF - Digital Photo Frame

EMA - Energy Metering Application

GUI - Graphical User Interface

HTTP - Hypertext Transfer Protocol

iiD - Interactive Informative Display

JPEG - Joint Photographic Experts Group

MIT - Massachusetts Institute of Technology

MVC - Model-view-controller

MP3 - MPEG-1/2 Audio Layer 3

PC - Personal Computer

RFID - Radio-Frequency Identification

RSS - Really Simple Syndication

SMS - Short Message Service

URL - Uniform Resource Locator

WWW - World Wide Web

Chapter 1

Introduction

The Home environment is becoming increasingly rich in digital devices. In addition to the already ubiquitous personal devices, such as mobile phones, PDAs and MP3 players, several other digital artifacts are now also becoming a common presence at home, such as energy meters, cameras, and **digital photo frames (DPFs)**. This already common presence of digital artifacts in the Home, is now gaining a new momentum with two increasingly strong and complimentary trends: network availability and service orientation.

The first trend can be observed in the increasing number of such artifacts that are networked and able to communicate with other devices in the Home. The second trend can be observed in the emergence of services associated with those devices that are able to give them a new role and an increased value. Consider for example the case of an energy meter. It is certainly useful to plug it to some device and directly observe the indicated energy consumption values. However, once the device is networked and able to share information with other devices in the Home, we may additionally have the opportunity to maintain a record of our energy consumption and possibly aggregate data from multiple meters, thus considerably raising the value of the energy meter. Even better, if there is some external service dedicated to energy optimization, we can delegate the analysis of our energy consumption to that specialized service. This would not only make the process much easier for people, but it would also open up the possibility for several value-added services such as rich visualizations, personalized power saving advices and gregarious data comparisons.

These two trends have been steadily reducing the role of the personal computer as the central information hub for the house. While it can still play a crucial role in many scenarios, it may very well be ignored in others. What is even more remarkable is to think that

rich digital services may exist in homes that do not even have a Personal computer. To some extent, a computer may always be needed for accessing the remote services, but that may very well be its only role in the Home eco-system. These trends bring new possibilities not only to the Home environment, but also to other scenarios that gather the same conditions. Scenarios that allow the delegation of tasks; usually performed by computers; to smaller and simpler devices.

In this work we are specifically considering the possible role of digital photo frames as generic interaction devices for these kind of scenarios.Our focus on this particular class of devices results from the fact that photo frames are one of few types of small screens for the household that has reached the mass market. The digital photo frame market was of 750M euro in 2009 just in western europe [Futuresource, 2009]. Figure 1.1 illustrates the digital photo frame shipments in western Europe.

Digital Photo Frame shipings in Western Europe 2009
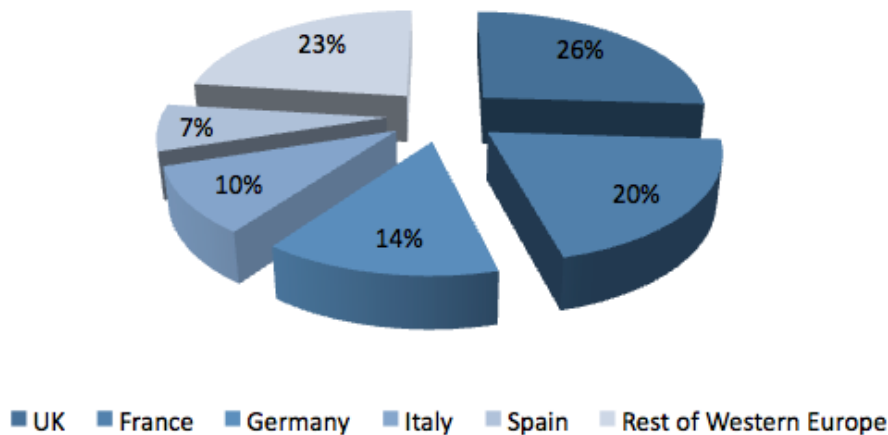
Figure 1.1: Digital Photo Frame Shipments in 2009 Western Europe

Digital photo frames are becoming increasingly cheap and they can easily be bought anywhere and taken home. We also consider this to be a very interesting example of a device that can be appropriated for entirely new purposes when networked and integrated into a service. A photo frame is conceived to display photo collections that may be up-loaded directly. However, once we have network connectivity, we gain the possibility of downloading images from any remote location. Additionally, once we have an adequate

service, those images may no longer be just photos, but any information that is considered relevant at the moment, transforming the photo frame into a generic display for the device and services of the home. This information can come from various sources, such as, the user favorite blog, a newspaper or website.

The motivating hypotheses for this work is thus that a properly managed photo feed can be used to generate a dynamic information stream that matches the operational characteristics of common photo frames.Enabling those devices to become generic information displays for scenarios such as, the Home or the Small Office environment.

1.1 Objectives

This work aims to conceive and evaluate a display-based information service tailored to the specific characteristics of wireless photo frames. As part of this major objective, this work aims to achieve the following goals:

- Characterization of the interaction space in digital photo frame based scenarios

- Exploration of the digital photo frame as an awareness mechanism about the state of the other services and devices in the eco-system.

- Specification of a service that enables arbitrary interaction with remote content displayed on digital photo frames.

- Specification and implementation of a content configuration service, that allows the definition of the various presentation contents and the presentation parameters.

- Definition of an interaction model and appropriate guidelines for new applications

- Implementation of a working service prototype that enables an evaluation of the service.

1.2 Structure of the Dissertation

In the second chapter, several projects and products that are related to this project are presented. They vary from services that deliver content to projects and concepts that use small

displays. All of the services that were deemed related use digital photo frame to exhibit their content. These projects span into different areas: from communication between users to minding the electrical consumptions. This chapter also explores some projects related to ambient displays.

The chapter 3 focuses on the process of designing the service, with sections about the envisioned environment of the project, expected scenarios of utilization, and interaction models. While presenting the envisioned environment some types of devices are made known, such as digital photo frames or other local devices. In the scenarios section, some of the anticipated scenarios are described and explored. It also, describes several event types that were encountered when the scenarios were analyzed The chapter ends with a section about interaction, the several types of interaction that the researched photo frames have, and about other types of interaction with the service.

The system architecture of the interactive informative display is explored in the fourth chapter. This chapter starts by describing the intended behavior of the service and it looks into the main modes of the service: the interactive modes, the notification mode and, lastly, the temporary notification mode. The chapter continues by examining the architecture of the system. It also explores the components, how components are divided and how the the components interact with each other.

The chapter 5 explores the evaluation process of the system, it starts by describing the prototype conceived to validate the system. The chapter continues by explaining the evaluation, the evaluation environment and the objectives of the evaluation. The chapter finishes by indication the results that were extracted during the evaluation and also by analyzing these results

The last chapter of the document contains the conclusions of this project and it is where the items of possible future work are enumerated.

Chapter 2

State of the Art

This chapter describes some of the projects and services that are related with the **interactive informative display (iiD)** project. This relationship can originate from the location intended for the projects, the home, or because the projects provide similar services, content delivery services.

2.1 Content delivery services for Digital Photo Frames

In addition to the related projects, content delivery services will be presented. These services have some features that will be supported by the iiD system. This section describes several services and systems that deliver content with Digital photo frames or digital photo frame like devices.

2.1.1 Ceiva

Ceiva Logic, Inc.[1] is a digital photo frame creator and photo sharing service provider, it supplies it's customers with an Connected Digital Photo Frame and a service that allows users to share their photos. The service that shares the pictures is called PicturePlan® and is only accessible to the owners of Ceiva Connected Digital Photo Frames™. This service allows users to send pictures to their own device and for their family/friends Ceiva photo frame. The pictures are sent trough several ways: using the Ceiva website, sending to the

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[1]http://www.ceiva.com/

digital photo frame email address or from other picture sharing services like Flickr[2] or Picasa[3]. There are plugins for picture software solutions such as Adobe Photoshop Elements[4] and Apple iPhoto [5] that allow them to send pictures to the DPF. This picture sharing service and photo frame is patented by Ceiva [Schiller and Yanover, 2003]. The service also features Ceiva channels that allow the photo frame to receive content other than pictures such as news or weather updates. The photo frame device requires no computer or even Internet connection to use the service, it can use a telephone line to connect with the service. This feature allows the end users of the photo frame device to be less knowledgeable in informatics.

2.1.2 FrameIt

FrameIt[6] was a content delivery service, included in the Microsoft Windows Live[7] brand, that aimed to extend digital photo frames by using the RSS capability of some RSS enabled digital photo frames. The FrameIt service could be used to manage the photographs that the photo frame displays, and it enabled the use of online stored photos that could have come from the most popular image hosting websites and sharing services such as Windows Live, SmugMug[8] and Flickr. FrameIt was not only used to display photographs in the digital photo frame, it could also be used to display content like local weather and text, image or html RSS feeds from RSS enable sites; such as, newspapers sites and blogs. Users can also schedule the content that appeared in digital photo frame. This service has been terminated by Microsoft as of 15 of December of 2010[9].

2.1.3 FrameChannel

FrameChannel[10] was a web service platform developed by Thinking Screen Media[11] that enablesd the owners of a connected device, such as a digital photo frame, to manage the

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[2]http://www.flickr.com/
[3]http://picasa.google.com/
[4]http://www.adobe.com/products/photoshopel/
[5]http://www.apple.com/ilife/iphoto/
[6]http://frameit.live.com/
[7]http://home.live.com/
[8]http://www.smugmug.com/
[9]http://explore.live.com/windows-live-frameit-help-center
[10]http://www.framechannel.com/
[11]http://www.thinkingscreen.com/

content that was delivered by the service to the device. The FrameChannel service was based on channels. These channels could originate from the users personal content, such as photo, tweets, favorite RSS feeds, or commercial, just like news reports, weather forecast, financial and local information. FrameChannel had nearly 1000 channels until the date it was terminated. Personal content photo channels were possible through partnerships with photo sharing and social networks, such as Facebook[12] photos, Flickr, SmugMug, Picassa, MSN Spaces[13] and Photobucket[14], to name a few. Commercial content providers delivered channels from popular sources, like, Time magazine, New York Times, BBC News, etc. These sources were divided into categories and the user could choose what section he or she wanted to be displayed. For example, the user could choose only the New York Time Business section. Users could also create their own channels, create them from photos that they have uploaded to the service or new RSS text or image feeds. All these channels could have been scheduled and had their priority set over each other, allowing a less random content exhibition schedule. Like it has also occurred with FrameIt this project has also been terminated.

2.1.4 Cherish

Cherish [Kim and Zimmerman, 2006a] [Kim and Zimmerman, 2006b] is a system developed at the Carnegie Mellon University and its main goal is to promote relations and interactions between people. It tries to achieve this goal by producing openings for narrative and story sharing by displaying photographs that are meaningful to the people present. Cherish has two different focus zones: the organization and the exhibition of digital photographs.

The Cherish System shows photos through a device called Cherish Frame. Seven participants used a prototype of this device in an interaction evaluation. It was used experimental prototyping and paper prototyping in the interactions evaluation. In each method it was used a Think Aloud [Wright and Monk, 1991]. There were three applications developed and evaluated, focusing on the interactions supported by the frame: the People Present that allow the users to quickly instruct the Cherish Frame to only display photographs of people present in the house; the Event Display, that automatically uses the Cherish Frame to display photos themed by an event, just like holidays and birthdays; and the Opportunistic Sharing, that enables the users of Cherish to share photos with distant persons using the

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[12]http://www.facebook.com/
[13]http://home.spaces.live.com/
[14]http://photobucket.com/

Cherish frame.

A feature that changes the frame to show images of a known visitor currently present at the house was not well received by the participants of the evaluation, they felt that the change of the digital photos was not sincere or authentic, and the testers would regulate the application options to only work with specific visitors. Another feedback from the participants of the evaluation was that it was more satisfying to navigate through Cherish frame menus using a stylus than using the finger, and a tester that used his fingers to interact with the interface recommended that the clicking areas should be bigger.

2.1.5   Analysis of the Services

The related services that have been presented all share with the iiD project the idea of the digital photo frame as a medium to channel content to the users. The Ceiva and Cherish platforms are designed to work with specific photo frames, the FrameIt and FrameChannel Services were created to cater content to different brands of digital photo frames. Despite this, all these services have similarities with the iiD service. The iiD can display different types of content from different sources, such as, Ceiva, FrameIt and FrameChannel, but it also presents content with context awareness just like the Cherish project.

Even though all these services share similarities with iiD, they differ between themselves. For instance, Ceiva and Cherish are services tightly coupled with their own hardware, and FrameIt and FrameChannel are, to this aspect, more similar to iiD. However in terms of the interaction with the content, FrameIt and FrameChannel are all lacking in comparison with Ceiva and Cherish, which are more similar in that characteristic to iiD.

