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Evaluation, redesign and implementation of a system to support early dementia contexts



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Dissertação de Mestrado em Informática – Especialização em Engenharia de Software

Trabalho realizado sob a orientação da Sra. Prof. Doutora Paula Alexandra Gomes da
Silva



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Abstract

Everywhere in the world, population ageing is perceived as a double-edged sword. While it does show an incredible perseverance of the human race and its ever-growing feats, it constitutes a problem when observed from the point of view of health care systems and governments. The current situation of a declining economy puts an even greater strain on the difficulties that nations need to overcome.

As people age, they experience changes related to perceptual, motor and cognitive systems. In these scenarios, chronic conditions are more likely to develop. Dementia is one such condition, notable for being very frequent and highly impacting to the lives of the elderly. Alzheimer's disease (AD) is the most common type of dementia and causes people to progressively lose their ability to live independently. Caregivers are thus essential to help them overcome a wide variety of obstacles, but in order to do that, they too struggle psychologically, socially and financially.

This dissertation focuses on the design, evaluation and development of technology to aid in dementia contexts, namely to people with early-stage AD and their caregivers. It builds upon a previous project in which a system called mobileWAY was partially designed and tested and not at all implemented. mobileWAY explores the concept of caregivers using a mobile application that can connect with the TV at the home of, and watched by the dementia-affected persons. The system enables caregivers to communicate information to the dementia-affected persons regarding who they are, their whereabouts and how long they will take until returning to the home of the dementia-affected person. In this dissertation, the initial version of mobileWAY is tested again, redesigned and improved, and a working prototype is developed and tested. This project encompasses the areas of Human-Computer Interaction (HCI) and Software Engineering.

During the project's development, a user-centred design (UCD) approach was followed and combined with agile methodologies to achieve the final working prototype. The project contributes with a tested system prototype that follows adequate design guidelines and best development practices. The system was systematically evaluated and makes use of state-of-the-art technologies that include an Android-powered tablet device and Google TV to provide support in the scope of dementia, which is a difficult yet increasingly important area of research.

Keywords: Human-Computer Interaction, User-Centred Design, Dementia, Alzheimer's Disease, Caregiving, Software Engineering, Assistive Technology, Android, Google TV.

Resumo

Em todo o mundo, o envelhecimento da população é encarado como uma faca de dois gumes. Apesar de demonstrar a incrível perseverança da raça humana e das suas crescentes proezas, ela constitui um problema quando observada através do ponto de vista dos sistemas de saúde e governos. A situação atual de uma economia em declínio coloca uma tensão ainda maior nas dificuldades que as nações necessitam de ultrapassar.

À medida que as pessoas envelhecem, elas sentem alterações relacionadas com os sistemas perceptivo, motor e cognitivo. Nestes cenários, as condições crônicas têm maior propensão a desenvolverem-se. A demência é uma dessas condições, notável por ser muito frequente e altamente impactante para as vidas dos idosos. A doença de Alzheimer é o tipo mais comum de demência e leva as pessoas a perderem progressivamente a capacidade de viverem de forma independente. Os cuidadores são assim essenciais para os ajudar a ultrapassar uma vasta gama de obstáculos, mas ao fazê-lo, também eles se debatem psicologicamente, social e financeiramente.

Esta dissertação foca-se no desenho, avaliação e desenvolvimento de tecnologia para ajudar em contextos de demência, nomeadamente a pessoas na fase inicial de Alzheimer e aos seus cuidadores. Ela tem por base um projeto anterior em que um sistema denominado mobileWAY foi parcialmente desenhado e testado e não foi, de todo, implementado. O mobileWAY explora o conceito dos cuidadores utilizarem uma aplicação móvel que se pode ligar à TV em casa das pessoas afetadas por demência, e vista por elas. O sistema permite aos cuidadores fornecerem informação a essas pessoas relacionada com quem são, onde estão e quanto tempo vão demorar até regressar a casa delas. Nesta dissertação, a versão inicial do mobileWAY é testada novamente, redesenhada e melhorada, e um protótipo funcional é desenvolvido e testado. Este projeto engloba as áreas de Interação Humano-Computador (IHC) e Engenharia de Software.

Durante o desenvolvimento do projeto, seguiu-se uma abordagem de desenho centrado no utilizador combinada com metodologias ágeis para atingir o protótipo funcional final. O projeto contribui com um protótipo do sistema testado que segue linhas orientadoras de desenho adequadas e as melhores práticas de desenvolvimento. O sistema foi testado sistematicamente e faz uso de tecnologias do estado da arte que incluem um dispositivo tablet equipado com Android e a Google TV para fornecer suporte no âmbito da demência, que é uma área de investigação difícil mas com uma importância crescente.

Palavras-chave: Interação Humano-Computador, Desenho Centrado no Utilizador, Demência, Doença de Alzheimer, Prestação de Cuidados, Engenharia de Software, Tecnologia Assistiva, Android, Google TV.

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Abbreviations and Symbols

AAL	Ambient Assisted Living
AD	Alzheimer's Disease
ADT	Android Development Tools
API	Application Programming Interface
AT	Assistive Technology
HCI	Human-Computer Interaction
HTML5	Fifth revision of the HyperText Markup Language
ICT	Information and Communications Technology
IDE	Integrated Development Environment
IP	Internet Protocol
MVC	Model-View-Controller
OS	Operating System
REST	Representational State Transfer
SDK	Software Development Kit
TV	Television
UCD	User-Centred Design
URL	Uniform Resource Locator
W3C	World Wide Web Consortium
XML	Extensible Markup Language
XP	Extreme Programming

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1 Introduction

An unprecedented reality is challenging humanity: the world's population is ageing at a very fast pace. Although being a testament to the huge improvements that have happened throughout the history of mankind, the fact that people are living longer poses significant problems to the world's economy and the sustainability of health care systems. Data from the United Nations (2010) shows that the number of older adults (60+ years) went from 205 million in 1950 to 737 million in 2009, which represents an increase by 3.6 times. Furthermore, predictions indicate that by 2050, the number of older adults will rise to 2 billion – that is nearly three times the 2009's number, representing 22 per cent of the world's population. In Europe alone, almost 35 per cent of the population will be 60 or more years old, making it the continent with the highest ratio of older adults.

As people age, there are many changes they go through. Older adults are likely to experience perceptual, cognitive, motor systems as well as psychological and social declines (Fisk, Rogers, Charness, Czaja, & Sharit, 2009); (Charness & Schaie, 2003); (Peters & Morrison, 1999). Chronic diseases such as heart disease and cancer are also more frequent among older adults. As shown by the National Center for Chronic Disease Prevention and Health Promotion (2010), chronic diseases “are among the most common, costly, and preventable of all health problems in the U.S.”, being the leading cause of death and disability in that country. The World Health Organization (WHO) furthers this information by stating that chronic diseases represent 60 per cent of the world's deaths, and “are by far the leading causes of mortality in the world” (World Health Organization, 2011). Recently, the WHO published a recent report stating that non-communicable diseases are the leading causes of death worldwide, having represented 63 per cent of all deaths in 2008 (World Health Organization, 2011).

The facts surrounding chronic diseases serve as a big warning for society. It needs to be aware of these problems and of the elderly, who need solutions to feel better, more integrated and happier. Chronic diseases are not going away; in fact, they greatly affect every country by challenging the effectiveness of health care systems and posing great threats to the global economy and society (World Health Organization, 2002). For this project, one particular chronic disease stands out for its impact on elderly: dementia. Dementia is a term that describes various brain disorders (Cayton, Graham, & Warner, 2002). This syndrome is caused by various progressive disorders “that affect memory, thinking, behaviour and the ability to perform everyday activities” (Wimo & Prince, 2010). Alzheimer's Disease International (2009) estimated that there would be 35.6 million people with dementia in 2010, and 115.4 million in 2050, an

increase by 3.24 times. Dementia-affected persons will require care at some point in their lives. Dementia care is a long process that significantly impacts the lives of caregivers, both at a physical and psychological level (Prince & Jackson, 2009). There are various types of dementia, but Alzheimer's disease (AD) is the most common. For example, in the United States, AD accounts for an estimated 60 to 80 per cent of cases – 1 in 8 Americans with or over 65 years of age has AD (Alzheimer's Association, 2011).

The reality of an ageing population world is making many people and organizations look for solutions which can prevent its vast impacts and enhance people's lives. This is where another element comes into play: technology has a big potential to serve as an enabler in introducing more reliable and helpful health care systems that will assist older adults (Center for Technology and Aging, 2009). In fact, technology that is designed to assist and improve functional capabilities of individuals with disabilities already exists – this is known as assistive technology, and was defined in the Assistive Technology Act of 1998¹. Studies show that these technologies are adequate in contributing to a more independent living of dementia-affected persons (Lauriks, et al., 2007); (Beech & Roberts, 2008), although the level of success in real life situations is still relatively small. In order to change this, there is currently a number of projects such as COGKNOW (Cogknow Limited, 2011) that aim to support people with dementia and reduce caregivers' stress. This project and others are described in section 4.2.

When looking at technology, the recent smart phone boom (Gartner, Inc., 2011) as well as the impacts tablet devices will have in the future of computing (Gartner, Inc., 2011) are definitely interesting. Moreover, studies have shown that mobile phones supporting health care display a number of advantages, such as portability and continuous communication (Free, Phillips, Felix, Galli, Patel, & Edwards, 2010). Hence, these devices present great opportunities of research in the scope of dementia-affected persons and their caregivers.

1.1 Problem Description and Context

An ageing society is something that defines our present world. Since ageing is associated with physical and psychological declines, health care systems need to give response to this ever-growing part of the population.

The impact of chronic diseases, and dementia in particular, on older adults raises the need to help them gain more independence and confidence, consequently improving their lives. Alzheimer's disease (AD), the most common form of dementia, is characterized by several stages

¹ Assistive Technology Act of 1998, Public Law 105-394, 105th United States Congress, November 13, 1998.

where the individual eventually stops interacting with the environment and loses the ability to carry a conversation or control movement (Alzheimer's Association, 2011). This evolution is accompanied by long-term care services, placing a heavy burden on caregivers. In this context, technology has proven to be capable to bridge the gap between the health care systems' cost and the well-being of dementia affected persons. By understanding the importance of Human-Computer Interaction (HCI) and using research methodologies related to user-centred design (UCD), it is possible to assess the needs of people in this context and thus make use of technology in forward-thinking ways that will enable not only improved support in this scope but also pave the way for better and smarter solutions in software engineering focusing this area.

1.2 Objectives and Motivation

This project focuses on supporting older adults with early-stage Alzheimer's disease (AD) and the informal caregivers that support them. The work of this dissertation builds upon a previous project, which was partially tested and not at all implemented: mobileWAY v1. mobileWAY v1 consists of a system in which caregivers, while out of the house, utilise a mobile device to send important information over to the TV of the dementia-affected person, which is at home. This information is related to the identification of the caregiver, the activity performed by the caregiver and the time that the caregiver will take to perform it; this is presented as the time remaining until the dementia-affected person has a caregiver in the house again. The system also considers optional messages to display to the dementia-affected person as well as multi-caregiver functionalities that allow every caregiver to exchange information.

This thesis will develop mobileWAY v1 further: new analysis, designs and evaluations of mobileWAY v1 will be performed to fine-tune details and subsequently develop mobileWAY v2. The project's main focus will be on the implementation of the tablet application as well as of the TV part of the system that will build upon the previously mentioned steps. Finally, mobileWAY v2 will be evaluated and validated with users. These different, yet related, sets of tasks – user interface redesign, implementation of the redesigned user interface and evaluation of the implemented system with end users – involve the use of a variety of methods related to the areas of HCI and Software Engineering.

Throughout this thesis previous work is going to be referred as mobileWAY v1 and the current implementation to which this thesis refers to as mobileWAY v2.

1.3 Contributions

This project contributes a tested and working prototype of mobileWAY v2 that is ready to be used in the context of dementia-affected individuals, particularly with AD, and their caregivers. By continuing and evolving an initial idea of mobileWAY v1, it was possible to effectively use widely accepted technology by diseased people and support the massive burdens of caregivers by providing a relatively cheap and meaningful way of diminishing their worries and easing their minds. The system combines a tablet interface, used by caregivers, with the TV at home, watched by the dementia-affected persons, to allow caregivers to display information to their dementia-affected relatives about who they are, their whereabouts and the time they will take before returning home. Additionally, caregivers can entertain their diseased relatives by using entertainment features that can be triggered remotely to play slides, audio and video on the TV. Multi-caregiver functionalities perfect the application by enabling multiple caregivers to keep updated on everyone's tasks as well as communicating effectively with each other.

During development, the needs of people in these contexts were carefully studied and observed in order to further optimize the system to them. Development guidelines and best practices were followed and the usability tests performed demonstrated a good acceptance rate of the system.

As work evolved in the development of this dissertation, continued literature review and research in the field of human-computer interaction (HCI) and dementia contexts allowed the contribution of a thorough analysis of related projects in this area.

The systematic evaluation performed with end users of the system allowed it to be more focused and complete in the eyes of those who need it and can benefit from using it.

Finally, the development of this work also contributed some advances in the use of the recent Google TV as part of an ecosystem that allows developers to construct broader, more interconnected systems and apply them to specific situations, such as the context of this project.

1.4 Thesis Structure

This thesis is organised in nine chapters. This first chapter contains the introduction to this work and outlines the problem description and context as well as this thesis's objectives, motivation and contributions.

The second chapter is dedicated to the methodology used during the evolution and development of this work. Chapters three and four consist of state-of-the-art chapters.

The third chapter discusses the context revolving around dementia-affected persons as well as their caregivers. In this chapter, dementia is explained as well as the characteristics and behaviours of dementia-affected persons. The obstacles that caregivers face and the way the disease affects them on various levels are also outlined.

The fourth chapter focuses on technology and how it is used in dementia contexts. Assistive technology is introduced and an analysis of other projects around the scope is displayed, presenting the current state of the art. In this chapter the chosen project that ultimately guides the rest of the work is also discussed.

The fifth chapter presents the redesign and new evaluations of the mobileWAY v1 project. It presents and discusses several aspects regarding the changes obtained from previous usability tests, new functionalities' design, new evaluations and respective conclusions that enable the final design of the second version, or v2, of mobileWAY (this project's version of mobileWAY that builds upon its initial version).

The sixth chapter details the technical specification and implementation of mobileWAY v2. The former includes the requirements specification, the main use cases definition and the system's architecture while the latter describes the methods and tools used, the system's functionality and a quick glance at how to use mobileWAY v2.

The seventh chapter outlines the validation and tests of the system. An overview of the participants and how they use the functionalities related to the caregiver status setup and collaborative tasks are displayed and relevant results are thoroughly discussed.

The eighth chapter discusses the results of the work developed in this thesis, where a summary of the main achievements and conclusions can be found.

Finally, chapter nine presents the conclusions of the developed work as well as improvement ideas and new functionalities that could guide future revisions and iterations of mobileWAY v2 in order to continue its optimisation and growth.

2 Methodology

This chapter details the research methodology followed to undertake this dissertation.

The development of this project is separated in different, but related, sets of tasks: the redesign of a user interface, the implementation of that redesigned user interface and the evaluation of the implemented system with end users. As a result of this, throughout the project's progress, a variety of methods are used.

First of all it is noteworthy to mention that this project is a follow-up of another which involved the design of a user interface for both older adults with early-stage Alzheimer's disease (AD) and their caregivers (Jordan, 2011). To properly continue that work, a review of the literature was conducted to understand the context of the older adult with dementia, allowing the comprehension of how these people behave, what their characteristics and limitations are, and how their informal caregivers are affected. Additionally, other state-of-the-art systems that try to help these users were researched and are included in this work.

This project aims to provide a functioning application to end users. Broadly speaking, this involves two parts: the interactive system and its users. In this context, to better understand the methods and tools used, the concept of Human-Computer Interaction (HCI) needs to be explained.

HCI "is the study of the interaction between people, computers and tasks" (Johnson, 1992), and "involves the design, implementation and evaluation of interactive systems in the context of the user's task and work" (Dix, Finlay, Abowd, & Beale, 2004). In the design of computer systems, it is important to make sure that users can quickly and efficiently get work done. Badly designed systems will increase user error and, in general, make users feel less secure and motivated in the completion of tasks. This is why usability is a vital aspect in the scope of HCI. According to Nielsen (2011), usability "is a quality attribute that assesses how easy user interfaces are to use" according to five criteria:

- Learnability – ease of learning and accomplishing basic tasks when first using the design.
- Efficiency – how quickly users perform tasks after knowing how to use the design.
- Memorability – ease of remembering how to use the system after a period of not using it.
- Errors – how many errors users make, how severe they are, and how easily can users recover from them.

- Satisfaction – how satisfying the interface is to use.

Nielsen (2011) also points out utility as another quality attribute. Utility is the system's capacity to do what users need. Making sure that these concepts are understood and correctly applied to user interfaces contributes to the achievement of HCI's goals as a whole: in order to be successful, products need to be useful, usable and used (Dix, Finlay, Abowd, & Beale, 2004). In software, even if its underlying code is flawless, it will be useless if the user interface fails to be intuitive and pleasant.

To make sure that systems incorporate the previously highlighted key concepts, users must be at the centre of the design process; this approach to user interface design is known as user-centred design (UCD). UCD “represents the techniques, processes, methods, and procedures for designing usable products and systems” (Rubin & Chisnell, 2008), putting the intended end users of a system at the centre of its design and development.

The International Standard ISO 9241-210, “Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems”², is an important standard that outlines six key principles in user-centred design:

1. The design is based upon an explicit understanding of users, tasks and environments – or in other words, it is fundamental to understand the context in which users will use the system and for what purpose.
2. Users are involved throughout design and development.
3. The design is driven and defined by user-centred evaluation – usability testing happens throughout all stages of design.
4. The process is iterative.
5. The design addresses the whole user experience – which includes perceptual and emotional aspects of the user experience.
6. The design team includes multidisciplinary skills and perspectives – a team that only includes experts of one type is not a good choice; a good mixture of designers, programmers, usability experts, end users, analysts and so on is ideal. The greater variety will bring about more views and better ideas.

During the development of this project, UCD methodologies were used, and some important techniques deserve to be further elaborated. These are: i) user requirements gathering, ii) usability testing, iii) low-fidelity and high-fidelity prototyping, iv) think aloud protocol and v)

² ISO 9241-210:2010. Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems.

questionnaires. The use of these techniques can be mapped to the various phases of development, as presented in the following sections.

2.1 User Research

The user requirements phase is a very important part of UCD; it “provides insight into the many possible solutions and allows a person to select and investigate the best solution from the users’ perspective” (Courage & Baxter, 2005). Although many of the system’s requirements were determined by Jordan (2011), who derived them from interviews with caregivers and their codifications, the studies undertaken during the present research brought to light new ones, and they set the stage for new tests. Chapters 3, 4 and 5 present the research around the scope as well as the new functionalities that called for new requirements.

Usability testing involves usability tests that have five characteristics, according to Dumas and Redish (1999):

1. The primary goal is to improve the product’s usability.
2. The participants represent real users.
3. The participants do real tasks.
4. What participants do and say is both observed and recorded.
5. The retrieved data is analysed and real problems are diagnosed so that solutions can be found.

Usability tests were performed with users when redesigning the user interface and after the system was implemented to understand whether it fulfilled their expectations. These can be seen in chapters 5 and 7, respectively.

2.2 Prototyping

Low-fidelity prototyping, which is also commonly known as paper prototyping, “is a variation of usability testing where representative users perform realistic tasks by interacting with a paper version of the interface that is manipulated by a person “playing computer,” who doesn’t explain how the interface is intended to work” (Snyder, 2003). Among other advantages, it is a fast and inexpensive way of obtaining a substantial amount of user feedback facilitating communication between the design and development teams and the users. For this project, the Wizard of Oz technique was used. It consists of a human simulating the system’s responses (UsabilityNet, 2006) and allows for rapid iterative design.

A high-fidelity prototype, on the other hand, is a prototype that is close to the final product (Foraker Labs, 2011) and runs on the actual device.

In the initial tests performed during the user interface redesign, paper prototyping was used (chapter 5) while in the evaluation tests of the caregivers' interface, a high-fidelity prototype was used (chapter 7).

2.3 Analysis

During the evaluation tests, the think-aloud protocol method was used. Think aloud “is a form of observation where the user is asked to talk through what he is doing as he is being observed; for example, describing what he believes is happening, why he takes an action, what he is trying to do” (Dix, Finlay, Abowd, & Beale, 2004). This allows the tester to better understand what is wrong with the design.

Questionnaires were applied to users after the tests to let them voice their opinion about what the system was doing right or wrong. These were only filled by informal caregivers; persons affected with AD did not have the ability to correctly understand the questions nor hold their attention enough time to answer them. As Jordan (2011) pointed out, user interface evaluation for people with dementia is a very difficult area of research.

Analysis of the first usability tests was done in chapter 5 and its conclusions and results led to the final design of the second version of mobileWAY, which was fully specified and implemented (chapter 6). The final usability tests, performed with the working prototype, were analysed in chapter 7 and paved the way to the final discussions (chapter 8) and conclusions (chapter 9).

2.4 Implementation

The implementation phase of the system (chapter 6) combined UCD methodologies and agile development methodologies. By integrating UCD and agile methodologies, deeper understanding of the users is attained, design decisions can better be validated and ultimately more usable and higher quality software can be created (Dickinson & Kumana, 2011). Agile software development follows some principles that include welcoming changing requirements at any point during development, delivering working software frequently and continuous attention to technical excellence and good design (Beck, et al., 2007). Various agile methods exist, but Extreme Programming (XP) was the chosen one to guide this work's implementation. XP is a

“lightweight methodology for small-to-medium-sized teams developing software in the face of vague or rapidly changing requirements” (Beck, 2000). The fact that XP assumes that requirements may change means that the product is developed in a series of iterations which guarantees that a usable version of the system will be readily available to use if there is a need to show it to customers (Kolawa, 2011). These characteristics make XP a suitable choice for this work. However, it is important to note that this project was made by a single person, so not all of the practices and principles of XP could be applied. Those that were used throughout the implementation are as follows (Beck, 2000):

- Features were determined and planned. They were not written as user stories (as XP describes) but the requirements obtained through testing allowed an adequate planning.
- XP defines short releases as a practice, in which releases should happen often in short cycles. Because in this project features were planned and built upon in a modular way, they could be added quickly.
- As features were added, they followed a simple design adapted to each that could easily be altered to meet new requirements.
- The code was refactored as necessary. Some functions used previously would need to be reused in new features, so steps like eliminating duplicate code and testing everything again to make sure that the system kept working correctly were taken often.
- The implementation followed a set of coding standards so that it would be easier to understand if another person wanted to work on it. This includes naming conventions for variables and comments where appropriate to make the code more readable and understandable.

The system was implemented for the Android mobile operating system, which uses the Java programming language. Along with the results of the analysis from the first usability tests (chapter 5), the implementation took notes from existing mobile design guidelines and best practices. The system was implemented on a tablet and on a Google TV. The communication between these two devices was made possible by a server powered by Ruby on Rails. The reasons for these choices and more information regarding these are detailed in chapter 6.

3 Understanding the Context of Dementia-Affected Persons and Their Caregivers

This chapter will develop an understanding of dementia, the characteristics of the persons most likely affected by it and the role of caregivers in the life of such persons.

3.1 Dementia

Everyone ages. That is a natural process. As people get older, they start experiencing multiple age-related declines related to cognitive and sensorimotor systems. These include deteriorations in visual acuity, hearing sensitivity and working memory (Charness & Schaie, 2003). Normally, as people age they just need to take better care of their eyes, ears and so on. However, if these declines are severe enough to interfere with the daily life and follow certain criteria, then a case of dementia may be developing (Alzheimer's Association, 2011).

Dementia is a brain disorder that initially meant “out of one’s mind”, from the Latin word “demens”; “de” meaning “out of” and “mens” meaning “the mind”, respectively (Maj & Sartorius, 2002). Dementia is not a specific disease; it is a syndrome – a group of symptoms which consistently occur together (Oxford University Press, 2011) – that mainly affects older adults with an age of more than 65 years. After this age, the probability of developing dementia doubles every five years (Wimo & Prince, 2010).

Dementia symptoms vary greatly. However, there are general criteria available that must each be met in order for dementia to be accurately diagnosed. The World Health Organization published the Tenth Revision of the International Classification of Diseases (ICD-10) for the “Classification of Mental and Behavioural Disorders – Diagnostic criteria for research” where the following (summarised) criteria can be found (World Health Organization, 1993):

- A decline in memory applying to both verbal and non-verbal material that must be confirmed with reliable history from an informant and supplemented, if possible, by neuropsychological tests or quantified cognitive assessments. This decline may have different levels of severity but will nonetheless have to interfere with everyday activities at the very least or threaten independent living completely at its worst. For a safer, more confident diagnosis, this decline should be observed for a period of no less than six months.

- A decline in other cognitive abilities that negatively affect judgement and thinking as well as the processing of information. Confirmation, severity level and diagnosis confidence follow similar guidelines to the previous criterion.
- Preserved awareness of the environment (e.g., orientation in time) long enough that the previously presented declines can be observed.
- A decline in emotional control or motivation, or a change in social behaviour, that can be found in the following: emotional lability, irritability, apathy or coarsening of social behaviour (e.g., eating without manners).

There are over one hundred dementia types (Cayton, Graham, & Warner, 2002) but some are much more common than others (Alzheimer's Society, 2011). The most common type is Alzheimer's disease (AD); other types include vascular dementia (the second most common type) and dementia with Lewy bodies. AD is the type of dementia that is of most interest to this project. It is important to note that AD has some mesmerizing facts around it such as being the sixth-leading cause of death across all ages and fifth-leading cause of death for people aged 65 or more in the United States (Alzheimer's Association, 2011) and there being no known cure yet (Alzheimer's Society, 2011).

The impact of dementia on the global economy is something that can neither be ignored nor underestimated. According to Wimo & Prince (2010), in 2010 there was a total estimated cost of US\$604 billion related to dementia worldwide, with Western Europe and North America representing roughly 70 per cent of it. Furthermore, it is estimated that by 2030, costs will have increased by 85 per cent.

3.2 The Dementia-Affected Person

As previously mentioned, dementia affects mainly older adults that are aged 65 years or older. After this age, the risk of developing dementia grows substantially. That is not to say that dementia is exclusive to this part of the population. In fact, the number of dementia cases in younger people has been rising and there is more awareness to that fact (Wimo & Prince, 2010). The cause of AD remains unknown, but scientific studies have been able to determine various risk factors, including advancing age (the main known risk factor), family history, genetics and gender (Alzheimer's Association, 2011); (James, 2009).

The Alzheimer's Association "facts and figures" (2011) reports that in the US, out of all the people with AD in 2011 (5.4 million), approximately 4 per cent are under the age of 65, 6 per cent are 65 to 74, 45 per cent are 75 to 84 and 45 per cent are 85 or older. This reality is pretty

daunting, even more because these numbers only consider the facts surrounding the most common type of dementia, AD. As such, it is important to understand just what kinds of changes these people suffer and what being affected by dementia means.

A dementia-affected person experiences a progressive loss of capabilities and may show behavioural problems such as agitation, aggression, wandering, apathy and psychological symptoms such as anxiety, depression, delusions and hallucinations (Prince & Jackson, 2009).

A person affected with AD typically progresses through seven stages, although not everyone will have the disease evolve at the same pace or experience the exact same symptoms. In stage 1, the person is still functioning normally and no signs of dementia can be detected, not even by a medical professional doing an interview designed to screen the disease. As the person progresses through every stage, increasing cognitive declines start to be shown until in the last stage, 7, when the person stops interacting with the environment and loses the ability to have a conversation or control movement (Alzheimer's Association, 2011). Martin and Jim (2009) rank the disease's advance in three stages:

1. Early stage – the first or second year. This is often overlooked but may include becoming highly passive, non communicative and having significant memory loss.
2. Middle stage – from the second to the fifth year. Day-to-day living becomes increasingly painful and difficult because of conditions such as needing help for basic tasks (e.g., going to the toilet), signs of wandering and loss of location skills.
3. Late stage – from the fifth year onwards. Independent living is no longer a viable option and full-time caregiving becomes a necessity.

The amount of time a person with dementia will be able to live is uncertain as it depends on many factors, however the disease “can progress for up to around ten years” (Alzheimer's Society, 2011). Furthermore, a dementia-affected person may not pass away because of dementia, but instead because of another illness (Alzheimer's Society, 2011).

The progress into a point of life where living independently is no longer an option leaves the person affected with dementia in a serious predicament – a situation that needs to be tackled by caregivers.

3.3 Caregivers of Dementia-Affected Persons

Caregiving focuses on helping people with physical or psychological problems and can be a lot of different activities such as (Schmall & Stiehl, 2005):

- Round-the-clock supervision;
- Shopping;
- Telephoning;
- Lifting, bathing, dressing and feeding;
- Providing social activity;
- Supervising medication;
- Arranging for health care;
- Listening, talking and providing emotional support.

Caregivers may be formal or informal. Formal care consists of “paid care work undertaken by a range of health and social care professions drawn from the statutory, voluntary and private sectors”, while informal care is the care support provided at home mostly by family, friends and neighbours (Milligan, 2009). In this project, and as described by Jordan (2011), the focus is on the informal caregivers of people affected with AD in its early stages – caregiving is still pretty much a family issue (Schulz, 2000); (Prince & Jackson, 2009), with informal caregivers providing the majority of care (as an example, in the U.S., 80 per cent of the care at home is provided by family caregivers (Alzheimer's Association, 2011)).

The life of caregivers is quite complicated, especially in the context of an advancing AD. The act of caregiving affects them both at a physical and psychological level and finances, social circles and emotions are some examples of highly affected elements in these people’s lives (Wimo & Prince, 2010). Caregivers are highly subject to stress and even depression (Alzheimer's Association, 2011), which is alarming because they may end up having a plethora of health and mental problems themselves.

These issues are interesting when the world and civilization evolution are put into perspective. Longer life expectancy increased the likelihood of suffering from dementia. At the same time, informal caregivers have less and less resources to adequately respond to the needs of people that need to be taken care of. LoboPrabhu, Molinari, and Lomax (2006) give several examples of factors contributing to these problems, such as the large movement of women into the workforce, lower rates of fertility and the low rate of economic growth.

Currently there are about 14.9 million unpaid caregivers in the U.S. and most of them (56 per cent) are aged 55 years or older (Alzheimer's Association, 2011). By coupling these figures with the previously outlined facts, it is understandable that solutions are needed and many areas can be improved as a result. Studies have shown that caregiving also has many positive aspects such

as companionship, enjoyment, fulfillment (Cohen, Colantonio, & Vernich, 2002), uplifts and satisfaction (LoboPrabhu, Molinari, & Lomax, 2006). Although there are many negative parts in this practice, in a way, the positives outweigh them because people want to, and do, provide care for their loved ones.

Since caregiving is a huge time-draining task that must be done, in many cases and while the disease is not in a very advanced stage, after working hours, caregivers need help in freeing some of their time for personal needs and keeping their minds fresh and in good health. At the same time, dementia-affected persons also need to know that their caregivers are certainly going to keep watching over them so that they feel safer and are able to live a more relaxed life. In light of this, technology, while not a silver bullet in and of itself, can help in responding to these necessities and diminish worry, sadness and stress for both parties while serving as a way to foster a stronger bond between them. By exploring its advantages, the well-being of dementia-affected persons and their caregivers can be kept or improved, thus solving important problems in this context, even if slowly.

Having developed an understanding of the context and the life of dementia-affected persons and their caregivers, the next chapter will focus on the technological solutions that have already been thought of to support people affected by dementia.

4 Technology within the Dementia Context

This chapter will focus on the technology available to support dementia-affected persons and, in some cases, their caregivers. The concept of assistive technologies (AT) will be described as well as the uses and benefits of mobile devices and some state-of-the-art projects that are related to this work.

Looking solely at an individual's age says nothing except for how long that person has lived. Even if some things may be assumed, such as the changes that happen as one ages, there is no way to know whether they apply to each individual because the person's characteristics, behaviours and limitations cannot be concluded from a number (Pak & McLaughlin, 2010). When talking about technology and the elderly, there is certainly the stereotype that older adults are not familiar with computers and so cannot properly use them. Of course, stereotypes might contain a kernel of truth but should not be taken as a solid truth so as not to lose track of reality and damage individuals or organizations when taking decisions (Salkowitz, 2008).

However, there is indeed a digital divide that can be described as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities" (OECD, 2001). People who have lived longer were around when computers started to be part of the mainstream population in the late eighties but did not grow as closely to them as the younger generations. This does have its implications, since when and how people start interacting with technology is tightly related to the way they use it (Salkowitz, 2008).

Older adults may not use technology due to a variety of reasons such as: i) not seeing the need to use it; ii) having the idea that it is expensive; and iii) not being able to clearly see what computers can offer that the traditional phone, letters or other conventional forms of communication do not already (Hanson, 2009). However, technology has an enormous potential as an enabler to the creation of systems that might support health and long-term care, making it possible for older adults to live in a more independent and healthy way (Center for Technology and Aging, 2009).

Dementia-affected persons have, naturally, higher challenges to overcome before they can effectively use technology. In fact, depending on the situation and disease, it may not even make sense for them to interact directly with it because of how easily they forget things and how hard, if not impossible, it would be for someone to teach them. However, technology designed to help

and improve the lives of people with disabilities does exist and is known as assistive technology (AT).

4.1 Assistive Technology

AT is “technology used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible” (University of Washington, 2011). It may be able to do things as varied as improving physical or mental functioning or replacing a limb, but it always serves as a capability enhancer (Robitaille, 2010).

AT ranges from tools that are very simple and not technological at all, such as ramps for wheelchairs, to high-tech solutions such as navigation systems that can help caregivers find missing or lost relatives (Alzheimer's Society, 2011). AT devices are often passive, meaning that they will activate automatically under certain circumstances or provide assistance without requiring the user to do anything directly to them; for instance, a light sensor that will detect motion and turn the lights on when someone is entering a room or a bath plug that releases water when it detects that the bath is too full are examples of such devices (Trent Dementia Services Development Centre, 2007).

As previously mentioned, AT was defined in the Assistive Technology Act of 1998. This Act was amended in 2004, and this reauthorization is known as the Assistive Technology Act of 2004³. Section 3 of this document defines an assistive technology device as “any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities”. By understanding that AT can significantly support and enhance the lives of those with limitations, it is easy to see that they can be used to greatly support dementia contexts – and AD in particular – by allowing people to live more independently and stay home during a longer period of their lives. As added benefits, AT can improve the user’s memory as well as helping reduce caregivers’ stress (Alzheimer's Society, 2011).

4.1.1 The potential of mobile devices as AT devices

Mobile devices such as smart phones and tablets are especially interesting in that they can provide a very good support to health care. Smart phones are basically inexpensive handheld computers that let users accomplish a broad range of tasks without being restricted by time or location (Sarasohn-Kahn, 2010). Currently available smart phones and tablets such as the iPhone,

³ Assistive Technology Act of 2004, Public Law 108-364, 108th United States Congress, October 25, 2004.