2.2   Alternative Display Concepts

There are several projects that focus on the use of small displays to show information in the home environment. This is also a very important goal of the iiD. Event though these projects are not limited by the digital photo frame medium, they can provide insight on other interaction methods. Several of these projects will be presented in this section, some of them are commercial products while others are academic.

2.2.1 Shoebox

Shoebox [Banks and Sellen, 2009] is a project developed by researchers at the Microsoft Research Cambridge lab. It mixes the storage and display of digital photos in one single device. This project was developed with the aim of exploring new ways of interacting with digital photos, that are comparable to the interactions using physical photos. Another goal of this project was to include methods of storing and interaction that would stimulate the local sharing of photos and stories. To achieve these goals, the project was developed with three abilities in mind: the capability of easily becoming part of the home environment; the capacity of being used to display and share photographs with people at home, in particular the ability of complementing the oral narration of an event with photographs; and the ability to provide an original type of interaction.

The shoebox design was chosen because of certain aspects of its design: the domestic aesthetic that fits naturally in a household; the simplicity of use, by automatically acquiring its content through wireless devices; flexible archiving for sharing, by using simple paper markers to associate the shoebox to a specific occasion, person or stretch of time; simple interactions, such as using a sensitive surface, to emulate the thumbing through physical photographs, by doing this, the users perceive the chronological order of the photographs; the last aspect of the shoebox that was analyzed was the belief that photographs "live" in the device, this aspect allow the users to easily save their precious collection of memories in case of an emergency, such as a fire or a flood. This easiness of spirit originates from the fact that the shoebox, even though it is part of the environment, is also easily accessible, allowing a straightforward emergency rescue of valuable photographs. From this design it was created a "proof of concept" prototype that is still being worked on.

2.2.2 Whereabouts Clock

The Whereabouts Clock [Sellen et al., 2006a] is a prototype device developed at the Microsoft Research Cambridge lab, and it is intended to support the awareness of the location of persons and their occupation in a family or office environment. The whereabouts clock prototype was used to aid in awareness and people communication. While making this prototype, there were several clock design characteristics that were considered important and that ultimately shaped the device. The first one was that this device would have to become part of the daily life of the household. To achieve this the prototype was built to be fixed on

a wall, just like a regular clock. The second characteristic was the interface, a regular clock exists in the periphery, allowing the family to quickly access the information that is shown. On a regular clock, time is displayed. On this device, the location of the house members. Two design characteristics of a regular clock, that were considered important: that anyone could consult the information that the device shows; and that this information could only be seen physically. These aspects give some privacy to the information of the device while not turning it into a personal device. Another aspect that the prototype features, but that is not related to regular clocks is the rough information level. This means that the location data shown by the device is not pinpoint precise; but that type of granularity is not important for the purpose of the device.

To test the robustness and reliability, to calculate the value of concept, to bring forth an office point of reference and to compare with a home deployment, the whereabouts clock was deployed on the research group office. The interviews that were made after the experiment reveal several valuable aspects of the device: the users enjoyed being linked with the office while absent through the device. The users also used the whereabouts clock to check the location of the other users and to help locate them, but because of the coarse-grained nature of location information, this aspect was not usable to locate users within the building. Another issue that users encountered was the lack of expressiveness of their virtual presence in the device. They wanted to add some information about their availability, current action and other type of messages.

Another prototype Whereabouts Clock, a "home" version, is currently being developed and issues that users found are being dealt with. This new version will be tested at selected homes.

2.2.3   Signchannel

After the shutting down of FrameChannel due to financial problems, the alternative suggested by the FrameChannel to their commercial customers was Signchannel. This system is a digital signage solution by Scala, a global digital signage company that provides software advertisement management products.

Signchannel uses a content scheduler interface very similar to FrameChannel and it allows an also similar scheduling solution, regarding both the available content and the automatic content update system. However, because it is a commercial solution, it is not focused to be used in the home environment. In fact, Signchannel is marketed to doctor's

offices, restaurants, hotels, auto dealerships and other small and medium businesses. For this type of markets, their custom templates allow the customers to create their own content. Another difference from the FrameChannel is that this solution does not make use of photo frames, it uses integrated frames or a combination of media players and LCD screens.

2.2.4   Carenet Display

The CareNet Display [Consolvo et al., 2004b] [Consolvo et al., 2004a] is the first prototype created at the **Computer-Supported Coordinated Care (CSCC)** [Consolvo et al., 2004a] area of Intel Research Seattle. This device was created to help senior citizens caregivers with information about the everyday life of the elderly. The CareNet Display is an augmented digital photo frame that shows a picture and information about the quotidian of the elder. Still, this device does not only has an ambient display setting, it also has an interactive setting that allows the members of the care-network access more information. On the ambient display mode the CareNet Display shows the overall data of the elder's day, such as: if the elder has eaten his or her lunch, if the elder has fallen and other occurrences. This information is shown in the form of icons that change colors to signal changes. The interactive mode enables a deeper inquiry of the elder's daily information, such as at which hours has the elder eaten or when the elder has eaten in the last five days. This daily information that is shown by the device originates from data inputted by the elder, the caregivers or from sensors that monitor the house.

A CareNet Display prototype was deployed in several houses to be tested. However, in this prototype there was not an associated sensor network, the only data source of the device came from manual input by the elder and by the caregivers. After this evaluation, that lasted for three weeks in each house, several issues were found, but, overall, the users of the device were pleased with the prototype and consider the possibility of buying such a device if it becames available and affordable. One of the issues found regarded the size of the device. Some of the testers said that even though the CareNet Display was good looking and matched the decoration it was a little too big. Another issue that was spotted was that, in the dark, the display continued still on and it was distracting. The other issue encountered was in the icons exhibit the state of the elder: the colors that change during the events were not very distinct from each other and some users did not perceived the contrast between the grey icon (that represents "system not able to update") and the black icon ("event occurred as planned").

After this prototype, the researchers noticed that the next challenge was to reaserch the adoption of this technology when sensors are used to collect data as an alternative to humans.

2.2.5   TxtBoard

The TxtBoard [O'Hara et al., 2005] is a prototype developed by Appliance Studio to explore person-to-place communication. This device slides away from the normal communication patterns that emerge by the mobile communication providers. Because of the personal nature of the devices, the mobile providers promote the person-to-person communication and, while this type of communication is important, it does not necessarily fulfills all the public's needs as it doesn't explore the individual-to-group type of communications. This led the researchers to investigate other procedures of communication by using prototypes and deploying them into households to evaluate them. The first of these prototypes was the TxtBoard, a device that uses a small display to show the SMS messages that have been sent to it. This device enables one-to-many communications and the context in which it was envisioned was the home when a person sends a message to its family. The prototype was intentionally built as a simple device, in a way that underlines its function of displaying the messages. An added interaction complexity was possible to achieve in the TxtBoard, but because of the simplicity of the device it was easer to find what future interactive technologies would add value to the project while keeping the prototype simple.

To test the TxtBoard, the device was deployed in a household. The members of the family had the freedom to put the device wherever they think it would be more beneficial, and then they started to use it for a period of two months. After analyzing the interviews, log and other data collected in the process, it was discovered that the device was used in several types of family interaction. The first one was about calls for action. In this type of social interaction a family member uses the device to transmit the message to as many people as possible. This type of communication is not only is included in the one-to-many communication pattern but also is more similar to a one-to-whoever-is-in-the-house communication pattern. The second type of family interaction was in informing, awareness and reassurance. One typical example of this form of interaction is when a family member is away from the house and is delayed for any given reason. This member still wants to inform the other family members or even reassure them of his safety. To this effect, he can send a SMS to the TxtBoard and notify the members that are at home. Another type of

family interaction is social etiquette, by avoiding the direct approach of the call for action, using only their location information, a family member can ask more politely and indirectly for some favor just like a car ride. Another important family communication were the "I'm thinking of you messages". This type of messages supports a social touch to the family's interactions.

TxtBoard has added value because it uses a already existing communication method (the SMS) and extend it for a better adaptation of the home ecosystem. And because of the peripheral nature of the system, it didn't need a big family lifestyle change to affect the family interaction.

2.2.6   HomeNote

HomeNote [Sellen et al., 2006b] is a project developed at Microsoft Research Cambridge, that explores home and family communication in two areas: it displays scribble notes and it receives and shows SMS messages. HomeNote builds in the Appliance Studio TxtBoard [O'Hara et al., 2005] project, a device that investigates person-to-place communication. HomeNote inherits from the TxtBoard the simple design and the SMS communication feature. The device also improves on the TxtBoard by enabling users to scribble notes on the screen using stylus markings. The researchers involved in the HomeNote project worked to unravel four issues: consider the affordances and value of person-to-place over person-to-person communications; assist not only situated messaging but also note scribbling; study home communications; research for fresh and original concepts to assist home communications.

In order to solve some of the issues described above, a HomeNote prototype was deployed in several homes in the United Kingdom from 2 weeks to 8 months time. After analyzing the results, the researchers found that the families used seven types of messages on HomeNote. Several of these types were already found on the TxtBoard project, but the scribble feature of this project added some new types of messaging. Calls for action, awareness and reassurance and social touch messaging were the types of family interactions that were found to be heavily used during the TxtBoard deployment. However, these home communications also included the scribbling of messages in addition to SMS on the HomeNote testing. The other types of family interactions that were found during the HomeNote field test were the Broadcasting identity, reminders, passing on messages and information storage. The broadcast identity type messages were similar to the social touch

messages but instead of focusing on "I'm thinking of you" it was more similar to "Think of me" messages. The reminders were mainly scribble-based messages that some family members used to remind others or themselves of events. "Passing on messages" were called by researchers "the equivalent of paper notes by the phone". "Storing information" were the least common messages types encountered. They were mainly scribbled information that often resulted from phone calls, such as phone numbers and addresses.

One of the features that users said be very useful in a future prototype of the HomeNote was the ability to send SMS messages from the device in order to respond to calls for action and social touch messages. Another issue found was related with the ease of deleting important messages.

2.2.7   EMA

The **Energy Metering Application (EMA)** [Rodrigues, 2009] is an affordable energy metering system created at the Fraunhofer Assistive Information and Communication Solution research center. It aggregates energy consumption readings from the devices in the environment through electricity meters. This energy metering system results from studies on an open framework architecture that supports an affordable energy consumption awareness. The goal of this energy awareness is to change the consumption behavior of the members of a home environment to a more energy saving one. The keys to achieve an affordable energy consumption system are to use affordable equipment and to use any existing infrastructure with the system. With that in mind, several guidelines were defined to be followed while making the EMA prototype: using a power plug meter is favorable, because it is more affordable than a no contact sensor meter; reducing the components complexity, by using more simple components, reduces the cost of components and the occurrence of malfunctions; using an existing internet network allows a better use of already existing structure; the use of standards and modularity in the design allow for a better adaptation to a future larger metering infrastructure and other sensor systems that will be found in the residential environment. The EMA prototype gathers electrical energy consumption data through the sensor and displays it using a web page, which can be accessed by a computer or a mobile device. This energy information consumption data can also be visualized through a photo frame using its RSS capability.

2.2.8 Context-Aware Informative Display

Context-Aware Informative Display [Zhu et al., 2007] is a project that aims to explore a framework and a digital information exhibition philosophy with displays in the home or other shared spaces environments. To achieve this goal two critical conditions must be established: the infrastructure, i.e., the devices that support the information dissemination; and a non-intrusive approach to information exhibition. This project's framework has as main contribution the weave of the information that originates from different roots and then it blends this information, including the users personal data, into one display; it creates an anchor image for each of the exhibited information, this image is acquired from a bank or from its information source; in the end, the framework is context-aware, it changes the presentation to adapt to the context of its environment, such as showing a family member portrait on his\her birthday.

The Context-Aware Informative Display has two main states of execution an "idle" state and an "user" state. The idle state is activated when the display senses that no attention is directed at the screen, and because of that it starts to exhibit artwork for embellishment purposes. However if a user approaches the screen, the context-aware informative display will load his\her profile and present suitable content. The display will detect and recognize the use by using RFID and a proximity sensor. The several users of the display will be able to customize their "home screen" to match their preferences. This is achieved by choosing their data interests and by identifying applications to extract data from. The information will then be added to a rendering template that is also customizable by the user.

This display framework hopes to contribute to a consolidation of multiple information sources of the user's interest and present this content with images. This display can be used in the home environment, but also in other shared spaces, such as schools and offices.

2.2.9 Analysis of the Alternative Concepts

While these alternative concepts can greatly differ between themselves, they all share similarities with the iiD project. This likeness can be encountered on several features, such as the use of small display or even in some cases, a photo frame like display. The main or most important envisioned environment, the home, and in function, some of the concepts are used to inform its users about data that they have marked as important.

The Shoebox project differs from all the other projects because of its scope, it was

created to provide a novel means to store and display photographs and explore a type of interaction that allows todays digital photographs to feel like the paper photographs of before. On the other hand, the whereabouts clock displays the location of family members and, in common with the iiD concept, only has the medium of informing and the main environment: Small display in the home environment. Signchannel is very similar to FrameChannel and FrameIt, but is focused on commercial use.