Android devices and the iPad are able to run a plethora of applications related to health and health care. Data from Gartner, Inc. (2011) shows that mobile devices registered a 5.6 per cent increase worldwide in the third quarter of 2011, with smart phone sales having increased 42 per cent. Recent statistics from comScore, Inc. (2011) show that in the U.S., the age groups of 55-64 and 65+ years, while accounting for a small percentage of total users, still experienced the strongest growth of percentage increase. They represent 7.91 per cent and 5.35 per cent of the total installed base, respectively (Figure 1). These growing numbers are encouraging because as more people of higher age groups use these devices, more can be done technology-wise to support them and mitigate problems.

Older adults are definitely interested in learning and making use of new technologies. However, because in many instances these types of devices tend to target younger people, they fail at being adapted to users with specific needs (Massimi, Baecker, & Wu, 2007). The desire of these people to experiment with the unknown is heartwarming and encourages and validates research work in this area. Even if in the context of dementia these technologies may be harder to introduce, the numerous ways in which they can help is certainly an important point to look at in future projects.

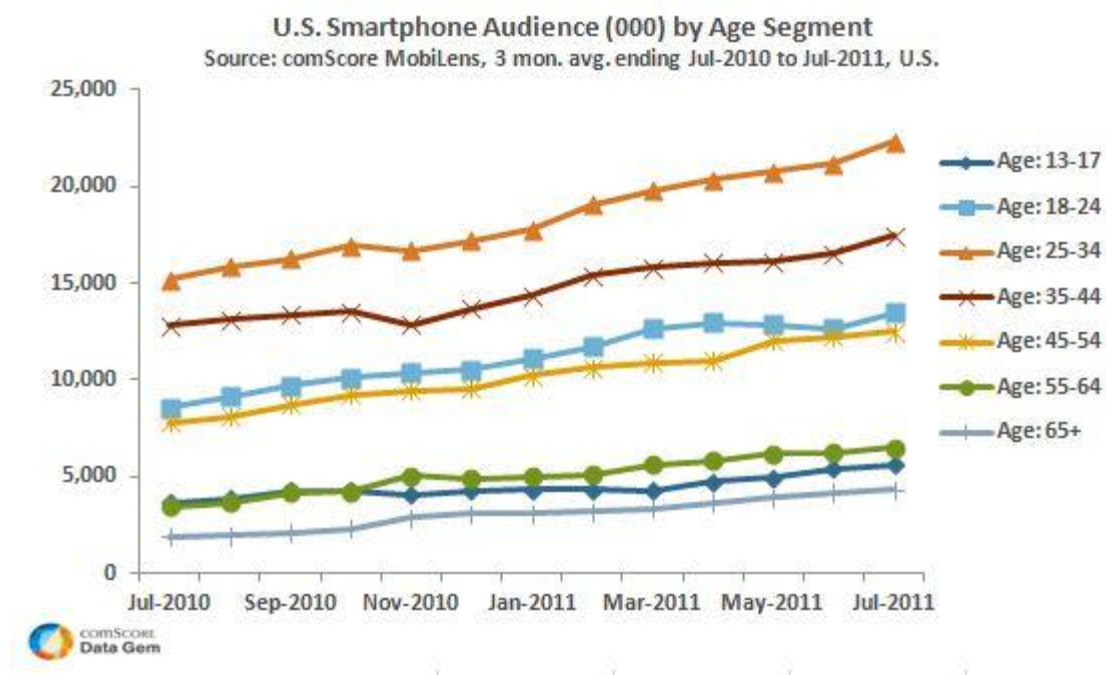


Figure 1 – U.S. smart phone audience by age segment. Source: (comScore, Inc., 2011).

4.2 State-of-the-Art Projects

In this chapter, state-of-the-art projects related to the current research will be presented and explained. These projects are introduced by gathering information publicly available on their site

or others and, where appropriate and applicable, may have related findings by their authors or others who published research papers and investigations based on them.

For a while now, the area of chronic conditions and information technology (IT) has been receiving attention from researchers and practitioners. The projects described in this section share many commonalities with this research, namely the promotion of independence and general well-being of dementia-affected persons and their caregivers. These projects strive to help people in doing an active self-management of their own health care and making it possible for people affected with diseases to be more connected to their caregivers and families, as well as enabling the latter to more effectively watch over their relatives without being stopped by geographic distances or time (Kamel Boulos, et al., 2009).

4.2.1 Easy Line Plus

Easy Line+ (Information Society Technologies, 2010) was a European project that focused on developing near-to-market prototypes of advanced white goods, which would help elderly persons with or without disabilities to live with fewer hazards and in a more independent way. This project started in January of 2007 and ended on April of 2010.

Since they found that a high number of disabilities prevented the elderly to take care of home tasks and about a fourth of accidents involving these people happened in the kitchen, they set out to solve this issue by developing prototypes of appliances such as a refrigerator that, among other things, would comment on what goods are put inside or taken out as well as control expired goods, and a stand-alone reader that would identify tagged products coming into the kitchen after shopping.

The project used a variety of technologies to achieve the desired results: RFID, wireless sensor networks, artificial intelligence, ubiquitous computing for ambient assisted living and distributed software. Of special interest are their human factors foci, which were accessibility, usability, usefulness and efficacy.

The system was evaluated with numerous people and was found to have the right functionalities as well as proving its usefulness in letting users live more independently.

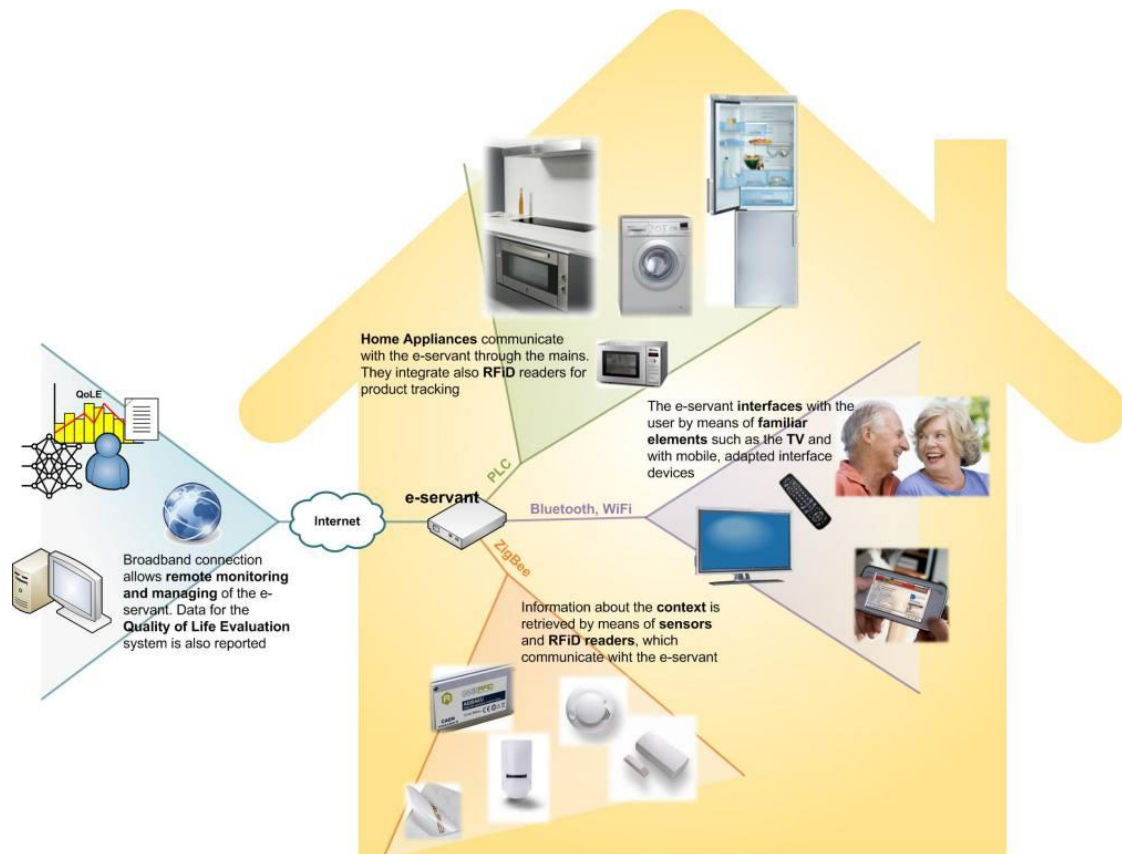


Figure 2 – The new Easy Line+ kitchen concept. Source: (Information Society Technologies, 2010).

4.2.2 I2HOME

I2HOME (European Commission, 2011) was a European project started in 2006 and finished in 2010 that focused on letting elderly people and those with disabilities interact with modern technologies available at home.

To achieve these objectives, they implemented a standards-based open platform that goes by the name of Universal Control Hub (UCH) in which personal user interfaces could be implemented for the target users. The project used the industrial and mainstream standard Universal Remote Control (URC). Moreover, the project managed to successfully integrate traditional smart phone appliances and support software systems such as reminders.

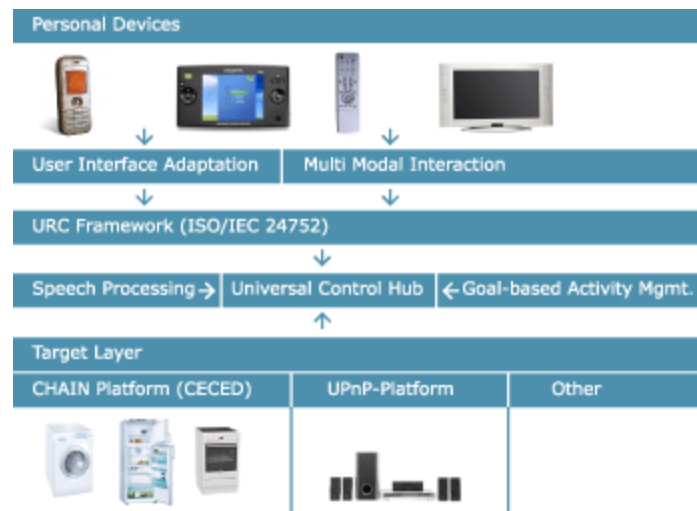


Figure 3 – The I2HOME platform architecture. Source: (European Commission, 2011).

I2HOME used a “Design for All” and “Adaptive Design” approach; this allowed the design to be used by everybody but adapt to special needs as they arise. As has been pointed out, the elderly and especially dementia-affected persons go through various changes that vary in severity, thus an adaptive system can be greatly beneficial for its flexibility. This also has advantages regarding costs, as it allows a product to be developed having the needs of a wide range of users in mind, thus allowing this product to be used and adapted as their needs change, instead of constantly buying new ones.

One very important highlight of this project is that, along with the aforementioned approach, it also used UCD methodologies; in this way, the work was validated for its feasibility, usability and accessibility with end users, which included impaired persons and dementia-affected persons. At the same time, they were able to conclude that the elderly and people with chronic diseases are a very diverse group that needs adapted and focused user interfaces which are specifically designed for them.

4.2.3 MyHeart

MyHeart (Koninklijke Philips Electronics N.V., 2011) was a European project led by Philips that started in 2003 and ended in 2008. This project focused on preventing and managing the cardiovascular disease.

The project identified four key areas, each of them addressing a specific goal:

1. Activity Coach (for healthy people) – to promote regular exercise for a more healthy life;

2. Take Care (for people at risk of developing the disease) – to reduce risk factors through vital body signs monitoring, lifestyle coaching and motivations;
3. Neuro Rehab (for stroke victims) – to promote physical and mental exercise to shorten rehabilitation period;
4. Heart Failure Management (for heart failure patients) – to enable the early detection of problems and improved patient management to enhance quality of life.

During the project, various products and technologies were developed to successfully reach the objectives; examples are wearable electronics and body sensors to measure vital signs, advanced heart failure management systems and signal processing algorithms to extract data from electrocardiograms. A complex system with many components like this needed to follow a multidisciplinary approach involving hardware and software engineers as well as health care and clinical experts.

4.2.4 SOPRANO

The SOPRANO (EXODUS S.A., 2011) was a European project that stands for “Service-oriented Programmable Smart Environments for Older Europeans” and that started in 2007 and ended in 2011.

The project, which contextualizes itself within the area of AAL and independent living, had the aim to design user interfaces for older people so that them and their caregivers could more effectively manage health care. Figure 4 shows prototyped equipment that was used for home trials.

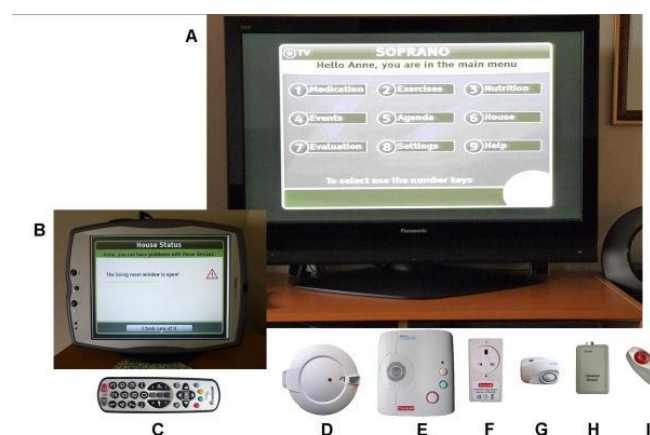


Figure 4 – Equipment used for the home trials. Source: (EXODUS S.A., 2011).

SOPRANO used the Experience and Application Research (E&AR) design methodology “which involves research, development and design by, with and for users” (EXODUS S.A.,

2011). This more user-centred, user-driven design approach involves the end users through all development phases and takes notes from their suggestions, therefore answering their needs directly.

The system was well-received and much potential was seen on it to assist independent living. However, some issues pertaining to stability made some evaluations hard. Another point brought by participants was the concern regarding costs. The researchers involved in this project found that these users expect a great amount of flexibility and personalization.

4.2.5 CompanionAble

The CompanionAble project (The University of Reading, 2011) is an ongoing European project that started in 2008 and has an expected duration of 4 years. This project addresses the problem of independent living by using a robot companion within a smart home environment.

The project combines various experts in these fields and follows a user-centred design methodology by involving care recipients, their caregivers and other important stakeholders. It combines Robotics and Ambient Intelligence technologies to assist in a caregiver's environment, providing cognitive stimulation and therapy management for the person looked after.

Amongst its advantages, this project targets a scalable and cost-effective integration solution and addresses issues of social inclusion and homecare of dementia-affected persons.

4.2.6 COGKNOW Day Navigator

Cogknow Day Navigator (Cogknow Limited, 2011) was a European project that started in 2006 and ended in 2009. The project targeted people with mild dementia and strived to provide higher levels of independency to these persons while at the same time allowing caregivers to care for them in a more relaxed way (i.e., not being around 24 hours per day).

The system provides a range of services to persons with mild dementia, namely memory support, activities of daily life, social contacts, safety and security. All these services can be activated via an integrated system that provides touch screen devices in various sizes (such as those of smart phones and tablets), a living environment with sensors as well as support and personalization. The system is prepared to show reminders, play music, dial by picture and navigate persons home. All of this allows for important benefits such as increasing the autonomy of persons with dementia as well as making life easier for their caregivers.

4.2.7 MATCH

MATCH (Scottish Funding Council, 2011) stands for “Mobilising Advanced Technologies for Care at Home” and is a collaborative project funded by the Scottish Funding Council. It is an ongoing project that started in 2005 and is planned to end in October of 2012.

The project focuses on the use of AT to maintain the independence of those with disabilities, not only improving their own quality of life but also that of their caregivers. As of now, the reported achievements indicate the successful creation of a home care system that exposes a very flexible design. Specifically, there is support for connecting digital equipment to networks inside or outside of the house, rules to guide the system in situations such as fall detection, automatic speech recognition and synthesis, the possibility to use the system via various modalities such as audio and touch and techniques that discover trends in the usage of the home.

4.2.8 EMERGE

EMERGE (Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V, 2011) was a European project that ran from 2007 to 2010. The project’s motivation arose from the fact that delayed calls to the emergency medical systems caused the elderly with disabilities to need to be hospitalized or to be put in nursery homes, a situation that not only threatens their independent living but also causes significant costs to health care systems.

The project’s idea was to support these people with a more intelligent and useful emergency monitoring and prevention system. To achieve this, they used ambient and unobtrusive sensors that would monitor location, activity and vital data. The people involved in the project outlined that a transparent system that the user does not notice since it does not get in the way is a major requirement for high acceptance.

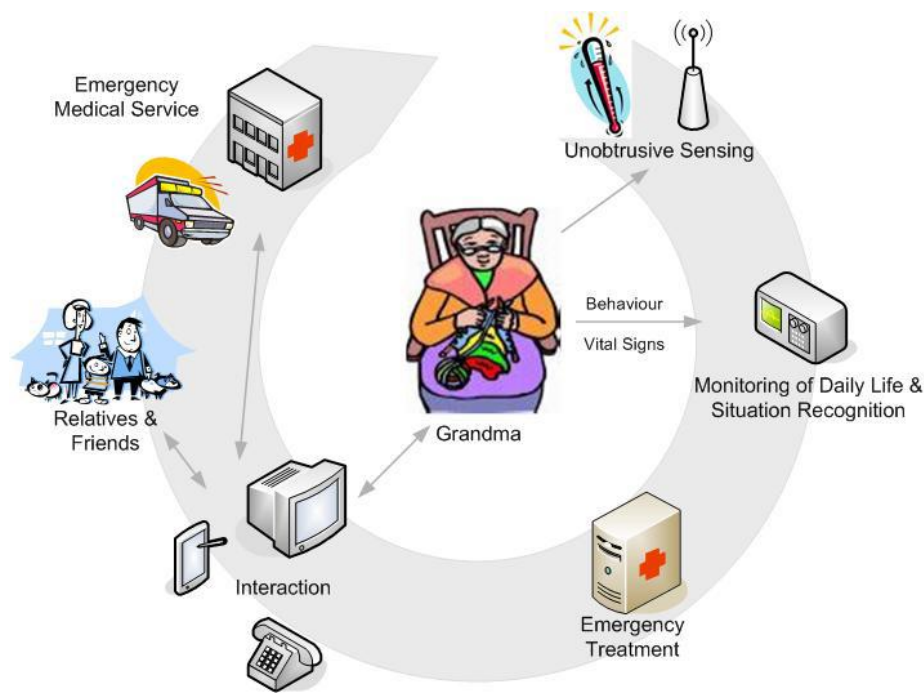


Figure 5 – EMERGE’s system. Source: (Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V, 2011).