The Carenet display and EMA resemble with each other and the iiD in the display type used. They all use digital photo frames to present the data. However, while data differs between them all, the iiD display a bigger variety of information types. EMA only display the energy consumption; the Carenet display that is inserted in the AAL technologies, enables both caregivers and family of the elderly to obtain information about the elderly's life.

The TxtBoard and the HomeNote projects are very similar. In fact, the HomeNote builds on the work that was built for the TxtBoard. They are both built around the concept of person-to-place communications; they use small displays to show the information and they were both designed with the home environment in mind. It is in these last characteristics that they are similar with the iiD project. Between themselves they differ on the number of affordances that each one of them enable: one is focused on being simply a SMS receiver that every inhabitant of a home can use to broadcast their information to the other inhabitants; the other builds on that and also enables the inhabitants of the house to scribble notes on the device

Context-Aware Information Display is very similar with the iiD project regarding on the kind of information that they display; they both provide their users with several types of information that they have classified as important, and they also share the ability of being relevant not only in a home environment but also in other environments. This project differs from the iiD in the kind of screen used, a small screen vs a large screen in the Context-Aware Information Display. Another difference found is on the focus of the project; while the iiD focus on the interaction of users with the screen, the Context-aware information display focus more on the proximity of the users and it changes accordingly to match the users preferences, discarding the interaction of the users with the screen.

2.3 Ambient Displays

Ambient Displays [Wisneski et al., 1998] communicate with the user using ambient media [Ishii, 2008]. This information is acquired by the users' periphery perception and becomes part of the users' background information. This is achieved by using objects that allow multiple states or by using several kinds of displays. However if the users perceive that anything is abnormal, they can change this background information to the foreground of their attention.

One of most famous ambient displays is the dangling wire created by artist Natalie Jeremijenko [Weiser and Brown, 1997]. The dangling wire is a plastic string, about 244 cm (8 foot) long, that responds to the network traffic. It moves vigorously while the network is busy and it shivers while the network is less engaged. The system works through an ethernet connected motor that moves the wire. The movement of the wire can be both seen and heard, this allows the users to quickly move their attention to it when a big difference in its whirling occurs.

Another example of an ambient display is the Informative Art project [Redström et al., 2000]. Which is not only an aesthetic pleasing object but also a display that provides its user with information. This is achieved by using an image to represent the information, but this information is not apparent. For example, the weather application uses mondrienesque[15] images in which the squares represent various cities, the size of the squares represent their temperature and its color represents the weather conditions, for instance a big yellow square represent high temperatures in a sunny day (Figure 2.1). However, this complexity limits the understanding of the information to a most of people. InfoCanvas [Miller and Stasko, 2002] is another similar project that also uses information through art. This project, however, allows the users to create their own personal abstract representations of information.

One other project still within the ambient display scope is the ambientRoom, developed by the Tangible Media Group of the MIT Media Laboratory [Wisneski et al., 1998]. The project is based on an enclosed mini-office installation augmented with embedded sensors and several kinds of ambient displays. While in the ambientRoom, the users are inside an augmented environment that displays information to them by using several ambient displays. Within the ambientRoom the ambient light, sound airflow and physical motion represent information that is displayed to the user periphery. This project has also created two standalone ambient displays that inform users by using "digital wind" (pinwheels) and

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[15]http://www.pietmondrian.org/
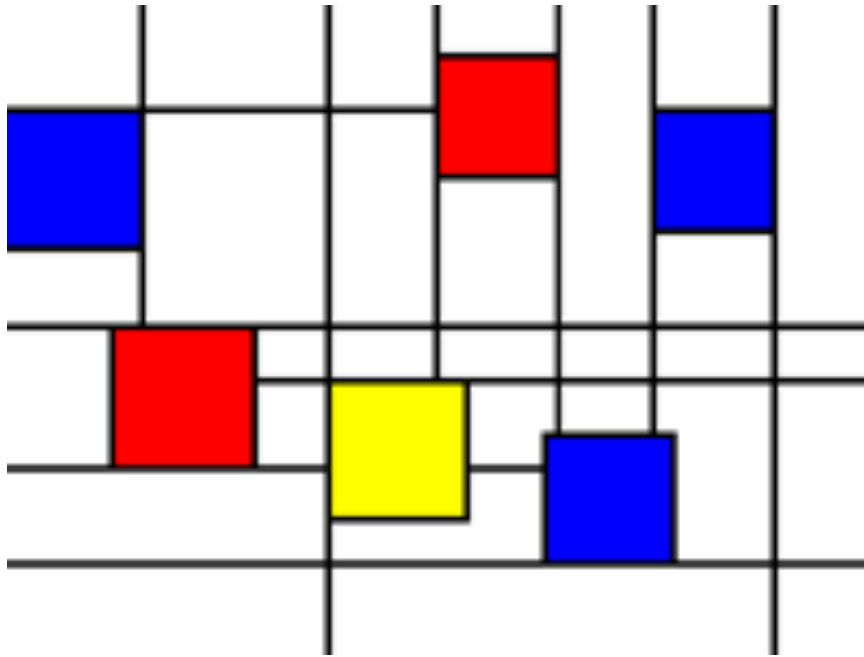
Figure 2.1: Weather Composition application from the Informative Art project

"bits of rain"(Water Lamp).

Ambient displays are now becoming accessible to the general public, several companies have invested in its potential and released various products to the market. One of the most famous is the Mindscape Karotz [16], previously known as the Violet Nazbatag. Karotz is an internet connected rabbit that can inform its user of the weather forecast or even read out loud its emails. It displays the information by using indicative lights or speaking out loud the information.

Another company that offers a variety of ambient displays products is Ambient Devices. It sells several appliances, such as Ambient Umbrella, whose handle glows when rain is predicted in the weather forecast; or the Ambient Orb whose color represents the Dow Jones Industrial Average, changing from, red to green ,to indicate if the market falls or rises.

The iiD relates to ambient displays since it can be used only as a peripheral informa- tion source. It presents its data using a digital photo frame, a small screen, discrete and functional, something that is used to show information provided by the data source, but can also embellish the environment. It is system that shows the information in this manner, on

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[16]http://www.karotz.com/home

a technologically calm way [Weiser and Brown, 1997].

2.4 Analysis of related work

The services and projects presented have provided an important contribution to our work, highlighting many of the communication patterns that can be enabled by this type of small displays and enforcing our design for a more generic approach. While each of these systems is designed with a particular objective, we aim to explore how to integrate a generic interactive functionality using off-the-shelf digital photo frames.

The related services that are here presented share some features with the iiD. However, these services are aimed to a specific problematic, they do not share the large scope of the iiD. They do not share the broader interaction possibilities or the possibility of the integration with AAL systems that the iiD allows. The iiD service also has a stronger connection with the hardware; in this case the digital photo frame, for the interaction possibilities that the service enables to the photo frame. In spite of this, the system is not tightly coupled with any specific brand or type of photo frame, it allows the use of any photo frame that meets the system requirements. This allows the users to choose a photo frame that matches their preferences.

The related projects shown share one of the target environment with the iiD: they are aimed to be deployed in the home environment. But the iiD is targeted to a more extensive environmental scope, not only targeting the home environment but several others, such as medical offices and classrooms. These, just like the related services described above, are more focused on their intended functions and so they contrast with the iiD, which is a general display that shows information that is relevant to the users. There is only one project that approximates to the iiD project on both information and environment scope, the Ceiva Connected photo frame. However this project, as already stated, does not explore the interaction between the users and the device and that feature is central to the iiD. Table 2.1 presentes the similarities and differences between the features of the iiD and its related projects.

Ambient displays relate to each other by providing information to the user in a non-intrusive manner. Most of the time, they only require the peripheral attention of the user, enabling the him \her to center their attention on them only when it is needed. This aspect of the Ambient displays is also a feature of the iiD system. Despite of this, the biggest

Table 2.1: Comparison between related projects and iiD

Projects	Usage of digital photo frames	External Content	Interaction	Non proprietary hardware	Various Environments
iiD	✓	✓	✓	✓	✓
Ceiva	✓	✓	X	X	✓
FrameIt	✓	✓	X	✓	✓
FrameChannel	✓	✓	X	✓	✓
Cherish	✓	X	✓	X	X
Shoebox	X	X	✓	X	X
Whereabouts Clock	X	X	X	X	X
Signchannel	X	✓	X	X	✓
Carenet Display	✓	X	✓	X	X
TxtBoard	X	X	✓	X	X
HomeNote	X	X	✓	X	X
EMA	✓	✓	X	✓	✓
Context-Aware Informative Display	X	✓	✓	X	X

novelty of the iiD system is the possibility of interaction. It not only allows the users to be informed with some kind of data, but it also allows the users to actively locate data that they want to consult by navigating through iiD system.

After analyzing several services and projects it is possible to notice that the iiD service range intersects several of them, while it differentiates from most of them to achieve a feel of novelty. Only one service/product is very close to the iiD service, but still the range and relationship with the hardware of the iiD distinguishes itself enough to disregard any similarities.

Chapter 3

Service Design

In this chapter we are going to describe the assumptions, the environment and the Design process of the iiD system. It will start by addressing the environment of the system describing the devices that will compose the system. These devices range from the digital photo frame to the home gateways. We will then describe and analyze possible usage scenarios of the project. We will end this chapter by exploring several concepts of service such as interaction modes, integration with external content and application ideas that seem relevant for the service.

3.1   The Photo Frame Eco-system

This is a system designed primarily for the Home or Small Office environment, which is expected to be deployed and operated without requiring much more than the display itself and a wireless connection. However, a broad understanding of the target environment and the elements that may be present in that service eco-system may help to improve the integration of the iiD and, when certain conditions are met, provide additional services. This section intends to analyze what are the minimum expectations for the target environment and, in particular, how certain services, when present, may be used to enhance even further the features provided by the iiD.

This section will first describe the main assumptions of this work in terms of what features to expect from photo frames. It will then consider which other elements may be commonly available in the photo frame eco-system and how they may be leveraged to extend the user experience of the photo frame. The parts that form the iiD eco-system

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are quite simple to infer. The first is the digital photo frame. This is the device that is intended to be used by the system operator. It will present the content and will be the default interaction method. Several interaction methods will also be analyzed, they will range from different methods that are offered from different digital photo frames to the existence of compatible interaction devices. It is also important to analyze the interaction possibilities the are available to the user. While analyzing the service eco-system, were also studying the system data sources. These are very important since most of the data presented by the photo frame comes from them.

3.1.1 Digital Photo Frames

The iiD project uses a small display to present the content that the service creates. This display should be something that is starting to became part of the house of today and could become part of the furniture in the future: a digital photo frame. This photo frame can show pictures of the household, like it is intended to, but it will also be able to show data that is relevant to the people living in the house.

It is important to study the associated interactions of the digital photo frames, interactions like input to the device using the controls in the photo frame, like the connection that links the device with the internet or even output interactions like audio. Table 3.1 describes the studied digital photo frames.

Interaction

All photo frames support some other form of interaction. The most common way of interaction between the user and the photo frame is the simple push buttons in the photo frame. Another form of interaction very commonly found in photo frames is the remote controls. This form of interaction is usually featured with another one, like the push buttons or touch sensitive buttons. This form of interaction adds the value of being able to control the digital photo frame from a distance. Users can be comfortably on a couch or a bed and remotely control the device. The most emerging form of interactions of photo frames is the touch sensitive buttons; this type of interaction gives something beyond function. They are also used to add aestectic value to the photo frame.

The more high tech photo frames use touch screen to control the photo frame. This type of interaction is one that, usually, brings more style value to the photo frame. It is also the

type of interaction that can allow more quality of use just because the interface designers have more power to make the interaction more satisfying, more efficient and more effective [ISO, 1998]. This kind of controls allows this because, they are not bound by physical interfaces, just like the number of buttons or their size. Another form of interaction, in this case output from the photo frame to the users, is the sound; some photo frames have built-in speakers. These speakers are usually used to play background music to the slideshow, listening to music using a built in MP3 player or, if the devices has some type of Internet connection like Wi-Fi[1] or a Ethernet cable, this enables the photo frame to access web radios.

Internet and data sources

An internet connection enables using remote content data sources with the frames. This capability allows the user to display their content from media hosting sites such as Flickr. Because of this web integration users can now skip the hassle of transferring the photographs from the camera to their personal computer, edit them and transfer them to the

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[1]http://www.wi-fi.org/

Table 3.1: Digital Photo Frames

	Connection Capabilities	**Interaction Support**
Sony VGF - CP1	RSS Feeds and web-browsing	Push buttons, Remote control and Joystick
Kodak w1020	RSS Feeds	Touch Sensitive buttons
iGala	RSS Feeds through Framechannel or FrameIt	Touchscreen
Samsung SPF - 105v	RSS Feeds	Touch Sensitive buttons
e-Starling 802.11n Connected Touch-screen Frame	RSS Feeds	Touchscreen
Kogan 8"" Wi-Fi LCD	RSS Feeds	Touch Sensitive buttons and Remote control
ViewSonic VFP 838-11	RSS Feeds through Framechannel	Push buttons and Remote control
Toshiba DMF82XKU	RSS Feeds through Framechannel	Touch Sensitive buttons and Remote control
LG F8400p	Web Album support	Push buttons,Remote contro and Joystickl

frame or the device that will serve as storage of the frame every time that the users want to update the content of the photo frame.

As it was previously mentioned, digital photo frames have several network connection methods. Today the most common method is Wi-Fi. The lest common method is the ethernet cable interface and, in a product studied in the related work it, the interface method can be through a phone line. However, as previously mentioned, the ordinary method is Wi-Fi. In fact, all the studied photo frames allow internet connectivity through Wi-Fi. Internet connecting also enables the photo frames to explore other types of content, such as RSS feeds and online stored photographs that were not taken/uploaded by the frame user.

Cache

Cache is defined by the New Oxford Dictionary as *"an auxiliary memory from which high-speed retrieval is possible"* [Oxford University Press, 2005]. In other words cache is memory with high speed access used for storage and retrieval of regularly or recently accessed data, allowing the reductions of cost in re-accessing this data. In the photo frame it is conventionally used to store images that were retrieved from remote sources of information(internet), enabling the photo frame to display the content with less network cost.

All the analyzed digital photo frame have internet connectivity. However, information about the existence of a cache like function was not disclosed. One other important cache related information was if there was any kind of way of turning off the cache. But because of the lack of information concerning the cache of the device the only way of answering this question was by contacting the customer support. The companies that were kind enough to respond reveal their photo frames were not capable of switching off the cache.

3.1.2   Other devices in the home

Local devices are the ones that can be used with the iiD service and exist in the envisioned environment of the digital photo frame. These devices can range from the ones used to interact with the service, the ones that feed the service with information, to the ones that are used to connect the device to the internet.

The local devices that are used to interact with the service may include devices like RFID readers [Martinussen and Arnall, 2009], universal remote controls, cell phones or even the sensor network from a AAL system used to capture interactions from the user.

However, sensor networks are ordinarily used to provide data to create content. The internet-connected rabbit Karotz from Mindscape is another example of a local device used for interaction. It offers an integrated solution of several interactions, just like RFID reader and voice commands, to enumerate some. Some of these local devices, interaction devices will be further explored, interaction-wise.

Another type of local devices are the home gateways. A home gateway is *"a node that resides between the public network and the home network, and it is the "ingress" to the home network"* [Saito et al., 2000]. From this definition it was predicted that the local router were a contestant for the home gateway. However this is only the communication view of a home gateway. A home gateway should discover and aggregate newly found devices and their services with the home network in addiction to being the central node for all the home network types that can be found in the future's smart home; such as security systems, entertainment systems, communication systems, data systems, lighting, appliances and climate control [Valtchev and Frankov, 2002].

The gateways that allow more freedom to the systems being assisted are the ones that are more configurable. But many of the gateways currently available to the public have proprietary firmware that limits the customization of the hardware. However, another type of gateway is becoming more available to the users: the gateways that use a linux-based firmware. These type of gateways enable the user to add or create new features allowing a bigger possibility of customization of the gateway and, therefore, better serving the needs of the users.

3.1.3 Interaction Devices

Interaction is not a major requirement for the iiD, but it is a feature that may considerably enhance the usage situations of the iiD. Interaction with the iiD should address the following features:

- The user will be able to select the content to be displayed by using the photo frame.

  - The user will be able to browse through the content, in order to choose it to be displayed.

- The user will be able to use the service web site to pick or add content to the display list of the screen.

In order to address the interaction needs, a study was made about interaction devices available to be used with the iiD system. The devices described in this subsection are the ones that were classified as options to be used. Several other devices may be used to interact with the photo frame. But these are the one initially envisioned. Other devices may appear as new technologies are created. Some of them are available in every household some are not, but they all constitute interesting ways to users interact.

Violet mir:ror : Violet mir:ror [2] is a RFID reader that is used to add an augmented meaning to simple household objects. This is a simple process, the user tags, with a RFID, an object, and after the mirror reads the tag, specific actions, configured by the user, occurs. For example, after the reader scans the tagged umbrella, the computer shows a weather report. The system requirements for this device are a broadband Internet connection and acomputer.The mir:ror could be a good device to interact with the iiD. For example, it could be used to select specific content for the iiD, such as using an RFID tagged keychain to request information about traffic congestions.

Remote Control : The remote control, or remote controller, is one ubiquitous device in daily life. Nowadays it can be found in almost every house. Hi-Fi, TVs, DVD players and cable/DVR systems, all come with remote controls making them available to all kinds of users. And even though the more complex task that these devices enable are not used by the large majority of the users, almost all of them can perform the simple tasks, such as turn the volume up or down on a TV. The remote controller could be another good device to interact with the iiD. For instance a user could press a button to skip content. Another usage of the remote control in the iiD could be using the number keys associated to one type of content, such as #4 standing for weather reports.

Mobile Phone : The mobile phone is another example of a device that is widely spread among the general population. For example, in Portugal the estimated number of mobile numbers being used are 15,5 million [ANACOM, 2010] a number that is higher than the of population of Portugal (10,6 million) [INE, 2011]. Reusing the mobile phone as an interaction medium with the iiD is a great way of using already existing technology. The mobile phone would be a very powerful interaction device because it enables numerous interaction possibilities for the user. It could be used

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[2]http://www.violet.net/_mirror-give-powers-to-your-objects.html/

just like a remote control or as something more customizable. Another advantage of mobile phone interaction is bypassing the router: with a mobile phone, the router becomes less important for the communication from the device to the service.

Digital Photo Frame Buttons : All photo frames have some other form of direct interaction. This interaction normally uses buttons. And even though the type of buttons can vary (push, touch sensitive, ...) these buttons are used to navigate though he digital photo frame menus and to configure its settings. They are also used, during a presentation, to move forward or backward through photos.This kind of control is one of the more obvious interactions to be implemented in the iiD. The idea of fast-forwarding types of content by pressing the next button is a simple but effective interaction that users should be able to produce.

All these interaction devices have their own capabilities and uses. However, each one has an area where their potential can be improved. The mir:ror would function well in a AAL environment where, for instance, a tagged medicine box could interact with a medicine alarm application. A remote control and/or cell phone is a good choice because it adds some convenience to the interaction, but these types of devices have their own issues. Simply some photo frames will not support a remote control, the ecosystem must be prepared to accommodate the device. The mobile phone market is still very heterogeneous, considering the mobile operative systems, thus making a truly universal interaction application very difficult. Other non envisioned types of interaction, possibly using other devices, should also be possible, as long as the information captured can be sent to the iiD service.

The most default interaction mode for the iiD will be the digital photo frame buttons. This is because they are the default mode of interaction of most photo frames and also, since they are the common denominator interaction-wise of all embodiments of the iiD.

3.2 Scenarios

In order to inform our design process, we have conducted a study of usage situations for this type of small digital display. These scenarios will not only demonstrate the envisioned features but also drive the design of the system to discover other features that only have appeared during the writing of the scenarios. To also demonstrate some flexibility of the

iiD, scenarios with different environments were created. To aid the visualization of these scenarios, personas were created (Table 3.2). The main envisioned scenario is the Home scenario, the original scenario to the iiD. Still because the possibilities that the iiD enables, it was relevant to create scenarios with other environments.

Table 3.2: Personas used in the scenarios

Name	Daniel	Matthew	Nuala	Chelsea
Age	20	34	28	24
Occupation	CEO of a publishing company	Personal Assistant	Assistant at a medical office	Part-time Waitress
Family status	single	single	married, one child	single
Environment	He normally accesses the device at home. He is very comfortable using a computer or a mobile device	He normally accesses the device at another person home. He is very comfortable using a computer or a mobile device	She uses the device at Work. She is very conformable using a computer. She is comfortable at using a mobile device	She uses the device at College. She is very conformable using a computer. She is a expert mobile device user
Key Attributes	He likes music, plays and stories. He considers his big sister as his best friend. He doesn't care about money and he is resistant to change. He usually stays and works at home.	He likes music, driving and football. He considers his boss as a friend, and his work as his most important thing. He feels that money is not important and he enjoys new technologies and gadgets. He usually travels a lot during work.	She likes reading tabloids, gossip and her daughter Joana. She enjoys Sunday mornings in the beach and window-shopping.	She enjoys old movies, feeding the birds and meeting new people. She enjoys traveling, has a big collection of floppy hats and has two goldfish pets. Although she cares about all her siblings, she is easily irritated by her younger brother's mistakes.

Home scenario

This scenario demonstrates the use of the iiD in the home environment. It accompanies the persona from waking up and ends when it leaves the house. This scenario features the Daniel and Matthew personas. *"It's is a cold summer night and Daniel, a 20 year old, CEO of a publishing company, relaxes on the couch at his house. He looks at the iiD and reads the headline of his favorite newspaper. The night carries on, and after a quick snack he decides that he wants to know how much of energy is consuming his fridge. He then notices that his computer is turned off, and how i could be too much of a bother to turn it on. He then remembers his iiD and, using his phone he selects the energy metering application to be show next in the iiD. It is now morning and Daniel wakes up with the doorbell ringing. He then looks at the iiD and notices that the frame of the picture is highlighted. It shows a message from Matthew, his personal assistant, telling him to open the door. He then gets up from bed and still sleepy, opens the door and says hi to Matthew. Matthew, while his boss takes his morning shower, looks at the iiD and after watching some photographs of the last holidays, it is shown to him a big increase of gas consumption, by the gas consumption application, while the water is being heated. He then presses the next button and the iiD changes its content to a newspaper. Daniel, while preparing breakfast, glimpses the iiD and notices that the device is showing his favorite blog and that there is a new post. While eating breakfast with Matthew, Daniel looks uninterestedly at the iiD until the weather is shown; he then takes a mental note to pick up his umbrella before going to his appointment with his doctor. "*

Medical Office

The medical office scenario demonstrates the use of the iiD as an information screen that aides the office assistant in the waiting room. The scenario describes a short interval of time in the waiting room of a medical office. In this scenario the personas that appear are Daniel, Nuala and Chelsea. *"Daniel, after arriving to his doctor's medical office, glimpses the photo frame standing in the assistant's counter. He reads that his appointment is going to be delayed for 10 minutes so he sits on the chairs and watches the changes in the display: it is showing some news about medical breakthroughs. He notices that someone has left the doctor room and he looks at the frame for confirmation that he is next. After reading his name as the next patient, he stands and goes in. Still in the waiting room is Chelsea talking to Nuala to schedule a new appointment, Nuala states that they are fully booked until the*

next week, but after that the doctor is available. She then instructs the display to show a calendar to help Chelsea to set a date. After the new appointment has been set, Chelsea notices that the display is now showing a highlight title from the local newspaper."

Classroom door

This scenario demonstrates the use of the iiD as a screen used to display local related information, such as the schedule of a classroom. In this scenario, the personas that participate are Nuala and Chelsea.

"Chelsea after going to the doctor notices that she is late to classes. She arrives at the classroom door, but after looking at the classroom door display she notices that the class has changed rooms, and that room is being used for exams. She then runs to the new classroom and gets in. After the class she decides to stay at College to study for the upcoming exam. She then walks searching for an empty classroom and, by looking at the displays, she finds a room that is empty until 6 p.m.. She then enters and texts her friends informing them about the empty classroom. Nuala, after reading Chelsea's text message, begins to walk to the appointed room. She then walks past the development ward of the college and notices that the displays of the door are showing a different content that she usually encounters in the normal classrooms. She observers the laboratory display changing from the pictures of the developers to brochures from projects that have been created in that laboratory."

3.2.1   Scenarios Analysis

After creating the scenarios they need to be analyzed in order to obtain valuable information from them. In this case, the analysis of the scenarios will focus in the interaction of the personas with the system and, by that, trying to identify all the different forms of interaction that exist within the envisioned scenarios.

Content Push This is the ""normal"" state of the iiD at home. It is when the content currently displaying is chosen because of its relevance to the user.
  Home scenario:*"...looks at the iiD and reads the headline of his favorite newspaper..."*
  Medical Office scenario:*"...reads that his appointment is going so be delayed...",*

"...it is showing some news about medical breakthroughs...", "...display is now showing a highlight title from the local newspaper..."