4.2.9 CPVS

CPVS (Isle Interactive, 2011) stands for “Cell Phone Video Streaming in Alzheimer's disease” and is a project that started in 2007 and ended in 2010.

The project addressed the memory problems commonly found in people suffering from AD by developing a system that provided a wide range of memory cues. They used a mobile phone to keep the person in company of a virtual caregiver at all times. In this way, not only would the person feel safer but the virtual caregiver would also provide medication reminders, video streaming and a set of tasks for the person to fulfill.

This idea can be used to enforce the possibility of independent living by people affected with chronic conditions, and AD in particular.

4.2.10 ENABLE

ENABLE (European Commission, 2010) was a European project that started in 2007 and ended in 2010. Its full title is “A wearable system supporting services to "enable" elderly people to live well, independently and at ease”.

This project aimed to develop a personal and user-centred system that would improve the independence, autonomy, mobility, communication, care and safety of an elderly person whether inside or outside the home. The main idea of this project was to base the design on an open

platform that could be extended by way of plugging a variety of services into defined interfaces. The developed platform includes a mobile phone.

The idea of the functioning of the system included direct interaction with web based services, service centre operator and a care person via the network. The system architecture can be observed in Figure 6.

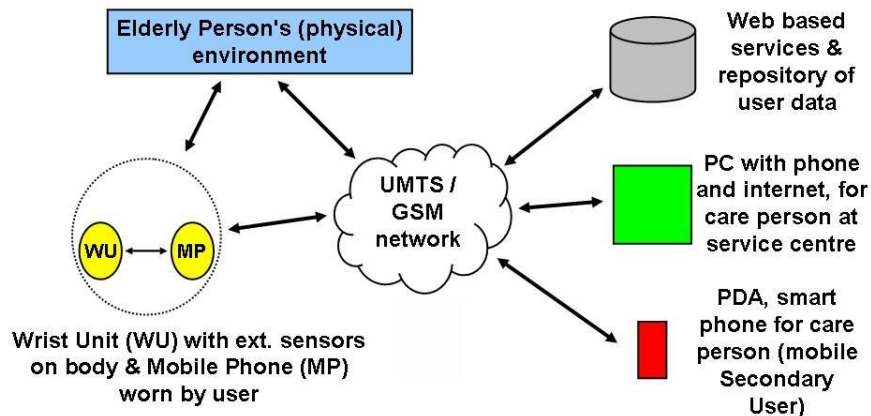


Figure 6 – ENABLE's system architecture. Source: (European Commission, 2010).

The project had a large input from end users in order to properly adapt to them and finally reached a prototype device that integrated all needed functions: a wearable wrist unit (Figure 7).



Figure 7 – The wearable wrist unit prototype developed in the ENABLE project. Source: (European Commission, 2010).

4.2.11 INDEPENDENT

INDEPENDENT (Isle Interactive, 2011) is a project funded by the Engineering and Physical Sciences Research Council (EPSRC) that started in 2003 and ended in 2007.

This project's work was mainly in the scope of dementia and technology. It had the goals of providing more quality of life and independent living to diseased people as well as better support for caregivers.

The outcomes of the project were three AT prototypes that were used to test suitability and usefulness with the target users of the system and, by its completion, two specific products were delivered:

1. A Music Player at a pre-marketable stage of development; and
2. A comprehensive set of guidelines titled “Guidance to Activities in Dementia Care”; these intend to promote activity for people with dementia.

4.2.12 eCAALYX

eCAALYX (ecaalyx.org, 2011) is a European project that started in 2009 and is planned to end in May of 2012. It stands for “Enhanced Complete Ambient Assisted Living Experiment”. This project builds on the acquired knowledge, infrastructure and functionality of the former CAALYX project. The main ideas of eCAALYX are:

- The monitoring of elderly people and elderly people with various chronic conditions whether they are at home or out of it;
- Quality of life enhancement for the elderly which results in a more independent and realized life as well as lifting some of the costs currently placed on health care systems;
- Continuous support, guidance and education for the elderly as a means of preventing or decreasing declines associated either with their advancing age or with their specific disabilities;
- A solution that is viable in the market, not only cost-wise, but also flexible, reliable, scalable and maintenance-free. This way it can garner acceptance both by stakeholders and the markets at large.

eCAALYX includes a strong and powerful, yet lightweight, management system for comorbidity patients as well as smart garments that can be used as electrocardiogram electrodes, for example. Tools such as weight scales and display of information on the TV are made possible and enrich the system’s array of possibilities. Furthermore, eCAALYX will be prepared to integrate smoothly with the contemporary technological infrastructure of most European network operators and homes. The following figure illustrates the concept of eCAALYX’s system:

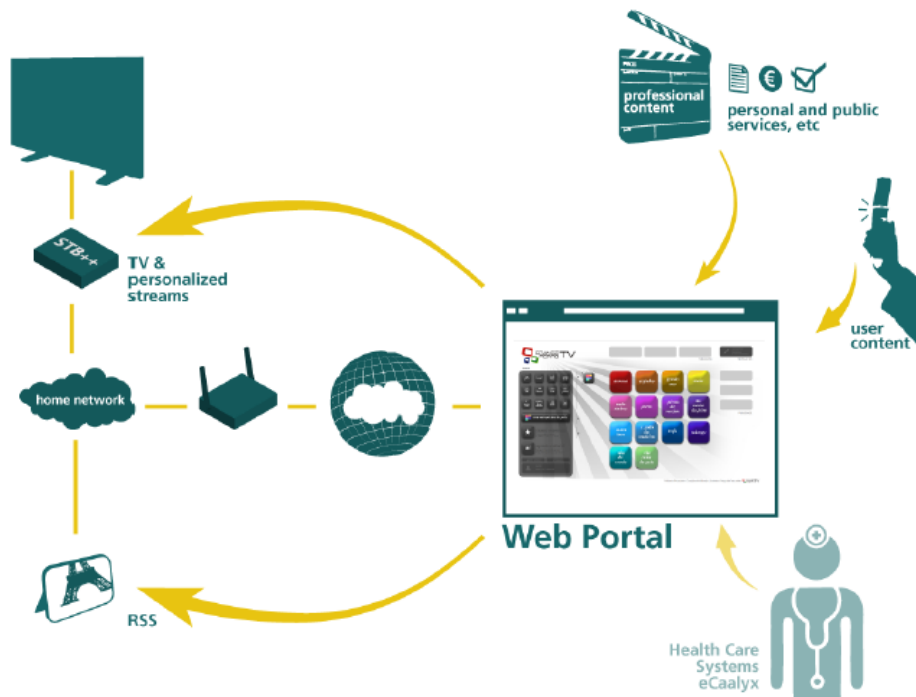


Figure 8 – eCAALYX's system. Source: (ecaalyx.org, 2011).

4.2.13 Networked Carers

Network Carers (Department of Health Policy Research Programme, 2011) was a research project undertaken by researchers of the Coventry & Warwickshire NHS Partnership Trust and the University of Warwick in which the focus was on caregivers, especially informal, and the understanding of how they could use technology to support their activities. The project started in 2007 and finished in 2008.

Essentially, they asked caregivers to give their opinion on networked technologies such as the Internet, telecare systems, and other technologies linking people and services in different locations. Important conclusions that resulted from this study are as follows:

- Caregivers need support and help as caregiving is a very burdening and stressful task;
- Technologies such as alarms and sensors were known by caregivers and many had Internet access;
- Very few people had direct experience with technology designed to help them;
- New technologies will be adopted as long as the prices are accessible and practical benefits are exposed;
- Caregivers are looking for specific solutions to specific problems;
- Caregivers see added value in having new technologies socially connecting them, however they fear that such functionalities will replace real people;

- Each technology is seen as having advantages and drawbacks depending on the situation;
- Lack of experience and awareness were observed;
- Caregivers expressed their fear of new technologies because dementia-affected persons would often be anxious about new artifacts and even throw them away.

These results are very important and outline some pretty important aspects of designing new products that are able to assist in these contexts. Namely, making sure that the end user is always involved through design and development of a given application is crucial as these users have very specific needs.

4.2.14 CIRCA

CIRCA (The University of Dundee & The University of St Andrews, 2005) was a joint project between the University of Dundee and the University of St Andrews that started in 2001 and ended in 2004.

The main goal of this project was to find ways to promote communication for elderly people with dementia, as these people tend to be impacted on short-term memory, it is important to be able to keep conversations and communicate in general. The project produced a reminiscence experience based on interactive multimedia, allowing people with dementia and their caregivers to select photos, video clips and music via a touch screen, with the aim of facilitating communication and reminiscence. Since the touch screen is a more direct input, the person feels more in control over what will happen and can choose what is thought to be the best material to be seen or heard in that particular moment.

CIRCA evaluations were very positive and it was shown that, compared to traditional reminiscence methods, CIRCA helped to create a more successful conversation, facilitating increased communication from the person with dementia, and helping them to take control of the interaction. The well-being of people with dementia, including the ones with AD, was found to be improved and as additional benefits, stress of caregivers can also be potentially lifted as well.

4.2.15 mobileWAY

mobileWAY (Jordan, 2011) was the result of a research project for a thesis that was developed in collaboration with Fraunhofer Portugal; it started and ended in 2011.

This project's idea was to develop a system that aimed to support dementia contexts. The author researched the situation surrounding older adults and dementia and, by identifying the context and problems surrounding this audience, designed a system to support early-stage dementia-affected persons (in particular, persons with AD) and their caregivers – that system was named mobileWAY (mobile-where-are-you).

During this research, it was found that the introduction and use expectation of a technical device, such as a smart phone, in the house of a dementia-affected person was nearly impossible. Only the TV and, occasionally, regular landline phones were found to be commonplace as well as actually understood and used by dementia-affected persons. These results shaped the outcome of the project.

There are two parts to this system: the TV which displays information about the caregivers to the dementia-affected person (Figure 9) and the mobileWAY application which is used by caregivers and allows them to display very simple information on the TV of the dementia-affected person (Figure 10):

- Who they are;
- Their whereabouts;
- The remaining time until they will be back home.



Figure 9 – The TV part of the system, displaying information to the dementia-affected person. Source: (Jordan, 2011).



Figure 10 – The tablet application with which the caregivers interact to be able to display information on the TV. Source: (Jordan, 2011).

Organizational helps, namely a to-do list, a forum and a calendar were also considered for a multi-caregiver environment.

The system was designed and tested (using UCD) but was not implemented.

4.2.16 Analysis of State-of-the-Art Projects for Dementia Contexts

The previously presented projects all relate to this work and display various things in common between one another; however, the complexity of some projects as well as the implications they might have in dementia contexts should be observed. In this section, a brief comparison between the projects will be made and it will define the choices that will continue to guide this work.

One thing that is very interesting about these projects is that many of them are, or have been, a European effort. The fact that so much funding is going to the investigation and deeper understanding of the humane and social aspects regarding the context of dementia, as well as the caregivers who are burdened with a lot of work and not so much help, is absolutely encouraging. This shows that the world is seriously looking at a very serious and very complex problem but also that research funding is actively encouraging the scientific community to look for solutions. This will guarantee that both younger and older generations will start to take part in a community that is in need of help, while at the same time gently push these people needing aid to better accept new technologies – which have the potential to diminish this (still) large gap.

These projects strive to help people in need of care by recognizing the potential of AT and how new technologies could pave the way for a more independent and better life for both diseased people and their caregivers.

The solutions to these problems vary according to the project's aim and approach: many of them resort to the use of external devices and sensors installed or placed within the house, while others try to be more conservative in their support approach. A very important aspect regarding this is that, as was mentioned before, elderly people are eager to learn new technologies but these are, in many situations, not designed for them; another big problem is that people hit with dementia tend to have a higher curve of decline regarding aspects such as memory and movement, which makes them more prone to forgetting things or have problems living independently. Some of the research projects, such as EMERGE and Networked Carers, found out that avoiding clashing users and technology is very important to guarantee the acceptance of the system. In mobileWAY it was found that dementia-affected persons do not have a very good knowledge of new technologies with the exception of the TV. Since privacy issues and the dangers of introducing new devices to be used by the dementia-affected person are well documented, going after solutions that involve the introduction of sensors, wearable gear and other such technologies within the house of a dementia-affected person is out of the scope of this work, for reasons of both cost and the needed available time that such an endeavor would require.

Another point that needs to be mentioned has to do with the acquisition of new hardware and its subsequent deployment. Many prototypes that resulted from many of the projects presented in the previous sections represent products that may be out of the financial range of people with disabilities and their respective caregivers, especially in the weakened and stagnated economy that is painting the world right now. In this project, the author will pursue a solution that is more accessible for everyone.

These reasons culminate in the choice of mobileWAY as the project that will be furthered and used as the basis for this work. mobileWAY not only clearly separates the people with dementia and the caregivers in its approach, but also tries to promote the use of currently available technologies – TV, tablets and smart phones – which are increasingly cheap and widely distributed. The project does not try to greatly interfere with the house of the dementia patient and requires small amounts of training on the caregivers' part to use. It attempts to address the problem of caregiver burden and people's loneliness in a simple but effective way. There is yet another good point regarding mobileWAY, and that is the fact that it attempts to solve a specific

problem and gives a specific solution, which is a good way of combating these kinds of issues that belong to users who have varied and specific troubles; it is not possible to solve everything at once. Additionally, the author of mobileWAY considered that much work regarding mobileWAY could be done to continue expanding that idea; and one of the main things is its implementation.

Because the present work described in this document is a single-person project, all of the above reasons make mobileWAY a research project that is worth considering and pursuing. The backdrop of this thesis is to be found on the research work of mobileWAY, which was closed when the low-fidelity prototypes were created. This thesis is a continuation of this work and will focus on further evaluation and implementation of mobileWAY. Nevertheless, each and every work that was presented in the previous sections greatly contributed to the knowledge of the author and in many ways encouraged the continued research in this area.

4.2.17 The Research Potential of mobileWAY

mobileWAY is a project that attempts to solve a tough and branching problem by returning to the basics and understanding exactly how dementia-affected people and their respective caregivers live daily and deal with the whole situation.

Informal and formal caregivers were interviewed to better understand and assess the two parts – the caregivers and the persons they care for. By acknowledging that diseased people are mainly older adults that have very little experience with IT with the remarkable exception of the TV, and that caregivers prefer to take care of their loved ones in a home environment albeit they highly fear getting out of the house and leaving their ill relatives alone, an interactive system was designed taking into account these primary problems with the aim of offering a solution.

The system relies on two parts:

1. The TV where information is displayed to the dementia-affected person;
2. The tablet application that allows caregivers to display information on the TV anytime from anywhere.

The design of the system and its evaluation tests, while very positive, have shown a lot of potential for its continuity.

Firstly, the system was tested with a low number of individuals. While the results did allow for promising conclusions, it needs to be tested with a larger pool of people so that a) further validations can be attained and b) possible new problems that might appear can be fleshed out

and evaluated again. Secondly, the tests have shown some additional considerations that should be studied in a redesign. Furthermore, new ideas and possibilities are bound to occur as new tests and additional research is performed, so that is also very stimulating. Thirdly, the system was not implemented, and that involves coding a wide range of material, from the user interface layouts to the integration of multi-caregiver functionalities. The implementation presents many aspects that are certainly interesting, such as the communication between the mobile device and the TV. Additionally, the concept of multi-device communication in the scope of software engineering is an area that is common and that keeps showing constant evolution in this increasingly connected world, so the difficulties and challenges presented by this system can be very enriching. Coupling that fact with a serious focus on very state-of-the-art technology (that is also inexpensive) and the intent to use it to support dementia contexts, it is easy to see that mobileWAY is forward thinking yet conservative in its approach.

Humanity has proven to be very capable of doing a lot to try to ensure its quality of life; the evolution of technology, as previously discussed, has a tendency to leave the less technical people, particularly the elderly, behind. If more focused applications can be created to help in these kinds of contexts and make life a bit better for everyone involved, then richer and more meaningful interactions and relationships can happen between people.

4.3 mobileWAY v1

4.3.1 Objectives and Achievements of mobileWAY v1

Since the work developed in this project builds upon the foundations and conquests of mobileWAY v1 (Jordan, 2011), it is important to introduce it more thoroughly. In this section, its objectives and main achievements will be outlined.

4.3.1.1 Objectives of mobileWAY v1

When the mobileWAY v1 project started, the main idea and context in which work was going to be developed and maintained fell within two main realms:

1. That of older adults and particularly those that have dementia, since this syndrome has a high rate of occurrence in this population segment; and
2. That of technology products that could provide help and support in the scope outlined in the aforementioned point.