Content Pull This type of interactions happen when the users choose a new specific content to be shown by the display.
Home scenario: *"...using his phone he selects the energy metering application to be show next in the iiD..."* **Classroom door scenario:** *"...by looking at the displays she finds a room that is empty..."*

Notification This type of interaction occurs when an event that requires the users attention happens. An example event could be the receiving of a message. The content only disappears from the display when the user interact whit the screen.
Home scenario: *"...frame of the pictures is highlighted, it shows a message..."*

Temporary Notification This type of interaction with the iiD occurs when a low level alert happens. The content shown gains extra relevance during a temporary time period, but after, it resumes to normal.
Home scenario: *"...it is shown to him a big increase of gas consumption, by the gas consumption application..."*
Medical Office scenario: *"...he looks at the frame for confirmation that he is next..."*
Classroom door scenario: *"...looking at the classroom door display she notices that the class has changed rooms..."*

Temporary content relevance increase This type of interaction occurs when something happens to the content that affects its state temporarily increasing its relevance. This type of interaction could be triggered by users configurations, such as displaying the weather at early morning.
Home scenario: *"...device is showing his favorite blog and there is a new post...", "... iiD until the weather is shown..."*

Shared screen This interaction happens when the display show shares the screen with two different types of content, such as a classroom schedule in a permanent state mode and other content, for instance a content relevance mode.
Classroom door scenario: *"...display changing from the pictures of the developers, to brochures from projects that have been created in that laboratory..."*

From these scenarios we have recognize three main interaction modes and, while there have been found other types of interaction, these three main modes are the defining ones

since all other interaction types are variations of the main three. So, after evaluating the scenarios, it was concluded that an effective interaction model for this type of display should be able to combine the following interaction modes:

Content push In this mode, the display is iterating through a content pool and content is seen by people without any intervention. This is the most obvious and common scenario and is already supported by existing services. However, in this basic model content is delivered to people who may not necessarily be interested and who may not see it. As an additional requirement, the display service should enable content to be selected considering some measure of the current relevance. The system would be able to select which content items from a potentially large content pool, are deemed more appropriate at any given moment based on the content itself or in the context of its presentation.

Content pull In this mode, the user approaches the display to request the presentation of a specific content item. This is not necessarily the ability to request arbitrary content. It may simply correspond to the ability to request a content item from a small content list. Still, supporting a pull model is key in enabling the user to actively seek a specific content item whenever needed.

Notification In the notification mode, the display locks itself on a single content item until the user explicitly interacts with the device, thus confirming that the presented information has been seen. A slight variant is the temporary notification mode, which works exactly the same way, except that there is some time limit associated with the notification, after which the photo frame should resume its normal operation mode. This is essentially a feature to support asynchronous communication, allowing people to be informed about relevant events that have occurred when they were not paying attention to the display. For example, a medicine reminder service may post a note about taking the pills, or a new message sent to the display may stay there until the person acknowledges having seen it. A temporary notification may be posted to alert the person for lower priority or transient events, such as an update on the content of one the services.

3.3   Content Management

The key feature in the iiD is the content to be presented. Content Management is thus a key part of the service design. Content Management for the iiD should address the following features:

- Create the content items form its sources:

  - RSS image feeds;

  - RSS text feeds;

  - External Applications;

- Calculate the relevance of a content item.
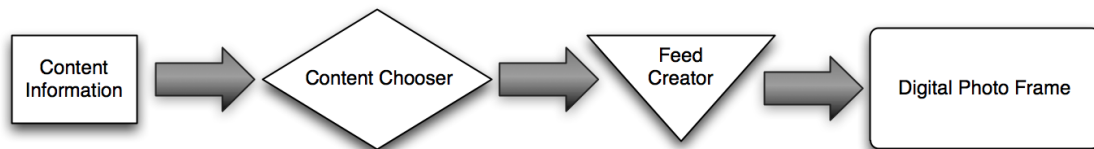
- Schedule the content items to be displayed.

Figure 3.1: Content information flow

From a information flow point of view the service will normally function in way similar to this: the user chooses the sources of the information, such as feeds, webpages, home services and photographs, in the display config interface. The user must classify these sources and this classification will influence the content chooser. After the content chooser decides the content to be displayed, the feed creator will create the feed that will be shown. The information, like the sources, their classification, list being displayed are all stored in a database. The path explained above will deviate when the user interacts with the service; these interactions will affect the content chooser. The content chooser will have to recalculate the relevance of the information and display the information accordingly. For instance if the display is showing information from a newspaper and the user decides to skip it, and if this kind of information was already skipped several times, the content chooser may decrease the relevance of that type of information in general.

3.4   Integration of external content

The iiD should not just be a place for presenting pre-defined content but rather a system that could be permanently retrieving content from multiple sources of any kind and integrating them into a coherent information stream. To comply with the characteristics of the photo frame, the content must be transformed into images. This integration should address the following features:

- The external applications must adapt their content to be displayed in the iiD.

    - The external content accepted by the iiD system must be in a RSS feed.

- The external applications are responsible for the security of the content and the RSS feed.

3.4.1   Service management Model

The iiD can only be used as part of a larger service that includes at least the server that will respond to the image requests sent by the photo frame. The service management model defines how this association can be created and what are the steps that need to be taken to associate a newly bought photo frame with a particular service specification created at the server. This service management model should address the following features:

- The users will have to have an iiD account.

- The users must configure their system:

    - Choose pre-defined content

    - Add custom content

    - Classify the content by relevance

- Use their private RSS address in the digital photo frame

Chapter 4

System specification

In this chapter we are going to describe the service, its behavior, its interaction modes and the iiD prototype implementation. It starts with the functioning and behavior of the service, we will begint by describing the different interaction events and finish by explaining several modes of the service. Following that, we will write about the architecture of the service explaining how the components are divided and how they interact with each other.

4.1 Service Overview

This work is based on the assumption that a digital photo frame can be configured with the URL of an image feed and that the photo frame will then use HTTP to obtain that feed and each of the individual images referenced in it. The photo frame may start iterating through the photos in the feed, but it may also support explicit control of the presentation sequence through interactive controls. The most common form of interaction supported by photo frames is the existence of push buttons to switch between photos, allowing the viewer to explicitly move back and forward in the photo sequence. These controls may also be available in the form of a remote control or in a touch-sensitive part of the display, but the essence of the interaction remains the same. Therefore, the choice to focus our interaction support on these capabilities was made, in order to guarantee that the proposed approach would be applicable across most photo frame products, regardless of the specificities of their interaction alternatives.

The RSS feed that each user has to access the service will contain a key element that makes it unique and is associated with the user.

```
feed:InteractiveInformativeDisplayService/UniqueUserKey/RSS
```

Associated to this RSS feed will be several images that the service will use. The frame will display these images that the service creates from the content items.

4.2   Interaction Support and Operation Modes

In order to enable to the user this type of interaction with the digital photo frame was created an approach, or method, that must ensure that it will work on the majority of the photo frames. The approach used is based on decoupling the back and forward buttons of the photo frames from their traditional iteration semantics. This is achieved by building on top of the HTTP requests generated by the photo frame an event model that supports other interpretations of the user interactions with the photo frame. When the photo frame requests an image feed, it receives a generic feed with N items (where N > 3) in which the urls corresponding to the images are simply indicating numbered names, such a 1.jpg, 2.jpg. and so on. As part of its normal operation mode, the photo frame starts iterating through the images, presenting a new image every T seconds. Assuming that the photo frame cache is disabled, every change in the displayed image results in a new HTTP request to the server. In its normal iteration model, this will mean that the photo frame will issue an HTTP request for the next image in the sequence after T seconds. However, if the forward or back buttons are used, different request patterns will occur and may be detected by the server to generate the three types of event described in table 4.1.

In its default state the iiD automatically chooses and presents new content. This mode is called auto mode. This mode can be associated with the content push interaction mode recognized from the scenarios. However while in the auto mode the iiD can change to several other modes: interaction mode, notification mode and temporary alert mode (Fig. 4.1).

4.2.1   Interactive Mode

The interactive mode is activated when the user interacts with the system using the rewind and forward transition events. These events will make the service enter in the interaction

Table 4.1: Requests and Events

HTTP request received in the server	Events generated
Previous image in the feed sequence	**Rewind :** This event occurs when the server receives a request for the previous image in the feed. This event can be interpreted as an indication that the user has pushed the back button.
Next image before **T** seconds	**Forward :** This event occurs when a request for the next image arrives before the expected time. This event can be interpreted as an indication that the user has pressed the forward button on the photo frame.
Next image after **T** seconds	**Timed next :** This is the event corresponding to expected request for the next image in the feed sequence. The arrival of a request for the next image, within the expected time between images, can be interpreted as being part of a normal iteration process when the photo frame automatically requests the next content to be displayed.

mode because of the next scheduled request to the service. After the service detected an off timed request, it will adapt the presented items. If the users makes the forward request the iiD enters in the shortlist state. If the users' press rewind the iiD enters in the menu state. This mode, and subsequently its sub-modes, relates to the "content pull" interaction mode that was elicited form the scenarios.

Short-list sub-mode

The Short List state allows the user to choose the next content from pre-defined favorite content items. In this state, the user choose the content items by scrolling through a list with the forward transition and rewind transition event. When the user stops using the transitions, i. e., when it reaches the intended content, the iiD will show this content for a greater period of time before resuming to auto mode. This waiting is represented with the "wait state" in the Short List sub state machine (Fig. 4.2).
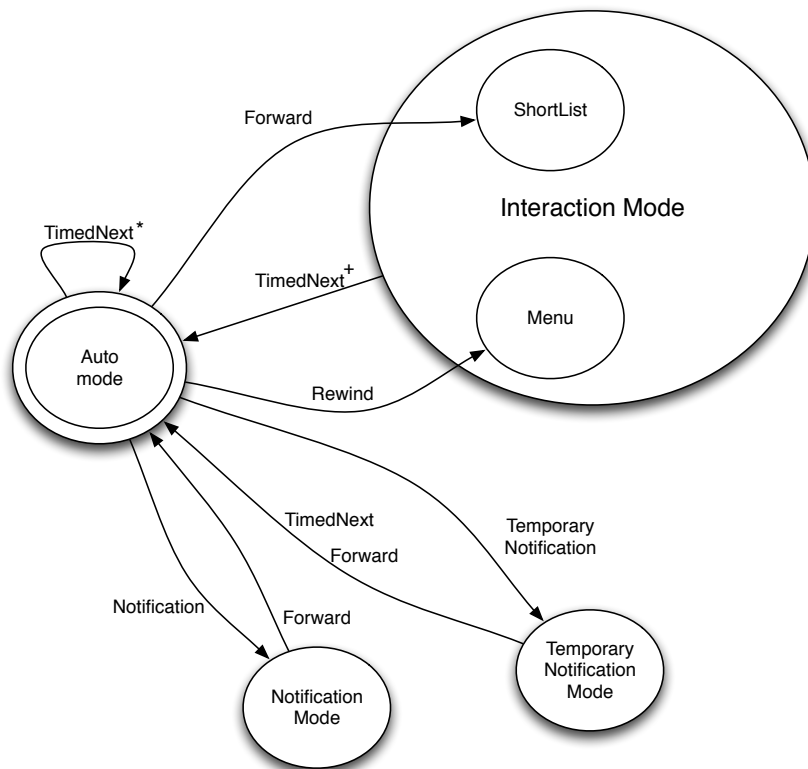
Figure 4.1: The iiD modes.