As research and investigation regarding these two major areas went on, the author found very interesting facts. Summarily, they were:

- Older adults have almost no experience with IT, and this reality becomes a lot more complicated when contextualized within the changes and declines experienced by dementia-affected individuals.
- AD affects mainly older adults with 60 or more years.
- The TV and phone are the only technologies that are known and accepted by these users; however, the phone displayed two main drawbacks that prevented its further exploration: dementia-affected persons lose the ability to use it early, and it has nowhere near the presence at home that the TV does.
- Caregivers are burdened psychologically, financially and socially as they need to pay full attention to their diseased relatives.
- Caregivers are fearful of leaving their diseased relatives alone in the house.
- These care situations involve multi-caregivers.
- Caregivers seldom forget tasks involving the diseased relative and use traditional tools, such as calendars, phones and notes to organise themselves.

These findings allowed the main objectives of mobileWAY v1 to become clear: supporting persons affected with AD in its early stages as well as their informal caregivers, and to do this, two user interfaces had to be designed; one for the dementia-affected persons in their home and a complementary interface for their caregivers.

All of these aspects paved the way to pursue a system that comprised a TV interface and its complementary mobile device – a tablet, in this case – interface.

4.3.1.2 Achievements of mobileWAY v1

During development of mobileWAY v1, a UCD approach was taken to ensure the user was always at the forefront of everything that happened during design.

As was already pointed out, a TV interface and a tablet interface were produced. These can be seen on the following figures:

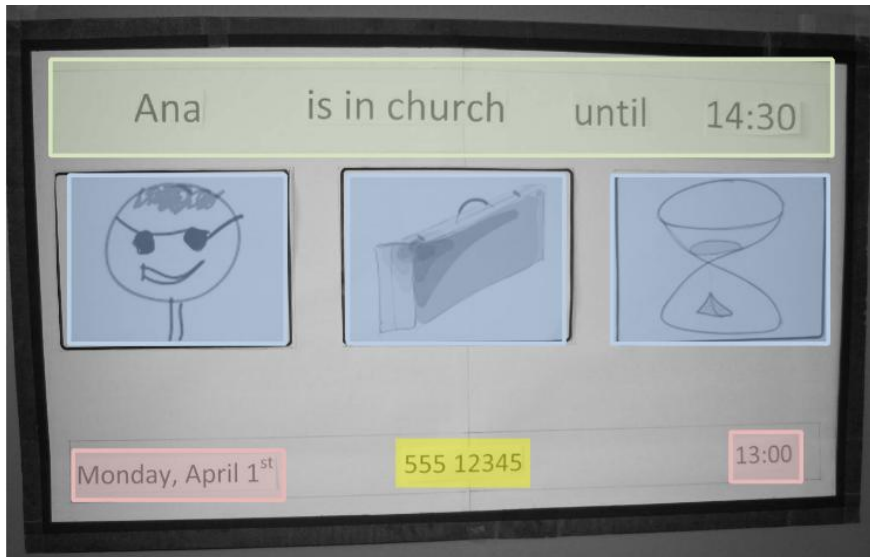


Figure 11 – A low-fidelity prototype of the TV, produced in the mobileWAY v1 project. Source: (Jordan, 2011).

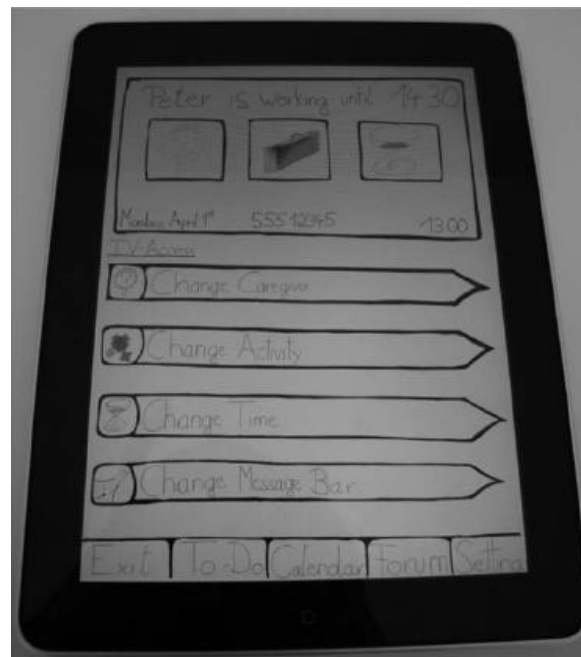


Figure 12 – The complementary tablet interface, also low-fidelity. Source: (Jordan, 2011).

The TV shows to the dementia-affected person information that the respective caregiver(s) put on it. This is a passive interface, meaning that no interaction is expected from the person; while this limits the possibilities from the diseased persons' point of view, it also means minimal error on their part, a conclusion that the mobileWAY v1's author extracted from the undertaken research. Along with the identification of the caregiver, activity and time remaining until the activity ends, there is an optional message bar on the bottom part of the screen that shows the

date and time and an optional message the caregiver might want to display to the diseased relative.

The tablet, on the other hand, has an application that allows the caregivers to perform four main tasks:

- Add caregivers to mobileWAY v1, with a name and photo;
- Add activities that caregivers will perform while outside of the house, also with a name and a photo (e.g., telling that Ana is at the church);
- Add the time the caregivers will take to perform that activity (e.g., two hours) and return to the home of the dementia-affected person.
- Add an optional message to be displayed on the TV (e.g., a phone number to contact the caregiver) allowing the caregiver to tell useful information to the dementia-affected person.

The workflow of the application was created using high-fidelity prototypes as shown in the following figure:

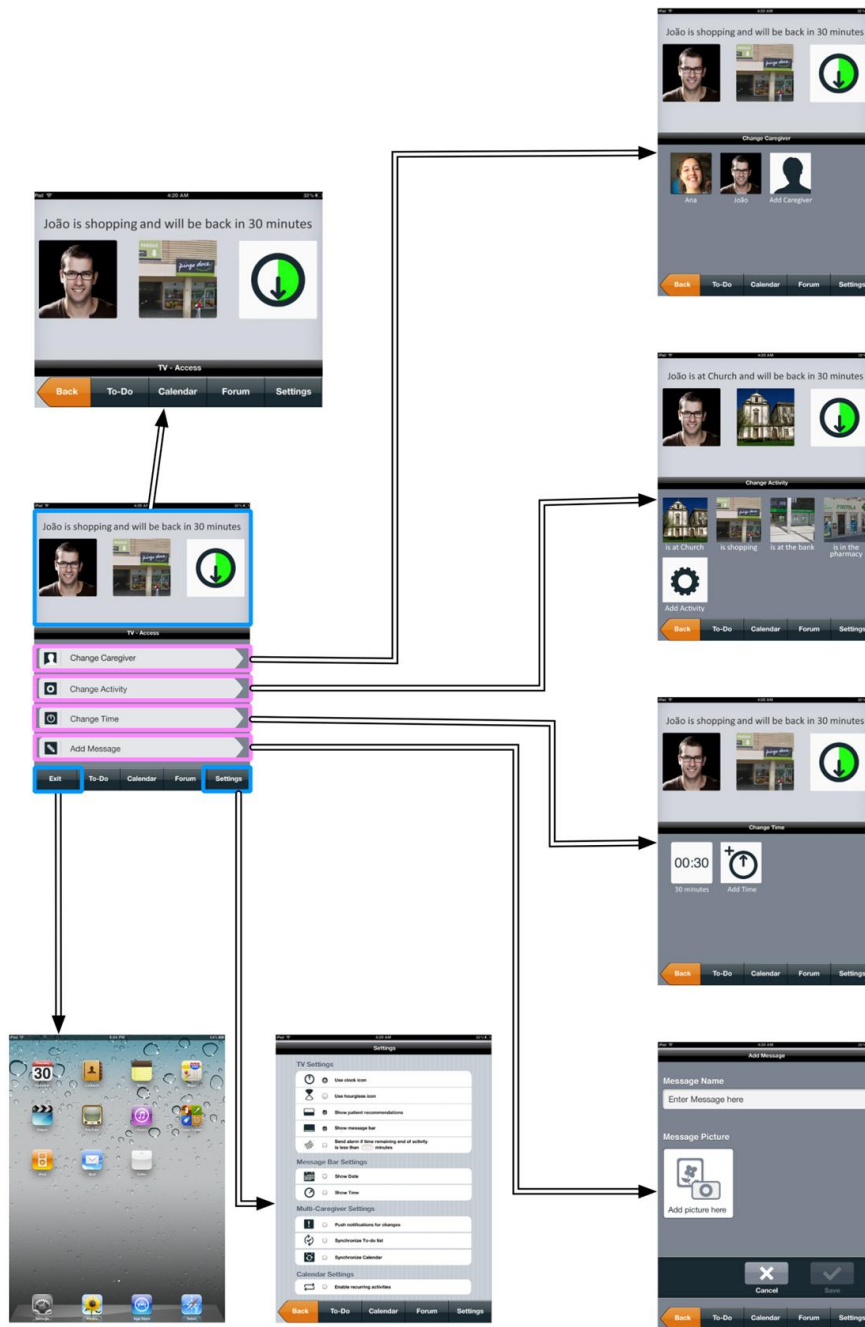


Figure 13 – The workflow of mobileWAY v1. Source: (Jordan, 2011).

The above image allows for a more detailed explanation of the application. On the left-hand side, the screen on the center represents the application’s main menu. The upper part of the screen outlined by the big blue rectangle, shows to the caregiver exactly what is being shown on the TV of the dementia-affected person. In the middle part, the previously outlined options can be seen; and the lower bar is where the settings (in which caregivers can personalize the application for their own needs as well as their diseases relatives’) can be accessed as well as the multi-caregiver functionalities. Furthermore, in this bar the option to navigate backwards is

present (if the main menu is the screen where the user is located, then the “Back” option is renamed to “Exit” instead, as in this case going back means exiting the application).

In this figure, two additional things deserve to be expanded on:

1. There is a zoom functionality that can be observed in the top-left corner screen. When the user touches the interface area that houses the TV display, it will zoom in on it, a feature that is particularly important for smaller displays such as those present on a smart phone.
2. In the application’s main menu screen, three out of the four main options in the center part of the application display the word “Change”. This is because the word “Add” only appears if a particular resource type – caregiver, activity, time or message – has not been added yet. If there is at least one added to the application, then “Change” replaces “Add”. This has implications regarding the workflow, too: if a given resource type does not exist, then the user will navigate to the respective “Add” screen pertaining to that resource type; otherwise, a list of the already available resources will be displayed (this behaviour can easily be observed in the workflow).

The remaining screens that can be seen in the workflow exemplify how mobileWAY v1 tackles the interface design.

Next, and by way of example, it is useful to display more screens that the workflow does not show and that highlight how the application handles its tasks and element placement. Every screen was defined and designed with the exception of the multi-caregiver functionalities (to-do list, calendar and forum). Since this is a touch interface, it is fairly easy to understand what is going on in each figure.

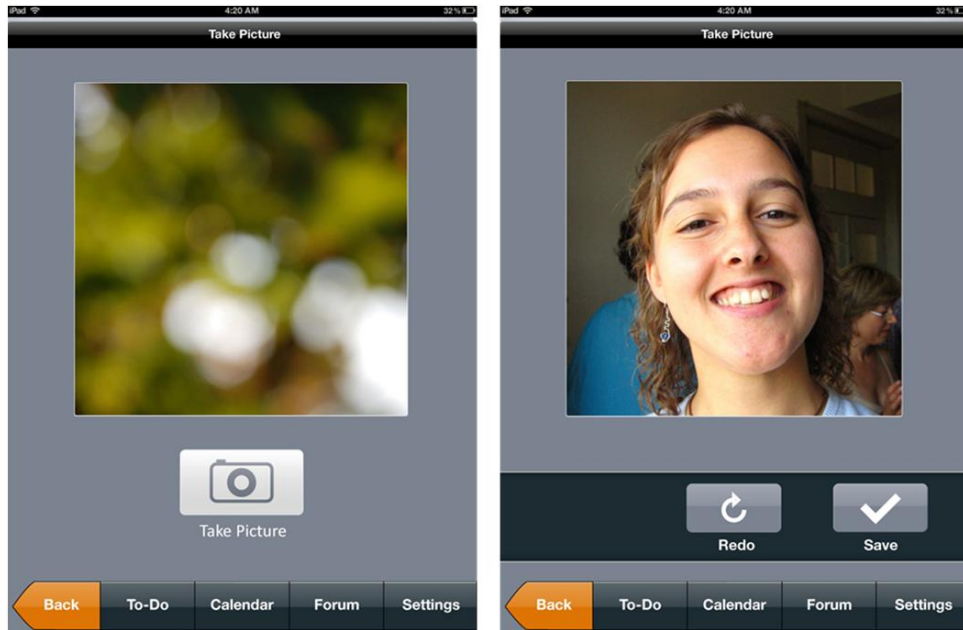


Figure 14 – Additional examples of mobileWAY v1's interface. Source: (Jordan, 2011).



Figure 15 – More examples of mobileWAY v1's interface. Source: (Jordan, 2011).

The system was evaluated with two dementia-affected persons and four caregivers. For this phase, low-fidelity prototypes were tested using two methods previously described in chapter 2: Wizard of Oz and think aloud protocols.

The low-fidelity prototypes used to test the TV interface with the dementia-affected persons were enriched by real pictures of both the caregiver and the place where an activity would

happen. These tests were performed in the presence of their caregivers (who tested the mobile device application at another time) in order to foster familiarity.

The tablet application was tested with the caregivers and after-questionnaires were given to them so that their satisfaction with the system could be assessed. However, neither the settings nor the multi-caregiver functionalities were tested because these functionalities had not been designed yet.

The evaluation results were very positive:

- Usability tests with dementia-affected persons showed partial to full comprehensibility of the TV information. Additionally, because real images were used, it was found that these persons made successful associations with their environment, which has shown memory stimulation and support.
- Usability tests with caregivers showed high effectiveness and efficiency in using mobileWAY v1 on a mobile device. Caregivers also reported in their answers to the questionnaire that this system would likely improve not only their life but also that of the diseased relative.

All in all, the unobtrusiveness, low-acquisition costs and low training required to use the system were all very positive aspects that got reinforced by the positive assessments of both dementia-affected persons and their caregivers. That the system was recognized to have the potential for improving everyone's quality of life in such contexts was one of its greatest achievements.

Having introduced the objectives and achievements of mobileWAY v1, the next chapter will focus on the redesign and new evaluations of the system.

5 (Re)Design and Evaluation of mobileWAY v1

As was previously said, this work continues to build on the achievements of mobileWAY v1. Since there are various areas where improvements can and should happen, this chapter will present how the redesign process of the system happened. Important things that were used to establish the new stage of the system's development will be outlined, new functionalities will be described and the evaluation process of these first steps will be exposed.

For clarity, the first iteration of mobileWAY developed in (Jordan, 2011) is henceforth referred to as version 1 (v1) while the second iteration (developed in the present work) is referred to as version 2 (v2).

5.1 Iterating the Design of mobileWAY v1

As the new phases of mobileWAY started, it was important to review the previous work and assess what improvements could be made.

The work of Jordan (2011) concluded with a number of suggestions in future work. These included:

- Implementation of a tablet prototype;
- Redesign of the application so that it would suit smart phone screens, which are smaller and less flexible;
- Workflow rearrangements as per the results of the evaluation tests;
- Usage of the TV interface to display tasks that the dementia-affected people could do while the caregiver is out, such as emptying the dishwasher;
- Integration of other modalities on the TV such as audio; this would allow for a reading (sound output) of the information on the TV at regular intervals, for instance;
- Integration of the mobileWAY application within the regular television broadcast.

Not all of the above-mentioned ideas could be pursued during the present work, mostly because of the limited time and resources available. As details regarding the developed work are explained and extended, reasons for the abandonment or postponement of certain features will be given.

In the first phase, to properly evolve mobileWAY v1, work happened throughout a four-stage process:

1. Usability tests from its author were analysed and the main results extracted in order to implement them in a new version for further development;
2. Missing functionalities were added;
3. New evaluations performed on top of these additions were conducted;
4. Finally, by assessing results, a new design was achieved.

The following sections describe the aforementioned tasks addressed by this thesis in the first phase.

5.1.1 mobileWAY v1 redesign – incorporating results from usability tests

Firstly, the results from usability tests that were conducted in mobileWAY v1 were analysed in order to understand how the current prototype could be improved.

Regarding the TV tests, not many necessary changes could be identified. In fact, since only two people were tested, the primary step was to test the current interface with more subjects.

The tablet interface, on the other hand, revealed things to be iterated. As the comments and notes were reviewed, the following considerations were gathered:

- The label “Choose” present on every screen where a button option can be selected raised confusion in one of the caregivers. In one screen, the caregiver commented that there was no relationship between the label and the options (Figure 16).

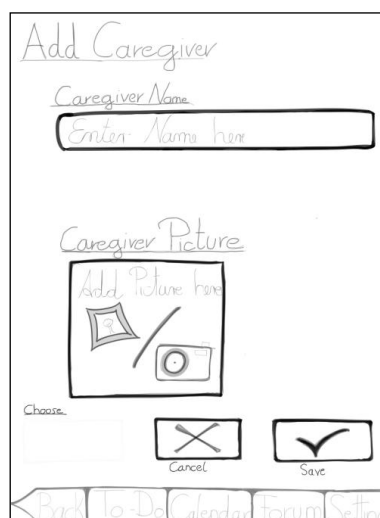


Figure 16 – The “Add Caregiver” screen’s low-fidelity prototype. Source: (Jordan, 2011).