Menu sub-mode

The menu state allows the user to choose the next content by navigating trough a menu. The
navigation will use the Forward and the rewind transition events. Because of only using
two transition to navigate the menu, the interaction is similar to a binary tree. Figure 4.3
represents a three layer balanced binary tree menu. Just like in the short list state, the user
chooses the content by not interacting with the frame and, also like the short list sub-mode,
the service will show the chosen content during a longer period of time

4.2.2   Notification Mode

While the interactive modes required a user interaction to be activated, the Notification
mode requires a Notification transition from the service, This kind of transition is used
when a high importance content is updated, such as receiving a new email. This mode
is a direct translation from the notification interaction mode defined in the last chapter.
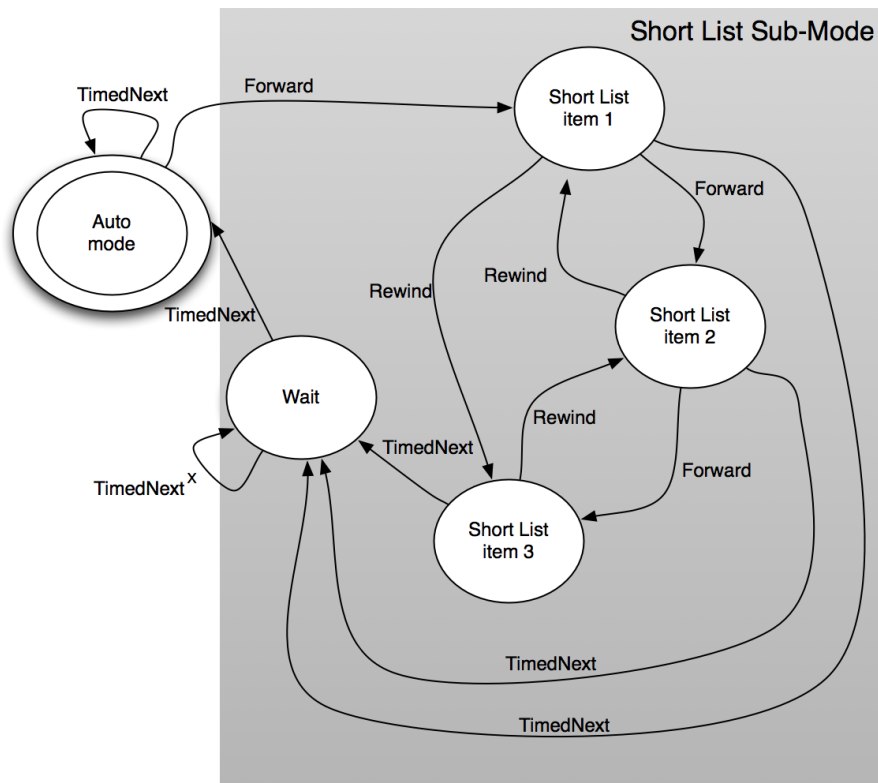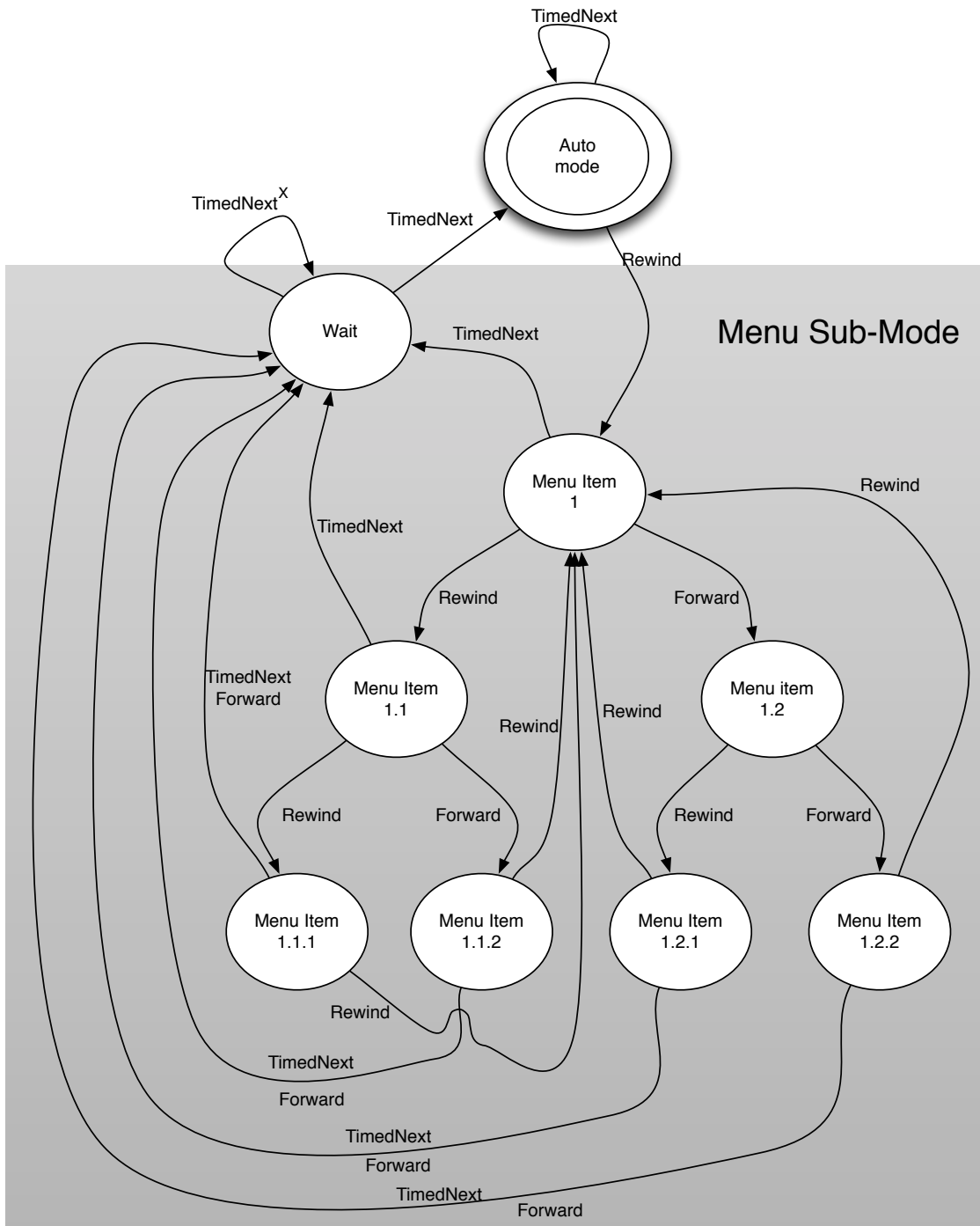
Figure 4.2: Short List sub-mode state machine.

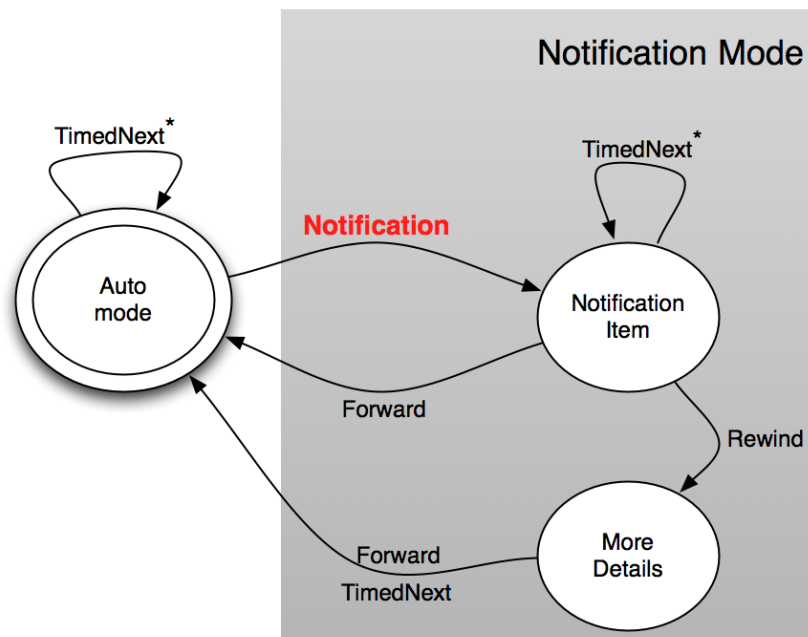Figure 4.3: Menu sub-mode sate machine.

Figure 4.4: Notification mode state machine.

Furthermore, this mode will not allow the service to automatically return to auto mode as it requires a user interaction to leave the interactive mode (Fig. 4.4).

4.2.3 Temporary Notification Mode

Similarly to the notification mode, there is the temporary notification mode. This event resembles the notification mode because it locks the screen with a Notification. This mode is an adaptation, even if an already envisioned one on its definition, of the notification interactive mode described in the scenarios. However, this mode, unlike the notification mode, allows the service to switch automatically to auto mode after a certain amount of TimeNext events (Fig. 4.5). This mode also requires a special service transition to be activated. In this case a temporary notification transition that is triggered, in this case, by a medium importance content update.
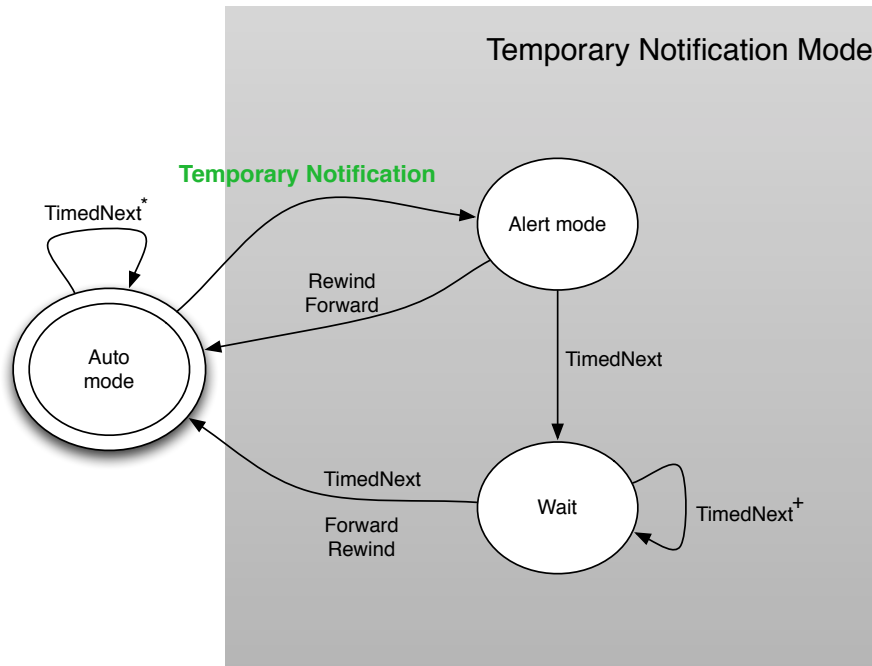
Figure 4.5: Temporary Notification mode state machine.
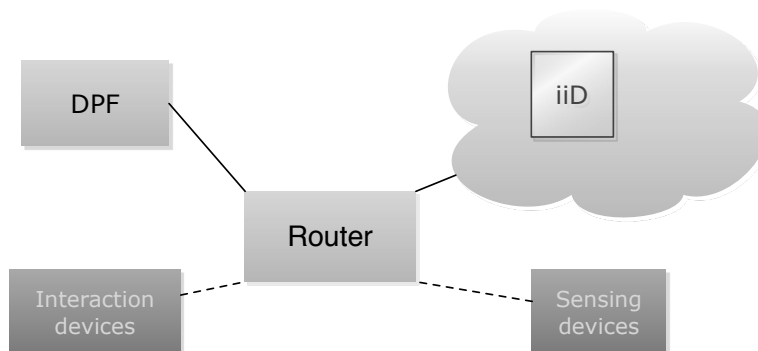
Figure 4.6: The iiD components.

4.3 Web server architecture

The iiD system is constituted by several components ranging from the iiD service to the digital photo frame (Figure 4.6). The iiD service is a web server mostly implemented in ASP.net technology and based on a Model-View-Controller pattern [Burbeck, 1997]. The Controller interpreters the HTTP requests received from the photo frame and instructs the view and the model to adjust as required. The view runs the presentation of information.

In this case, it is the RSS feed that is displayed on the photo frame and the content that gets inserted into the feed images items. This feed always remains the same, Changes occur only in the content, that is presented in the form of images. The model can be informally described as the system status. In this case the data model is composed by a set of content services, each being able to provide information for a particular set of content items. Figure 4.7 represents the main elements of the server architecture and the interaction between them.
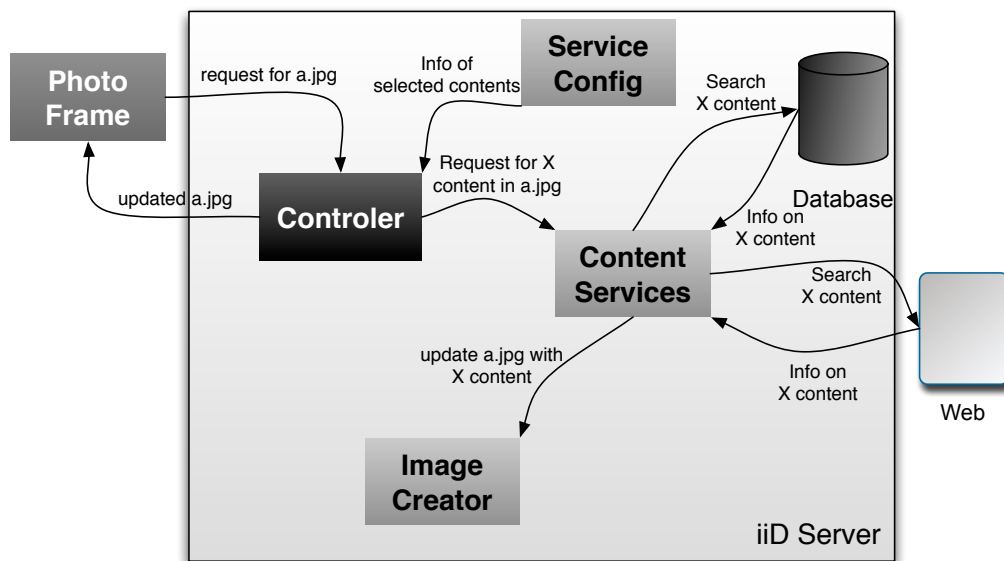

Figure 4.7: The iiD server Architecture.

The Content Service modules manages the information services that generate the content to be displayed. These are mostly simple web applications developed in PHP specifically for the prototype. While any kind of existing application could have been used, the visualization specificities of the small photo frame display dictate a need to create more appropriate visualizations. The applications available on this prototype were an e-mail application that triggers an alert event when an e-mail is received and a Facebook application that sets off an temporary alert event when it detects a new profile message. The user can select which content service to activate using the Service Config. Each service will be able to generate content items in the form of images. To support this process, an image creator can be used and it will take a snapshot of the service content and render it as an image. When an HTTP request is received, corresponding to a particular JPEG image, the controller determines the corresponding event and decides which content will be show next.

The corresponding service will be contacted to obtain the content and the image will be returned to the photo frame.

One other component of the system is the router. It guides the information from the home services and it can also be used like a failsafe in case of break of the Internet connection, by storing some emergency content in a cache. The devices that the user can use to interact with the service can be linked to the gateway to connect it with the service, such as a remote control. However, a device like a mobile phone can also interact with the service without using the router connectivity. The interaction devices and sensing devices are optional features, the system can still function with the absence of these components. The home services and the WWW services are the sources of the information that is going to be displayed on the photo frame. Home services can be systems like ambient assisted living services, and www services can be news and weather reports, other RSS feeds and webpages. The home services will use information from the sensing devices that are connected with the router.

4.3.1   Service Structure

The iiD service will be structured in the standard tree Layer architecture, the layers being: the presentation or graphical user interface layer, the business or logic layer and the data layer. In this service the presentation layer or the GUI was constituted by the display config and the feeds of the frame. The display config will be a website and the feeds will be RSS feeds. The technologies used in presentation Layer were ASP .net. The logic layer controls the application, serving also as a link process data between the presentation layer and the data layer and it makes logical decisions and evaluations. In the logic layer was implemented all the functionality of the service. This layer was implemented in C# .net. The third layer was the data layer. The data layer consists of the database of the service. It is the repository of the data from the users and from content, including the current relevance of the content. This layer was implemented in a SQLServer database. The several components of the layers interact between themselves by using a Model-View-Controller model. This interaction was implemented in MVC .net.
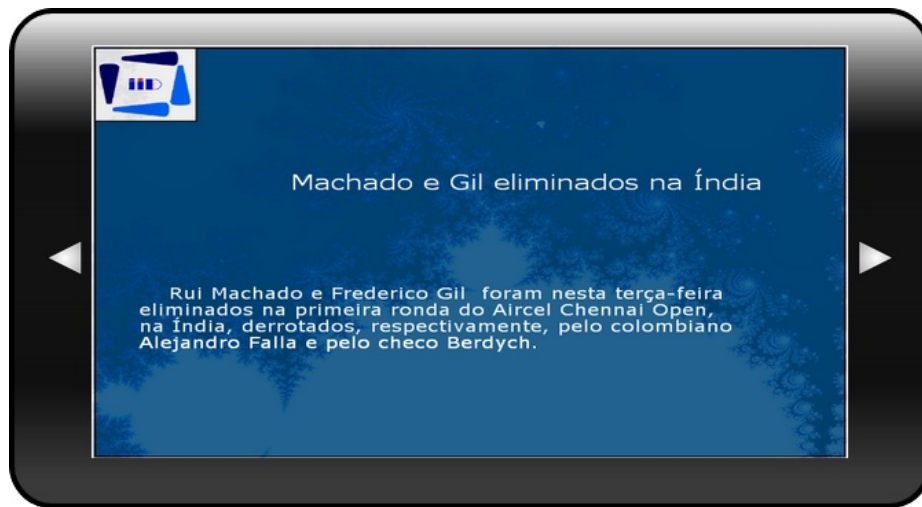
Figure 4.8: A digital photo frame using the iiD service.

Presentation

The presentation layer of the iiD system is divided in two parts: the feed that the users see in the digital photo frame and the display config. The RSS feed varies according to: the list of content to be displayed; the interaction transitions such as, the notification transition; the interaction input from the user. Content relevance may induce the RSS feed to change via alterations in the order of content list to be presented. In figure 4.8, for instance, the feed presents news from a popular news paper website.

The display config includes several webpages that consist in the backoffice of the service (Figure 4.9), from the initial login page to the display configure page. The pages that constitute the web site are: the login page, the initial page presented where the user must authenticate to access the functionalities of the display config component; the main page where the user can access all the functionalities of the display config and also consult the queue of the content; the add content page, where the user adds new content to his home display; the remove content where the user removes one or several content of his service; the edit website that the user accesses to change information relative to some content; and finally, the configure page where the users access the information of his home display service URL and other information relative to his service.
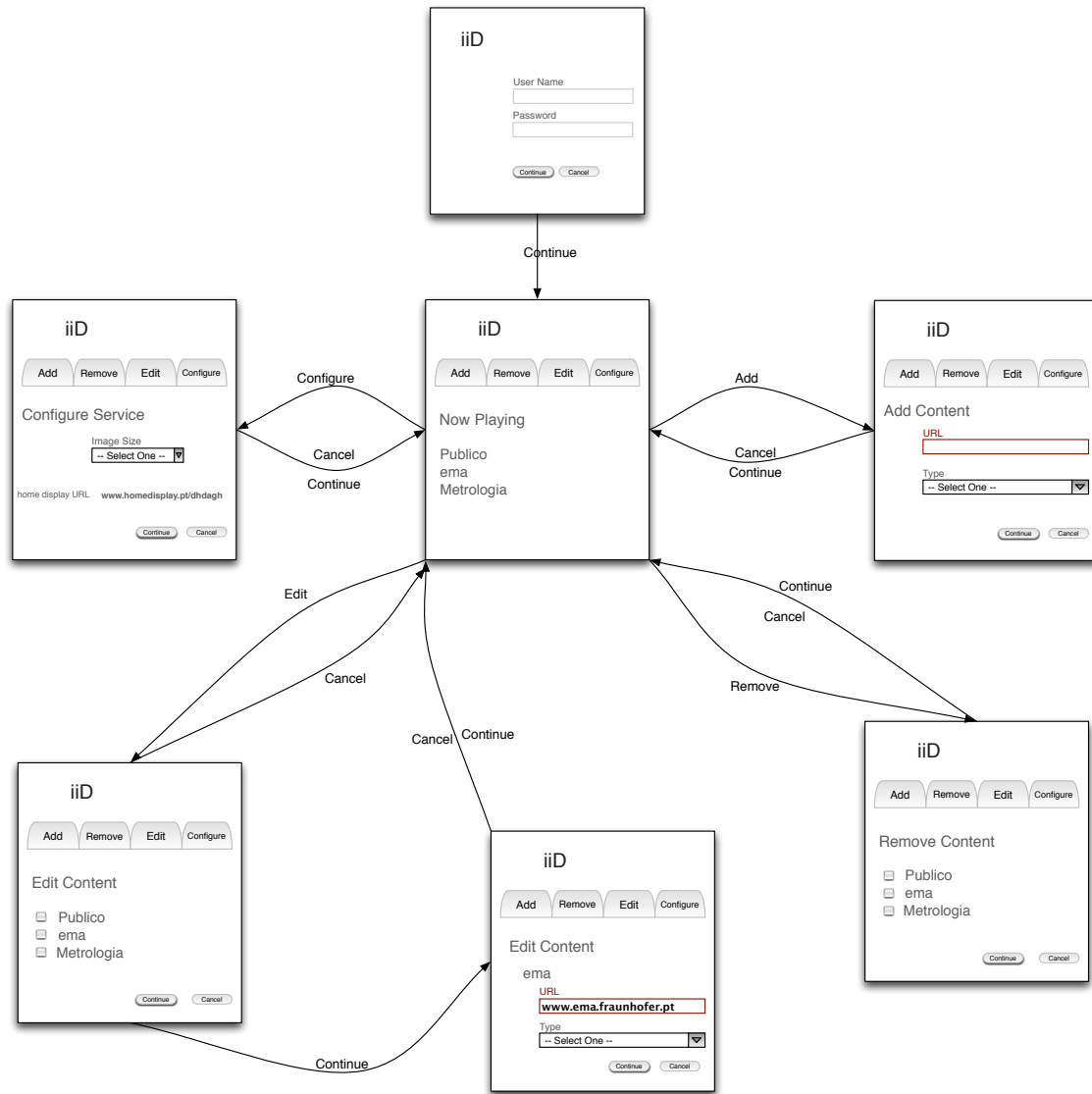
Figure 4.9: The iiD configuration website.

Logic

The logic layer is responsible for the home display's functionality. Most of the iiD components are included in this layer, such as the image creator or the content services. It updates the content list: when a user inserts new content using the service config website; and calculates the next item form the list to be displayed. It also creates the images from the content sources that will be presented in the RSS feed.

The component that controls this image creation feature is the image creator. This component can: adapt the content of a text based source to the default iiD appearance; create a screenshot image of a website, to create this image a external service is used, such as Thumbalizr. If the source data is already image-based it does not tamper with it, it is displayed directly on the photo frame. In order to discriminate between these two types of content data sources, this component also includes a simple parser. This parser is also used to retrieve the content data from some of the text-based sources.

One main function that the logic layer is responsible for is the interpretation of the user's interactions. It is able to determine which button is the user pressing and what it means. For example, it must differentiate a Timed next from a Forward event. It distinguishes these events by calculating the expected time for a new image request and match it to the request time.

Other iiD feature that is controlled by this layer is the scheduling of the content. It is in this layer that the service will interpret the transitions that affect the basic relevance of the content list order. Transitions such as a Notification transition also affect the image creator component. It will change from the default image usually presented with this content to another one that attracts more attention. This will allow the user to rapidly notice the transition and act accordingly.

Data

The data layer will be responsible for storing all the information. This layer is responsible for the access to the database and for the database itself. The information will be stored in a database implemented in SQLServer.

The database will consist on mainly two large entities: the content where all the information about the content will be stored, from the provider URL to relevance information; the other entity is the user, where will be stored information about the user, from the lo-

gin information, username password, to his personal home display feed URL. Figure 4.10
represents a Chen entity-relationship diagram of the iiD database.
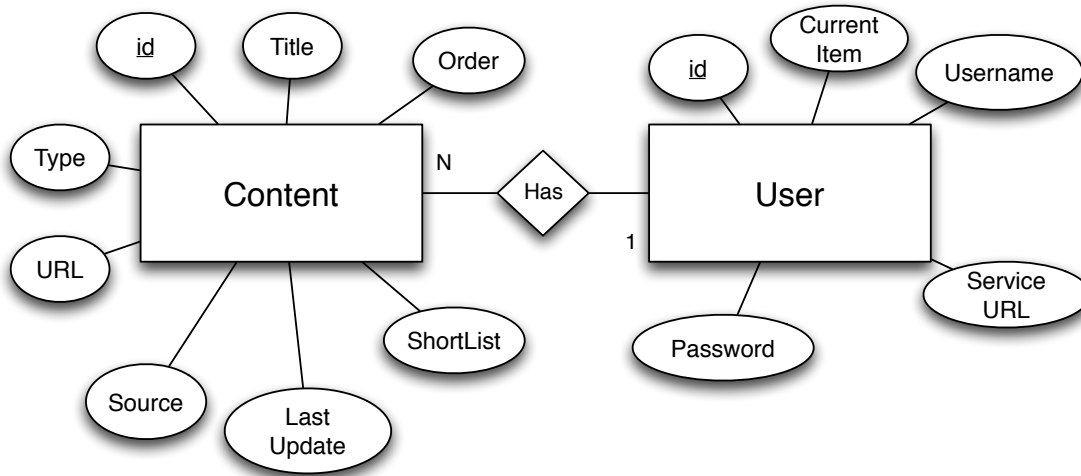
Figure 4.10: The iiD database.

4.4   Integration with Content/Applications

Table 4.2: Possible Applications

Mail Checker	This will alerts the user when a new email arrives at his inbox.
Sports results	This shows the latest sport results.
EMA	This will be connected to the EMA application to and relevance to drastic change in energy consumption.
Remember	This will allow the user to create reminder notes, that will set off at a given period of time.
Weather Report	This will inform the user about the weather status.

As mentioned in the previous chapter, the the iiD should not just be a place for presenting static content, but a service that would retrieve its contents from various sources. It should integrate the information of the various sources and present it in a way that is appropriate for the medium.

In order to generate more content for the iiD service, several small content generators applications were drafted. Table 4.2 describes the applications initially drafted for iiD. However, other application were designed after this initial draft. This applications would take advantage of the established market of social sites. Examples for these kind of applications are a Facebook application and Twitter application. Further exploration, about the applications that were implemented is delivered in the next chapter, the evaluation chapter.

Other that these small applications the iiD service can also collect data from already existing RSS feeds that can be interpreted with the iiD image creator parser.

Chapter 5

Evaluation Methodologies and Results

Any type of project with real world application, or directly linked to a product, must be properly evaluated to predict some probability of real world success. So, in order to evaluate both the application and the concept, an evaluation scenario was designed. In this chapter, it is explored the evaluation process, it is described the prototyping, the evaluation setup, the evaluation objectives and the chapter finishes by reporting and discussing the results of the evaluation.