- When performing a task involving adding the caregiver, activity and time to the TV screen, there was a problem that one caregiver faced. After having added the time the activity would take to the TV screen, the caregiver commented that the “Change

Time” title of the screen was not very explicit and suggested altering it to a more semantic version: “How much time will you take?” (Figure 17).

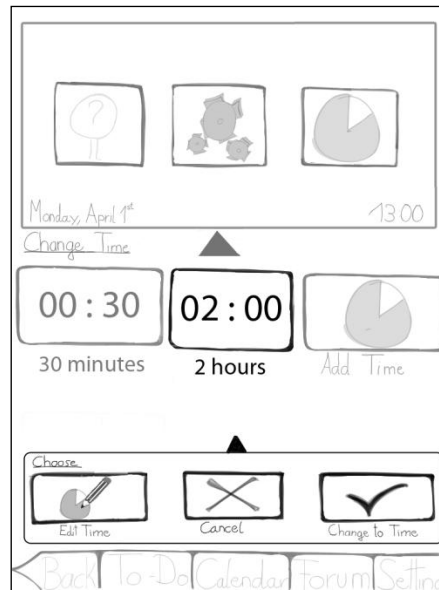


Figure 17 – The “Change Time” screen’s low-fidelity prototype with the context menu opened. Source: (Jordan, 2011).

- When adding an activity to the TV screen during one task, one caregiver got confused by one of the available options in the same screen, named “Edit Activity” (Figure 18). The caregiver considered that “Edit is to publish something”, and therefore questions could be raised as to what option would actually add the resource to the TV. This particular word and screen caused problems with a different caregiver, where it was commented that “Edit” and “Change” meant the same.

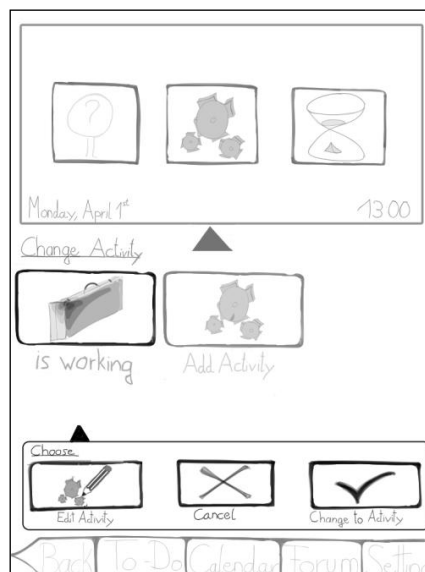


Figure 18 – The “Change Activity” screen’s low-fidelity prototype with the context menu opened. Source: (Jordan, 2011).

- One caregiver commented after the successful conclusion of one of the tasks (“Add yourself to the application”) that a confirmation was missing.
- There were suggestions of a revised workflow. Particularly, after completing tasks such as adding a resource type to the TV, it was suggested that the application returned to the main menu (during tests the facilitator did not do this, instead letting users see the screen prior to the one where they added the resource type to the TV).

By closely evaluating the current workflow and screens as well as the results, the following changes were made to the low-fidelity prototypes inherited from mobileWAY v1:

- The label “Choose” was eliminated since it did not add anything substantial to the interface and introduced confusion.
- To deal with the problems encountered with the “Change Time” functionality, terminology evaluation tests were conducted with 13 participants. These participants were chosen from a wide range of ages and included some caregivers. The questionnaire included more tests (appendix 11.1). Participants were asked how they would name an option that allowed them to tell a dementia-affected person how much time they would take to perform an activity outside the house. They could choose from the following options:
 - 1) Define activity duration;
 - 2) Indicate delay time;
 - 3) Indicate activity duration;
 - 4) Add activity duration.

The most chosen option, selected by six people, was 3). Thus, this became the new name for the option to define the time remaining until the caregiver came back to the home of the dementia-affected person. It is important to outline that the questionnaire, a quantitative evaluation measure, was chosen in this case because the goal was to obtain objective information quickly. Qualitative information is more difficult to analyse and in this case would likely provide a wide array of choices that would prove to be difficult to select from. Dix, Finlay, Abowd, and Beale (2004) confirm that the choice of evaluation methods is largely dependent on the information that is required in a given step, and must be chosen according to factors such as the immediacy of response and resources available. Additionally, it should be pointed that although the system is to be used by caregivers of dementia-affected persons, it has to be considered that such persons are hard to find and furthermore it

can be useful to have feedback of “regular” users. Even though caregivers will give more realistic and useful data regarding the caregiving and AD reality, most people are suitable to voice an opinion on whether a given option can, or not, be understood. Another positive side effect of acquiring information from these users is that they can be tomorrow’s caregivers, which might help in future-proofing the application.

- To solve the “Edit” word problems, a terminology test was also performed. This test is part of the questionnaire mentioned in the previous point (and can be seen in appendix 11.1). Participants were asked how they would name an option that would allow them to change resource elements such as the caregiver’s name or activity picture. They could choose from the following options:
 - 1) Configure;
 - 2) Adjust;
 - 3) Adapt;
 - 4) Tune;
 - 5) Perfect;
 - 6) Amend;
 - 7) Improve.

The majority of people (nine) chose 1), so that became the new term.

- Confirmation screens were added to the end of every task.
- When evaluating with the end users, the workflow was changed; now, after significant tasks like adding the caregiver or putting information on the TV, the user returned to the main menu.

Additional minor changes were introduced:

- A new screen dedicated to entering the resource name (e.g., the caregiver’s) was designed and included to be used after touching the option to do so (Figure 19). This is because previously, since the tests did not include the actual name-entering step, it was not found that the only way to do it with the available screens was to make the keyboard pop-up and obscure a lot of information (Figure 16).

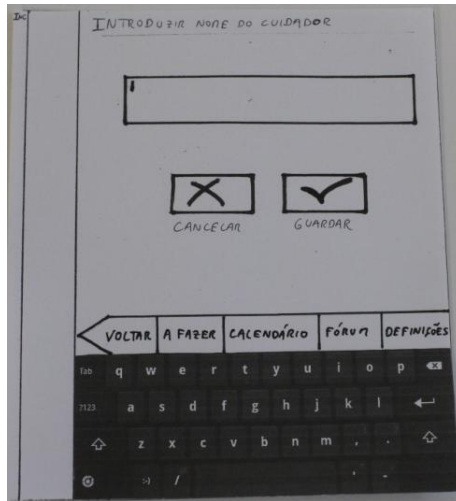


Figure 19 – The new “Enter Caregiver Name” screen’s low-fidelity prototype.

- Confirmation screens were expanded to every significant task that deserved them. For instance, after attempting to delete a given resource, there would be a screen confirming its elimination. This was primarily done for the case of errors in tests where caregivers could select an option that did not need to be selected for the completion of the task. Because users could potentially click all available options, it was important to design every screen in case it was needed.

Finally, one last significant change was made, involving the following screen:



Figure 20 – The “Change Activity” screen’s high-fidelity prototype. Source: (Jordan, 2011).

As can be seen, the high-fidelity prototype has space for eight tiles when listing a given resource type and arrows to change between screens. However, there are a few problems with this layout:

1. It does not account for the pop-up menu that appears when the user selects a given item (this is exemplified in Figure 15's left screen). With the screen like this, the pop-up would have to appear over other elements and possibly in different locations depending on the selected item (e.g., it would have to appear in the first row for items of the second row). This could lead to confusion as it is uneven behaviour.
2. The elements, particularly the arrows, are too close to each other. When analysing this screen one thing that was taken into account was the variety of screen sizes on mobile devices and how this arrangement would lead to serious problems.
3. The button to add a resource is pushed to the end of all available resources. So, if users want to add a new resource, they will be forced to scroll through every screen before doing so.

To solve these issues a new layout was designed. Now, instead of eight elements per screen, there are three on the upper row, and the last one is always the add resource button. This leaves a lot of space for users to comfortably use the arrows as needed. Additionally, the bottom row is dedicated to the pop-up menu. As a result, the space is never used for anything else and its behaviour will always be fixed and expected. An example of this can be seen in the following figure (in tests the arrows were not used so they were left out of the low-fidelity prototypes):

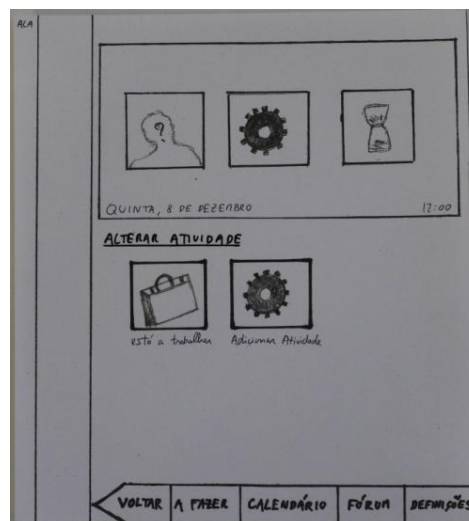


Figure 21 – The “Change Activity” screen’s low-fidelity prototype with two items. There is space for one additional item as well as arrows.

All these changes were incorporated in mobileWAY v2. Other functionalities were added and those will be discussed in the upcoming section.

5.1.2 Designing missing functionalities

Jordan (2011) considered the use of the TV interface as a means of encouraging the dementia-affected person to execute some tasks for entertainment purposes. So, while the information regarding the whereabouts of caregivers and how much time it would take before they would arrive home was being displayed, tasks such as “go water the flowers” or “go hang out the washing” could be displayed as a means of entertaining them.

There are some problems with these ideas, though. In its current state, the system does not have any way to guarantee that the person is actually fulfilling these tasks. Although the system itself can be used at various places within the house, it is nevertheless non-obligatory. Since the caregiver is away, there is a chance that the person will not notice the task and therefore will not actually do it (thus not extracting any possible benefits from doing it) and the suggestion might indeed lead to situations where the person can get hurt while being unmonitored.

As was described, since AD leads to severe impairments, it would be very useful to help and support people by trying to maintain their abilities for as long as possible. Many sources claim that visual aids and audiovisual stimulation are very beneficial to improve short-term memory, bring more relaxation and even help promoting social exchange (The University of Dundee & The University of St Andrews, 2005); (Powell & Courtice, 2002); (Prince & Jackson, 2009). The CIRCA project in particular has shown that photos, video clips and music were very successful in helping reminiscence and communication (The University of Dundee & The University of St Andrews, 2005).

These facts, combined with the ideas that were previously presented from mobileWAY v1 of helping the diseased person at home feel more relaxed and entertained, led to the introduction of new functionalities related to entertainment. This option allows caregivers to select slides, audio or videos that will share space with the caregivers’ information on the TV’s interface and allow the persons with dementia to be entertained with meaningful pastimes. Because caregivers are likely to know the person they look after very well, these entertainment options should be highly customisable on a case-by-case basis.

When designing these functionalities, lessons learned from the previous usability tests were applied. The first step consisted of a terminology test to understand how people would globally name an option that allowed for the display of audio and video to the dementia-affected person (appendix 11.1). In addition to choosing one of the usual words, the 13 participants also had to choose between two action terms – “show” and “select”. So, the possibilities were the following:

1. Show/Select entertainment;

2. Show/Select occupation;
3. Show/Select pastime;
4. Show/Select distraction;
5. Show/Select diversion;
6. Show/Select multimedia.

The term “entertainment” had the largest number of votes, being chosen by five people. As for the action term, looking at the results for the “entertainment” term, 3 people chose “Select” while 2 chose “Show”, so the used terminology ended up being “Select entertainment”.

Another thing that was heavily considered when designing these entertainment functionalities was the integration within the current look and feel of the application. As a result, the new options were introduced by following the same styles and principles of the initial mobileWAY version. The following figures exemplify the low-fidelity prototypes of the entertainment options:

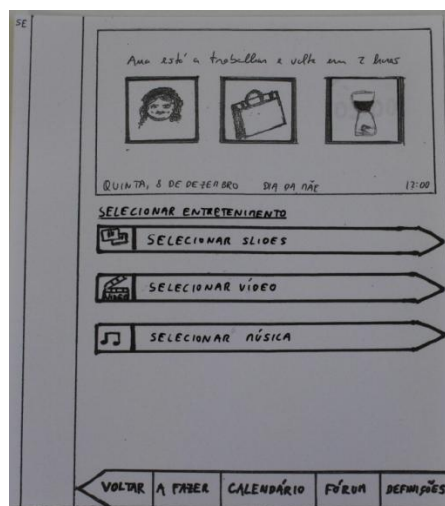


Figure 22 – The “Select Entertainment” screen’s low-fidelity prototype.

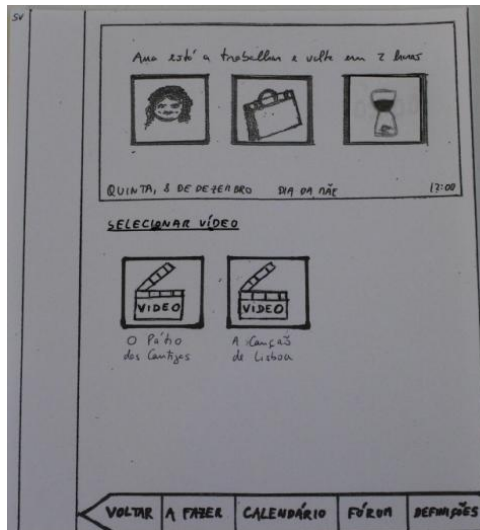


Figure 23 – The “Select Video” screen’s low-fidelity prototype.

Of course, these options did not just impact the core functionalities part of the application. They also had to be considered for the TV interface, both on the tablet application and on the TV itself.

Since displaying the caregivers’ whereabouts and activity duration is crucial, the entertainment functionalities make no attempt to eliminate or hide them. Instead, on the TV itself, the screen is divided such that the top half continues displaying the information while the bottom half is used to display the currently selected entertainment as well as the message bar. On the tablet application, there is no need to actually play slideshows, audio or movies. Since on this device space is also a concern, the TV screen fragment of the application is divided as on the TV. However, only a placeholder image of the selected entertainment, along with a sentence that tells the caregiver that everything is working fine, is displayed (Figure 24). The space is used dynamically both on the TV and tablet, so the division is only in effect when entertainment is playing; otherwise, the default mode (exemplified in Figure 23) is shown.

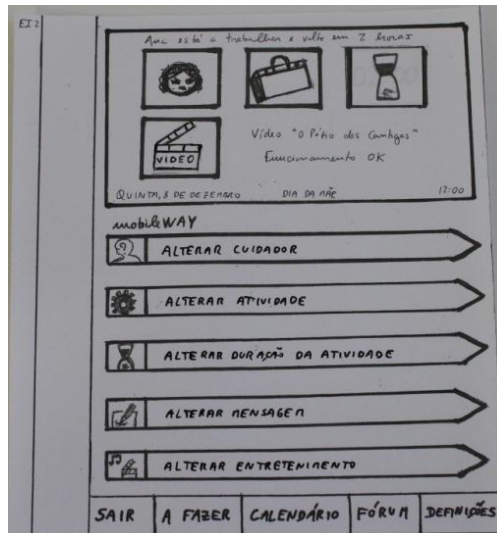


Figure 24 – A low-fidelity prototype of the main screen with a video playing on the TV. The TV screen fragment part tells the user that a video is playing.

Another area that was target of revisions was the settings screen. These were not tested in mobileWAY v1. The new layout can be seen in Figure 25. Essentially, the options were grouped in a clearer way and the option to hide the entertainment area (which includes its interface options) was included. One thing that is also important to point out is the number of activity duration icons that has increased.

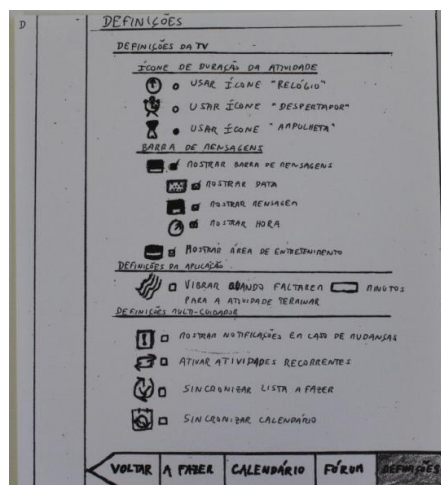


Figure 25 – The “Settings” screen’s low-fidelity prototype.

In mobileWAY v1, the author considered two icons to represent the activity duration: the clock and the hourglass. However, in talks with experts in the field, it was decided that having at least one more option would improve the usability. By researching a bit more with older people, the wide acknowledgement and understanding of the alarm clock made it a suitable addition as a new possibility for caregivers and dementia-affected persons, and so it was included.

One other consideration was taken into account when looking at the old interface and it had to do with how caregivers would push the information regarding caregiver, activity and activity duration to the TV. Since the TV fragment of the tablet interface should always show what the TV is currently displaying, there was a problem to solve: should each new piece of information be pushed individually or not?

The system has the goal of supporting and helping in dementia contexts. In that sense, one thing that was not intended was for the person at home to have feelings of uneasiness or confusion. If updates were pushed to the TV as the caregiver was selecting them, information could be incomplete. Even considering that the caregiver was fast in updating the TV, problems could occur that would prevent the person at home from seeing what was intended to be seen, thus potentially leading to confusion. As such, the design decision to ask the caregiver if it was alright to push updates to the TV was made. This question implicated the design of a new pop-up screen (Figure 26) that would only appear if the three most important elements (caregiver, activity and activity duration) had already been selected. Additionally, because some elements can be added individually (such as the optional message or entertainment), the question to push them to the TV only appears if the three aforementioned core elements are already chosen.

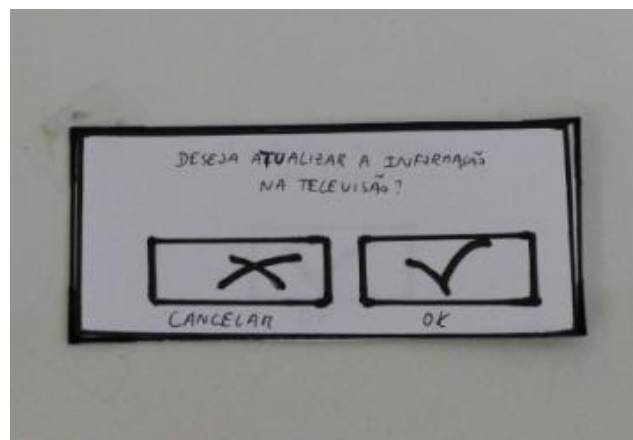


Figure 26 – The pop-up asking users whether they want to update the TV screen information.

The last major addition to the designed application has to do with the multi-caregiver options along the lower bar of the interface (to-do, calendar and forum). Although at this point they could not be designed and included in usability tests, considerations of how to integrate them and what technologies to use started being investigated.

As the new changes were completed and deemed ready for usability testing with real users, this stage came to an end.

5.1.3 Evaluating mobileWAY v2

In order to understand whether the system was answering the needs of those to whom it was intended, it needed to be tested. In order to do that, a protocol was used and tests were executed with both dementia-affected persons and their respective caregivers. The forthcoming topic will explain how these tests were conducted.

5.1.3.1 Evaluation Protocol

Usability testing happened with two target users: caregivers who tested the tablet interface and dementia-affected persons who tested the TV interface. A total of 10 caregivers and 5 dementia-affected persons participated in the tests. These people were not randomly picked; an effort was made to ensure that the caregivers were the actual people who took care of the persons affected with AD so that more realistic results could be gathered.

The tests were first conducted with caregivers, and thus they tested the tablet application. This was deliberate because by speaking first with caregivers, it was possible to obtain information regarding their relatives and their likes and dislikes, enriching the developed work and enabling the construction of realistic scenarios to be tested with the diseased persons.

5.1.3.1.1 Usability tests with caregivers

These tests made use of the same protocol followed by the author of mobileWAY v1. This would enable results to be compared and validated. However, since in this iteration of the application new functionalities and screens were added, the protocol was updated to reflect the new tasks.

The updated and revised protocol can be seen in appendix 11.2. Summarised, the process went like this:

1. First, the caregivers were given an explanation of what mobileWAY consisted of and what could be done with it. This also involved explaining the concept of paper prototypes and how the tests would progress, as well as the two core components (the TV and the tablet application).
2. Then, caregivers were asked to perform each task (nine in total). The tasks involved various steps like adding a caregiver, activity and activity duration as well as displaying entertainment on the TV and using the settings.

3. Finally, a questionnaire was applied to each caregiver so that an assessment of the overall system could be performed.

It is noteworthy to say that the caregivers that tested the application were different than those who tested mobileWAY v1. The following table displays their gender, age, the dementia-affected person they look after (who tested the TV interface of the system and is represented by the AP initials) and their relationship to the diseased person:

Table 1 – Caregivers' general data.

Information Caregiver	Gender	Age	Takes care of	Relationship to dementia- affected person
C1	Female	63	AP1	Daughter
C2	Female	58	AP2	Daughter
C3	Female	60	AP2	Daughter
C4	Female	47	AP3	Daughter
C5	Male	48	AP3	Son-in-law
C6	Male	37	AP4	Son-in-law
C7	Female	47	AP4	Daughter
C8	Female	51	AP5	Daughter
C9	Female	54	AP6	Daughter
C10	Female	64	AP6	Daughter's friend

As can be seen, it was possible to test with two caregivers per dementia-affected person for four of the dementia-affected persons. For the other two diseased people, only one caregiver was available to test. All of these are informal caregivers; they are relatives or friends who help in taking care of the diseased individual at home.

5.1.3.1.2 Usability tests with dementia-affected persons

The tests performed with dementia-affected persons were slightly changed from the initial version of mobileWAY. In mobileWAY v1, six scenarios were tested:

- The first test had the goal of understanding whether the dementia-affected person understood the icon of a clock labeled with the remaining time for the activity to end (Figure 27).
- The second test was like the first but tested the understanding of the hourglass icon.
- The third test consisted of asking whether the person preferred the clock or hourglass icon. If one was chosen, it would be used in further tests with that person.

- Tests four to six consisted of testing different scenarios of the caregivers going out for a given time to perform an activity as well as the message bar to assess if the information was understood.

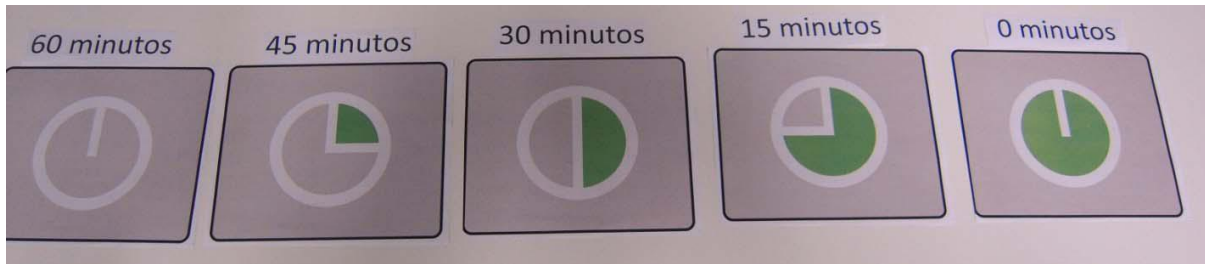


Figure 27 – Clock icon test performed in mobileWAY v1. Source: (Jordan, 2011).

In mobileWAY v2, the testing procedure changed. First, the testing of the icon preference was dropped. This happened because when speaking with caregivers, all of them said that their diseased relatives would not recognize nor understand the hourglass icon. Since the clock was approved by caregivers, and to maintain consistency with the tests of mobileWAY v1, it was therefore the chosen icon to be tested with all persons. Second, the three-scenario approach was not entirely followed because mobileWAY v2 had a new functionality to be tested: entertainment. As such, to minimize the time that the dementia-affected person would have to dedicate to tests, only two scenarios were tested:

1. A high-quality photo of a selected caregiver and activity were used to test a scenario where the caregiver was out of the house (Table 2 shows detailed combinations). This test aimed at understanding if the person i) knew what the clock icon represented, and ii) comprehended the message bar information and the sentences displayed.
2. After assessing the understanding of the person in the previous scenario, an entertainment situation was simulated on the TV prototype. Three slides with Christmas themes (Santa Claus, the Christmas crib and a Christmas's tree) were used after dividing the TV space properly to see if the person could understand the imagery as well as the purpose of the entertainment. Slides were swapped to simulate a slideshow. Additionally, the remaining TV information, described in the aforementioned point, continued to be assessed as before to see if the person was not fully distracted with the entertainment and could still understand it.

To use a real situation as the basis for tests, caregivers were asked about combinations of both caregiver and activity to perform. This ensured that there would be an adjustment to each

AD person's case as would happen in a real usage of the system. The following table shows the combinations used:

Table 2 – Combinations of caregiver and activity used for the tests with dementia-affected persons.

Dementia-affected person	Caregiver picture	Activity picture	Activity duration (clock icon)
AP1	C1	Paranhos's church	45 minutes
AP2	C2	Antas's church	45 minutes
AP3	C4	Antas's church	45 minutes
AP4	C7	Supermarket (shopping cart)	45 minutes
AP5	C8	Supermarket (shopping cart)	45 minutes
AP6	C9	Santo António hospital	45 minutes

Unfortunately, it has to be noted that AP4 was unexpectedly hospitalized and could not test the system.

The tests were all performed in Centro Social das Antas in a quiet and small room. One formal caregiver could be present during three of the tests and she was extremely helpful because she knew them well, and vice-versa. This situation was very beneficial because it helped in relaxing them and increasing their confidence to perform tasks and give feedback to the facilitator.



Figure 28 – Setting up the low-fidelity prototype of the TV on the wall for the dementia-affected person to test.

Lastly, it is also important to note that two people were in a more advanced stage of AD than the others. This was the case because it was difficult to find more people. However, on the other hand, this allowed the assessment of how the system could perform in worse-condition scenarios.

5.1.3.2 Results of Usability Tests

In this section, the results of the usability tests will be presented, starting with the caregivers' results and then the dementia-affected people's results.

5.1.3.2.1 Caregivers' results

Each caregiver tested nine tasks. Each task had a minimum number of steps that are needed to complete it. If a caregiver did not touch the intended option, an error would be registered. These errors add up to the minimum number of steps to analyse how many additional steps were needed to perform a given task and thus obtain the success rate. In the following, a per-task analysis will be given as well as a final global analysis. Each task had a success rate of 100% as it was successfully completed by every caregiver. In-depth results complete with caregiver commentaries and taken notes can be seen in appendixes 11.3 and 11.4.

5.1.3.2.1.1 Task 1 results

In the first task, caregivers were asked to add themselves as caregivers to the application. This task required 10 steps to be completed.

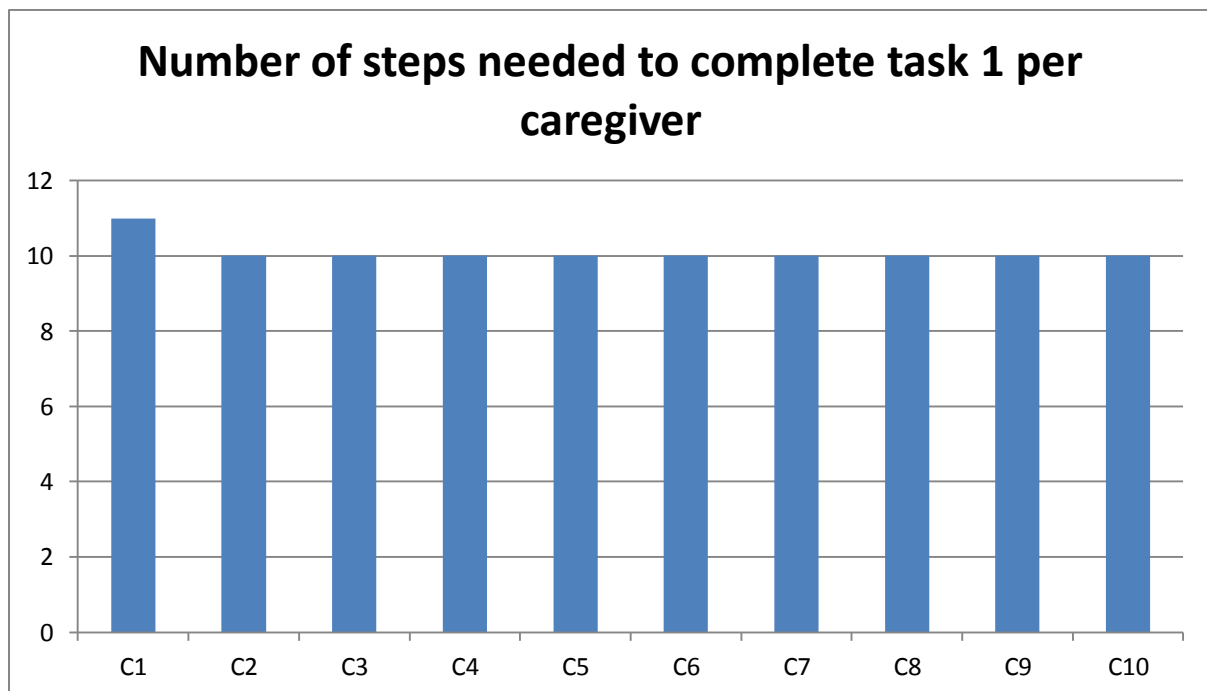


Chart 1 – Redesign phase: task 1 results.

In this first task, all caregivers with the exception of C1, who needed 11 steps, did everything without needing additional steps.

The error had to do with a hasty touch on the option's label instead of the option itself. The caregiver was still learning the interface, and no significant problems or suggestions were extracted here.

5.1.3.2.1.2 Task 2 results

In the second task, caregivers were asked to change the picture of an activity. A minimum of nine steps was needed to complete it.

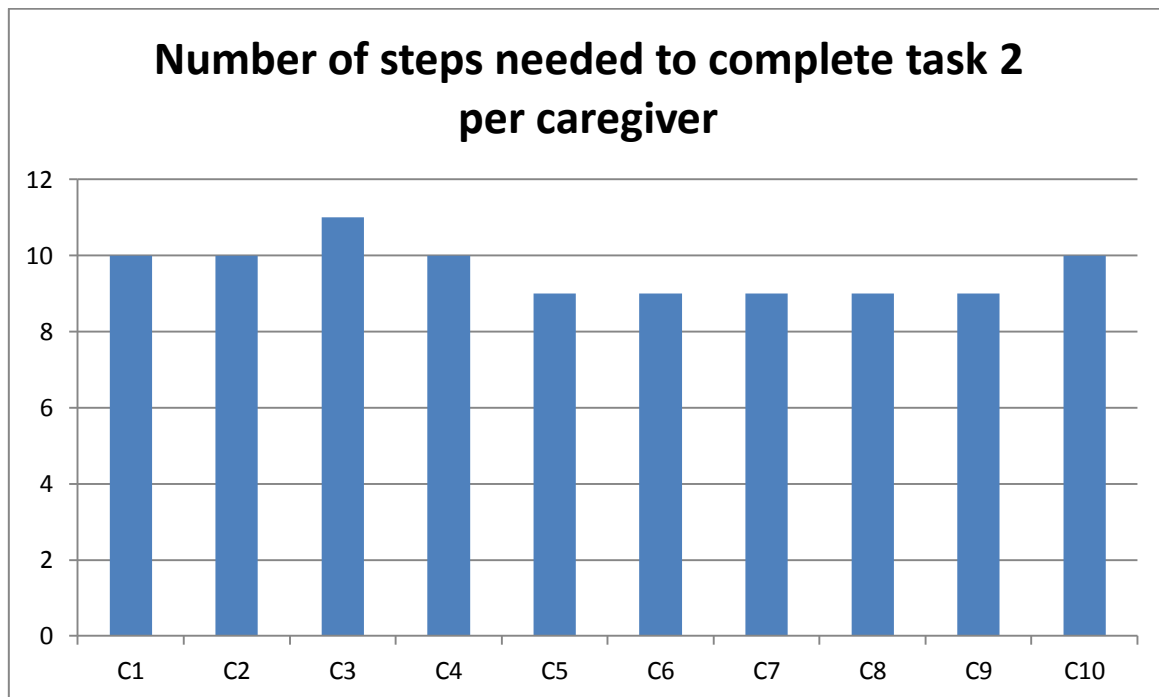


Chart 2 – Redesign phase: task 2 results.

Every caregiver completed this task successfully. 50% of the caregivers completed it without needing additional steps. Of the remaining 50%, 40% needed an additional step, and 10% needed two additional steps.

At first glance, this might seem like it was a problematic task. A closer look at the results however shows that is not the case. Out of the five caregivers who needed additional steps, three (including the one who needed two additional steps) required them because they tried to solve the issue differently than expected, by trying to delete the activity first and then add another one. Although the task involved changing solely the activity picture, caregivers made associations to the way they typically use computer systems: when something needs to be changed, a frequent way to solve the problem and achieve the desired results is to delete the previous item and then add the new one. Thus, although the task was not completed in a completely error-free way, the

manner in which caregivers attempted to solve the task is not only understandable; it is also realistic and certainly possible in the real application.

In the end, caregivers understood how the facilitator was expecting the issue to be solved and did not find any problems with it.

5.1.3.2.1.3 Task 3 results

The third task involved placing the caregiver, activity and activity duration in the TV's interface. Since the task involves various steps and parts of the application, it was divided in smaller subtasks when the person forgot what was supposed to be done (e.g., the facilitator reminded the user of what was supposed to be achieved). This was the longest task, requiring 14 steps to be successfully completed.

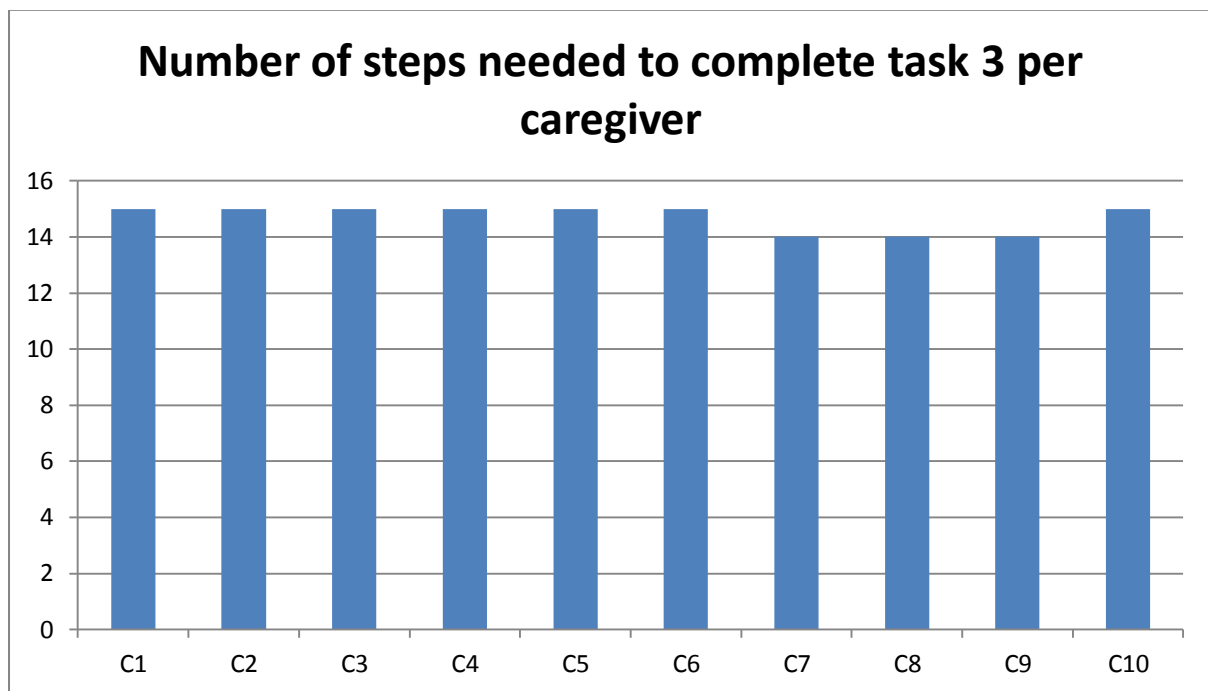


Chart 3 – Redesign phase: task 3 results.