5.1   General objectives of the evaluation.

When preparing the evaluation of the system, several evaluation goals have been identified. The use of these general objectives coupled with the results of the evaluation, will determine an estimate level of success of the iiD system.

- Evaluate the general acceptance of users.

- Discover the preferred content for users.

- Elicit feedback about the product.

- Test the usability of the product.

- Probe for new ideas for the product.

5.2   Prototype

To validate and gain additional insight into the proposed approach, we have developed a prototype implementation of the iiD system interactive service for photo frame. The implementation will not feature all of the iiD system components. The prototype only features what was considered as a minimum for its use work and therefore, the minimum to be tested.

This minimum includes the image creator, the content services and the controller, leaving the service config without an implementation. The content services with the image creator can parse content from RSS sites. For other content sites, some external applications, that would transform the content in order to be used by the system, are needed. To demonstrate these kind of applications several small ones were created. These applications were chosen from the drafted application described in the previous chapter. The applications were the mail checker, in this case using a Gmail inbox, a Facebook mural retriever and a twitter retriever. They are all very simple applications, the gmail inbox, for instance, retrieves the last received message. The system then verifies if it is a new message, if this is the case, it will trigger a notification transition. The Facebook application is very similar to the twitter one. They both fetch the last message received, on Facebook it's the last message on the wall, and if this message is considered new by the system, a temporary notification transition is set off. Figure 5.1a is a example of a retrieved content from the gmail application in notification mode.

Other content was displayed on the system but it did not need a dedicated content transforming application, those content sources were a Flickr feed, a newspaper feed and several blog feeds. If the content is from Flickr, it is shown without transformations. If it is from a RSS text based source, such as news paper site, the text of the last news is parsed and then transformed into the default iiD content image. Figure 5.1b is a example of a retrieved content from the a newspaper RSS feed.

The prototype was implemented, as according to chapter four, using MVC .net, and the content transforming applications were implemented in php.

The prototype was initially supposed to use a digital photo frame to present the content. This would allow a better understating of how users would react to the iiD system by using a prototype that would be nearly identical to the intended final product.

Cache Issue

A potential technical limitation that we have identified with the photo frame that was initially used was that, even with the cache disabled, the device would still use the cached images instead of retrieving the images from the server. And so the service would be ineffective, since this issue would nullify the user interaction aspect of the iiD system. While this may not necessarily be the case with other photo frame models, the details of cache management are not normally available in the technical information about photo frames, representing a major obstacle to the selection of devices with the appropriate characteristics. As a consequence, for the purpose of this evaluation we have decided to emulate a photo frame using a touch-screen device and a web application that will emulate the look and feel of the intended final product.

This touchscreen was linked to a nettop PC that was hidden from sight. This nettop PC ran on Windows 7 operating system and the prototype was displayed on a Chrome browser at Fullscreen. An example of the prototype is encountered in Figure 5.1a. In this example is possible to notice the two arrows at the side of the screen, these represent the DFP buttons. It is from these representations that the Forward and Rewind events are launched.

5.3 Evaluation Setup/Procedures

The real word deployment of the application was in the laboratory of the Department of Information Systems of the University of Minho. The evaluation experiment used a small touch screen as an interface between users and the system. The iiD system used several information sources related to the environment, such as the Facebook and blog page of the laboratory group, an email address included in the group's mailing list and several news pages and blogs. A main user was also identified. This user was instructed to interact with the system and to register his own impression about the system. The deployment occurred during one week. The information collected from this real world deployment was in the form of system logs and interviews. These logs have information such as the user interaction time and most and less seen feeds. Only the information collected in the working hours of the laboratory was considered. These kind of information can be used to add more alternatives to the most used feed For example, if the most seen feed is from a sport newspaper, it is possible that adding more sports newspaper as sources for new feeds is something desirable to the users. From the interviews, feedback about the features

that the main user would like to be changed, added or erased was collected. From the user interaction time, it can be calculated the relative success or failure of a future product, simple because it measures if the intended/target public will use it or not. This first type of evaluation is useful to measure the acceptance of the product in this particular scenario. After the deployment, a usability heuristic evaluation of the system was also conducted. This heuristic evaluation complemented the usability feedback from the interview.

(a) Inbox   (b) News Feed

Figure 5.1: Example of content presented in iiD

5.4   Results

After the experiment, an elicitation of the results was conducted. This elicitation resulted in various types of results, divided by the means of evaluation. The main method used to receive information about the experiment was the user interview. These means allowed a direct feedback from the main user. That had enabled the pinpointing of several issues that could be fixed in a new prototype or the subsequent product. Figure 5.1 shows two examples of the prototype used in the evaluation experiment.

5.4.1   User interview

Following the evaluation experiment it was conducted an informal interviews in order to receive feedback regarding the system. After the interviews with the users, several possible changes/improvements were listed, such as:

- Improving the overall appeal of the view or the size of the fonts used in the body of the text contents;

- Adding a sense of progress trough the content list, by incorporating some kind of visual aid to the content, like a "2 of 15" information;

- Improving the information of the contents, specifically adding the source of the content;

- Easing the interaction in the menu and shortlist modes by adding the titles of the contents that will appear if the forward or rewind buttons are pressed.

5.4.2 System logs

To complement the feedback from the users, the log files from the system were also analyzed. These logs collected information while the prototype was on site. Only the periods of time between the work hours of the Laboratory were considered. In these logs we found that only 1,3% of the run time was used in either shortlist or menu mode. These 1,3% are divided in 1% for the shortlist and 0.3% for the menu. These readings were made by calculating the total time in each modes. The metering for each mode interaction would start when the first event of each mode was triggered trough the last time it was observed before the system returned to auto mode. In terms of creating attention to itself, in other words, the time that it took until someone interacted with the display after an alert was triggered, was, in average, 8 minutes and 39 seconds. This time was calculate by adding the total time in which the system was in Notification mode and dividing it by the number to times that the mode occurred.

5.4.3 Evaluation using heuristics

When designing a system/product, usability is always a major concern so usability heuristics were consulted in order to complement the evaluation. In this case, it also serves the purpose of finding potential usability issues that were not recognized by the user. For this evaluation, the usability set of rules used was the Ten Usability Heuristics by Jakob Nielsen [Nielsen, 2005]. These heuristics are:

- **Visibility of system status:** The system should inform the users of its events. The system passes this heuristic because always informs the user in when it changes modes.

- **Match between system and the real world:** The language of the system must match the one employed by the user. This is achieved because all of the system content is chosen by the user. The only possible threats to this heuristics would be the names of the mode of the system. However, these names are quite standard, and so known to the user.

- **User control and freedom:** The user must have an emergency exit from each state in order to easily recover form unwanted situations. The system implements a universal exit from every state, the timed next transition. This allows the users to only wait some time, to exit an unwanted state.

- **Consistency and standards:** Terms used in the system must not have different meanings to the user. The system accomplishes this heuristic by following conventions.

- **Error prevention:** Eliminate error prone situations. This system achieves this heuristic by always providing a transition from each state to every user interaction.

- **Recognition rather than recall:** User should not be forced to memorize information from the system. iiD fails this heuristic because it requires the users to memorize its interactive mode for a more fast navigation.

- **Flexibility and efficiency of use:** Allow advanced users to speed up their interaction trough the use of accelerators. The system fails this heuristic.

- **Aesthetic and minimalist design:** Do not overcharge the user with unnecessary information. The design of the iiD complements the information from the content data source with information only enough to achieve the first heuristic.

- **Help users recognize, diagnose, and recover from errors:** Error messages must be written in an language that the user understands, and it should include instructions for a solution. This was not achieved.

- **Help and documentation:** The system should provide the user with help and documentation. This heuristic was not achieved.

After analyzing the iiD system with the heuristics, these are the ones that the system fails: Help and documentation; Flexibility and efficiency of use; Help users recognize,

diagnose and recover from errors and Recognition rather than recall. These failed heuristics and all the other feedback will be discussed in the next section.

5.5 Discussion of the results

A deployment was made using this functional prototype and data was collected using the system logs and an interview of the main user of the system. Even though the total time spent in interaction mode was less than expected and the average time of response after a notification was, on average, quite long, the deviation on the time of response to a notification was quite big, ranging from 13 seconds to 18 minutes. The low interaction may be related to information elicited in the interviews that state that a better looking and more informative interface would allow an increase of the usability of the system. So if these changes were done the interaction mode time number would increase and average time of response would decrease.

Several of the usability heuristics were very hard to apply to this type of system. One of these heuristics is the "help and documentation". This particular heuristics failed in this system, as the iiD does not provide help and documentation to user. The particular solution to this problem is not very gracious, it is the use of one content space to display help information. For example, this content could be the first content presented in the menu sub-mode. However, by defaulting this kind of content, more advance user would be annoyed. Furthermore this heuristic, in this system, may clash with the "aesthetic and minimalist design" usability heuristic.

Other heuristic that is hard to apply to this system is the "help users recognize, diagnose and recover from errors". This heuristic is hard to apply because the digital photo frame, or in case of the prototype, the small screen, is designed to prevent errors. This coupled to small user freedom makes errors partially avoidable. However this heuristic, and the earlier, "documentation and help", are more easily applicable in the system config component of the iiD system.

"Flexibility and efficiency of use" is also hard to implement in this kind of system, simply because, in any given situation, the user only has access to three kinds of interaction: pressing left, pressing right or waiting for the next screen. This lack of user interaction possibilities limits the possibility of offering advanced user shortcuts. The only kind of shortcut available to the user are trough memorizing the menu mode or the shortlist mode.

And this kind of shortcuts violate the "recognition rather than recall" heuristic. As also mentioned, for the other usability heuristics, this heuristic is more applicable to the system config component.

"Recognition rather than recall" is another heuristic that is very hard to implement in this kind of system. This is because the user must use his memory in order to navigate the menu mode of the system.This happens because of how the mode was designed. It results from its binary nature that always eliminates half of the content in each decision. This forces the user to memorise the menu in order to navigate it properly.

Chapter 6

Conclusions

The iiD system is designed to augment digital photo frames by enabling their standard interactive controls to become interactive features for remote content. This is achieved without any changes to the original digital photo frame firmware, which represents a major opportunity for unleashing photo frames as general purpose displays. Their off-the-shelf nature and the simplicity of their interaction model can make such photo frames easily adopted to other scenarios not explored in this document such as AAL scenarios. To evaluate the service, it was created a working prototype. However, because of technical issues, it did not use a digital photo frame as medium to interact with the user. Nevertheless, a working prototype using a small touch screen was created.

The results have demonstrated the viability of the concept, but the actual deployment of the system has also shown that the black-box approach with which most photo frames handle cache management may constitute a major obstacle to the selection of appropriate photo frame models. The results have also shown that several usability issues exist, some of them are easy to fix while others might take a carefully though solution. However, the novelty of this kind of system is undeniable. The ability of a system using a generic digital photo frames to display content and allow the user to interact with it, is such a novelty that allowed the proposal of a new patent from it.

After analyzing the objectives enumerated in the first chapter, it is noticed that several of them were fairly met, such as the study and characterization of the available interaction space in digital photo frame based scenarios, the specification of a service that enable arbitrary interaction with remote content displayed on digital photo frames and the implementation of a working service prototype that enables an evaluation of the service. How-

ever, the specification and implementation of a content configuration service, that allows
the definition of the various presentation contents and the presentation parameters objec-
tive, was not implemented. The use of a digital photo frame as an awareness mechanism
about the state of the other services and devices in the eco-system was not fully explored.
It was defined an interaction model but appropriate guidelines for new applications were
not defined.

6.1   Future work

The most immediate future work that ought to be made is to complete the implementation
of the prototype by creating the content configuration service, allowing one more objective
to be met. Other more immediate work is using the feedback elicited from the user, change
the interface allowing a better user experience from the user. This new visual interface
should be tested by user to evaluate its effectiveness. But all this work is only extending
the functional prototype, so the next big step in this project is to, after resolving the cache
issue with the photo frame, migrate all the implementation. This would allow a evaluation
closer to the initially viewed system. This evolution would allow a better real-world de-
ployment in home settings, allowing additional environmental factors to be accessed and
validating the interactive features with other target groups in other scenarios. Issues like
the authentication in the data access, that have remained untouched in this project should
be also addressed in future work. Other issues that could be addressed in the future work
is the development or adaptation of usability heuristics that would be better suited to this
kind of interaction.

6.2   Publications

Using the work reported in this dissertation, a publication was presented in the Ambi-
ent Assisted Living Third International Workshop, IWAAL 2011, Held at IWANN 2011,
Torremolinos-Málaga, Spain, June 8-10, 2011 [Bravo et al., 2011]. Also employing the
work done in this dissertation as a base, a patent was filed in the Portuguese Institute of
Industrial Property[1]. This patent is currintly being worked on and it is a request of patent.

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[1]http://www.marcasepatentes.pt/

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