Again, all caregivers completed this task successfully. However, this task brought some very interesting findings.

The task was only completed without any additional steps by three caregivers, so 30% of the total subject number. All others needed an additional step. This happened for different reasons depending on the caregiver:

- Some caregivers got confused when presented with the task. They thought that when they added themselves to the application in the first task, they also added themselves

to the TV. One of the main things causing this confusion was that when they looked at the interface, they read “Change Caregiver/Activity/Activity Duration”. The presence of the word “Change” was very misleading according to them. Therefore, one highly suggested action was the removal of that word.

- To change the information on the TV, some caregivers touched the TV interface part of the application. As Figure 29 shows, the low-fidelity prototypes represent the caregiver, activity and activity duration with a pre-defined, default image surrounded by borders. Because these borders were not adequately downplayed by the facilitator when developing the prototype, they appear as though they are touchable buttons. This was a very interesting finding regarding the interface usage, though, because it allowed seeing that caregivers would use the TV interface part of the application to achieve the task’s goals.

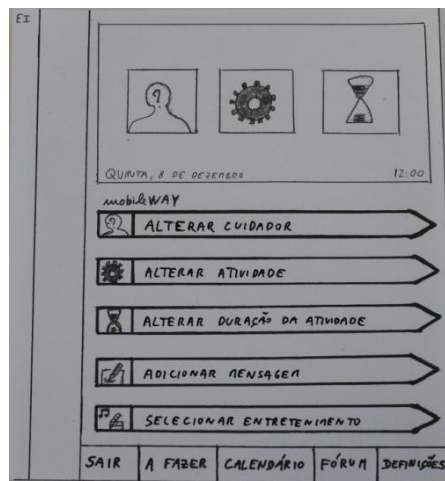


Figure 29 – The “Main Menu” screen’s low-fidelity prototype with the three placeholder pictures on the TV fragment.

- When intending to place the resources on the TV, the option to do it was labeled “Change to Caregiver/Activity/Activity Duration”. Many caregivers had to stop and think for a while looking at these options. Some attempted to go back because this option was not understood at first. All of the caregivers who had this problem voiced their concerns and said that “Confirm” was a much better word. One caregiver even commented that the “tick” image used by the facilitator definitely represents a “Confirm” action.

These comments and notes were investigated and led to changes that can later be seen in chapter 5.1.4.

5.1.3.2.1.4 Task 4 results

In task 4, caregivers were asked to add a message to the TV interface. This task required 10 steps to be completed.

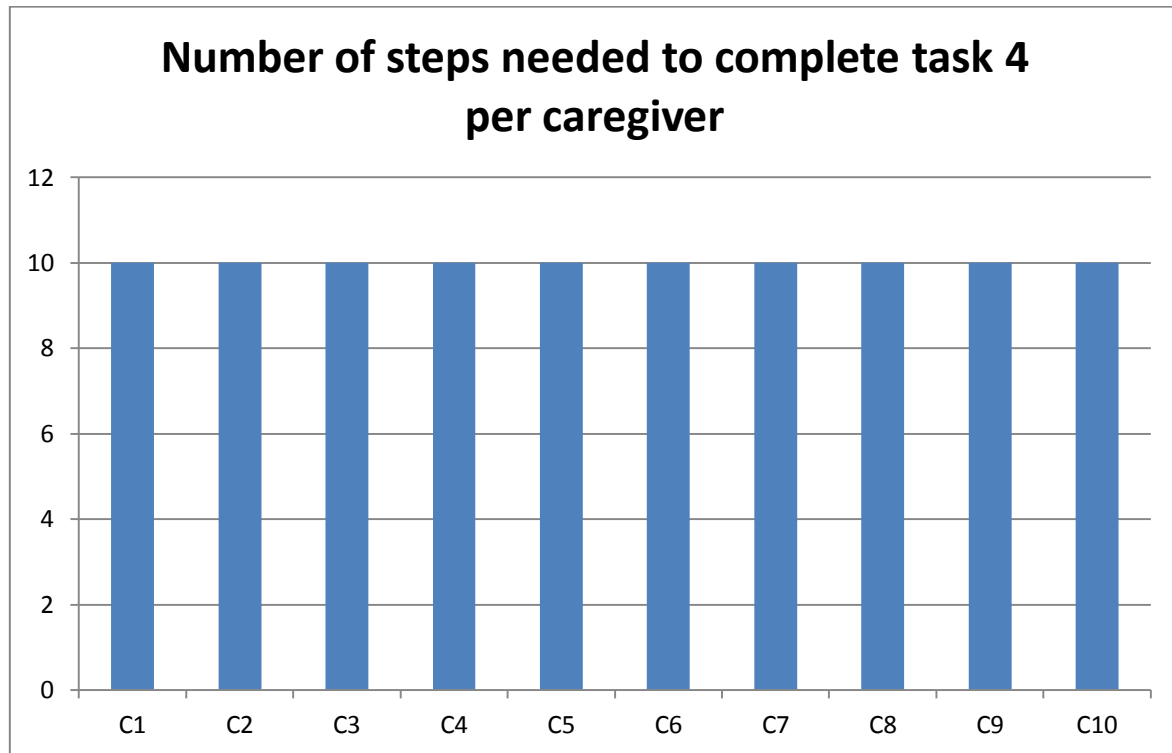


Chart 4 – Redesign phase: task 4 results.

Task 4 was successfully completed by all caregivers. Additionally, no caregiver needed additional steps. All completed the task with the minimum number of steps required.

The flawless execution of this task by all caregivers can be easily explained by the fact that it is very similar steps-wise to the third task. Thus, efficiency was observed on the system usability-wise.

5.1.3.2.1.5 Task 5 results

The fifth task had the goal of adding a video to the TV interface so that dementia-affected persons could be entertained. Six steps were required to complete this task.

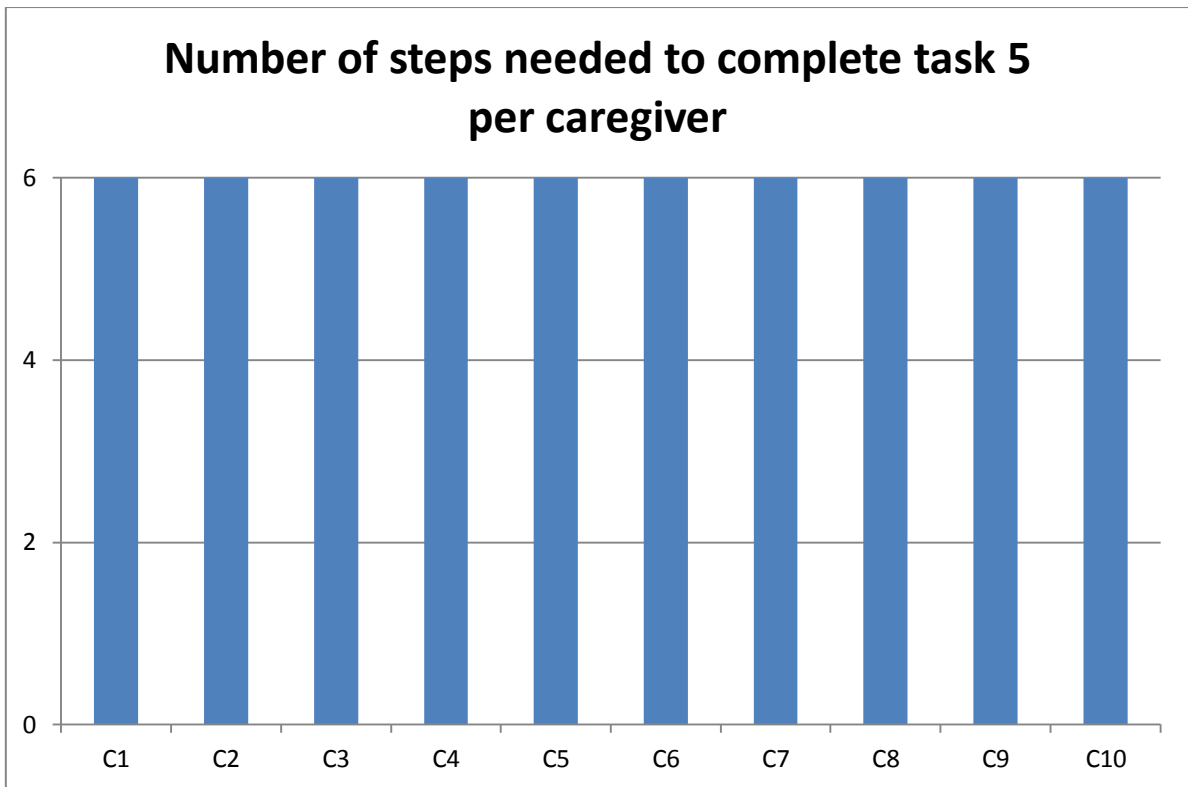


Chart 5 – Redesign phase: task 5 results.

Once again, all caregivers completed task 5 with no additional steps.

These results can be justified in the same way as the ones of task 4. There is however one important note that can be added here: the positive results show that the entertainment functionalities successfully followed the look and feel of the application and integrate well with it.

5.1.3.2.2 Task 6 results

In task 6, caregivers were asked to swap the active entertainment placed on the TV in the previous task. This time, they were supposed to show slides to the dementia-affected person. The task required six steps to be completed.

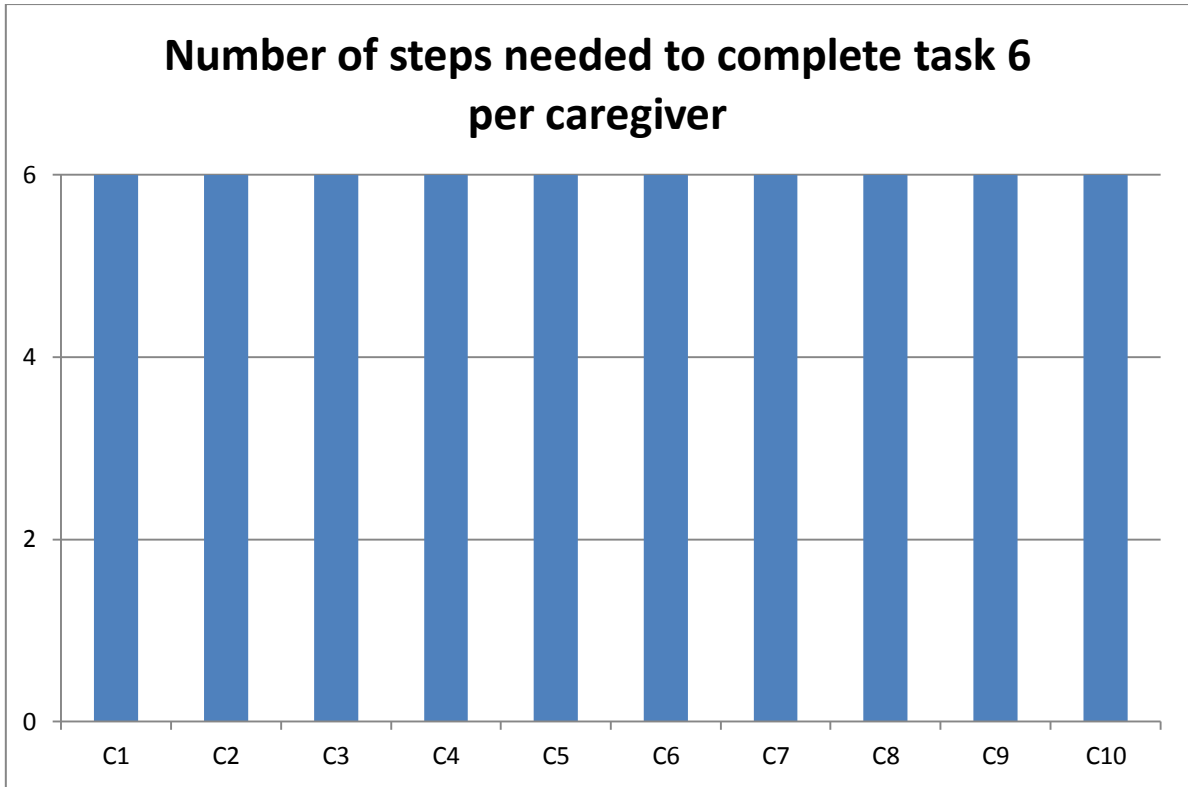


Chart 6 – Redesign phase: task 6 results.

Task 6 follows in the footsteps of tasks 4 and 5: no additional steps needed at all.

By this point, the regular navigation through the application and its behaviours seemed pretty well understood.

5.1.3.2.2.1 Task 7 results

In task 7, caregivers were asked to switch the activity duration’s icon from the hourglass to the clock. This could be done in the settings screen. This task required four steps.

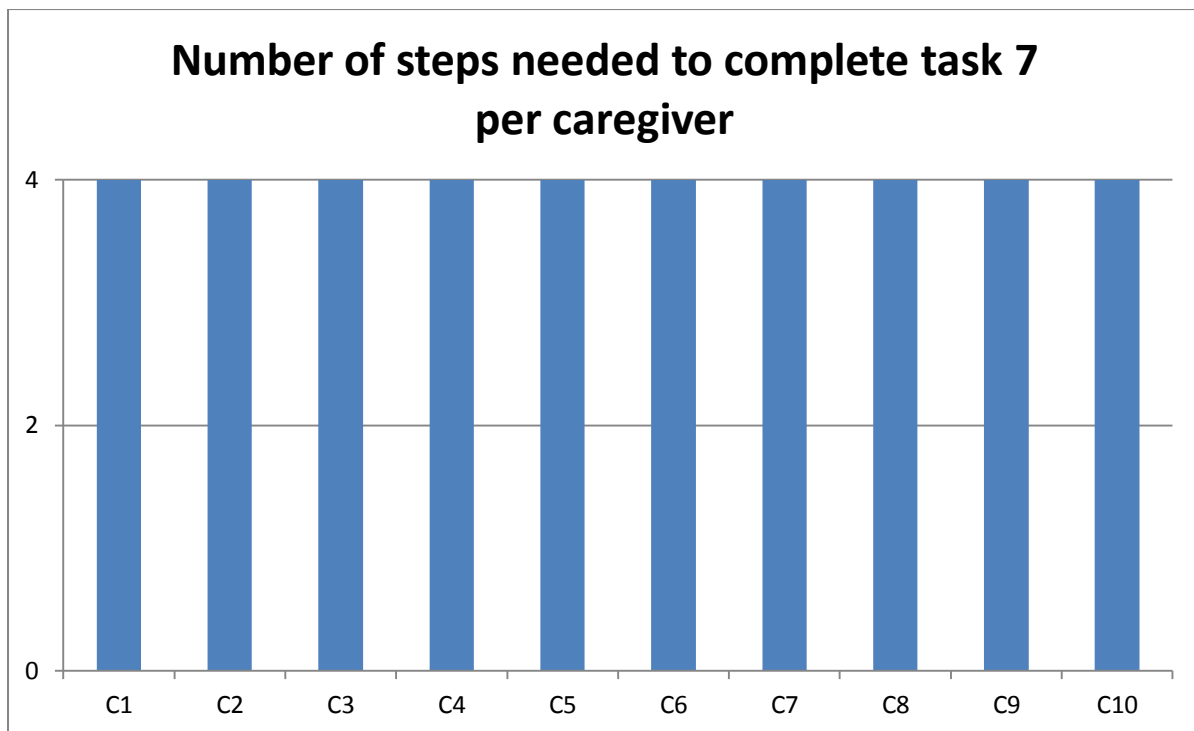


Chart 7 – Redesign phase: task 7 results.

This task was a very successful one. No additional steps were needed by any caregiver.

This task brought to the facilitator’s attention three notable points:

- One caregiver commented on how nice it was to be able to change the activity duration icon. Previously the same caregiver had troubles understanding the hourglass icon used throughout the tests and this was very well received, especially taking into account that the diseased relative would never recognize the hourglass.
- A “Save Settings” option was missing. This was a feeling shared by various caregivers. All of them tried going back but were never too sure that changes were actually applied.
- One of the caregivers was technology-savvy and had experience with the Android OS. This caregiver suggested changing the check boxes and radio buttons that allow for the changing of options to be placed on the right edge of the screen instead of being right next to the option’s icon.

While at first glance it may seem strange that no errors were made during this task, this is easily explainable: the settings screen is very text-heavy, so caregivers used some time to analyse the options and were careful in their choices. Additionally, they used that time to voice concerns as shown by the notes and commentaries.

5.1.3.2.2.2 Task 8 results

In task 8, caregivers were asked to hide the message bar along the bottom of the TV. This could be done in the settings screen and required four steps.

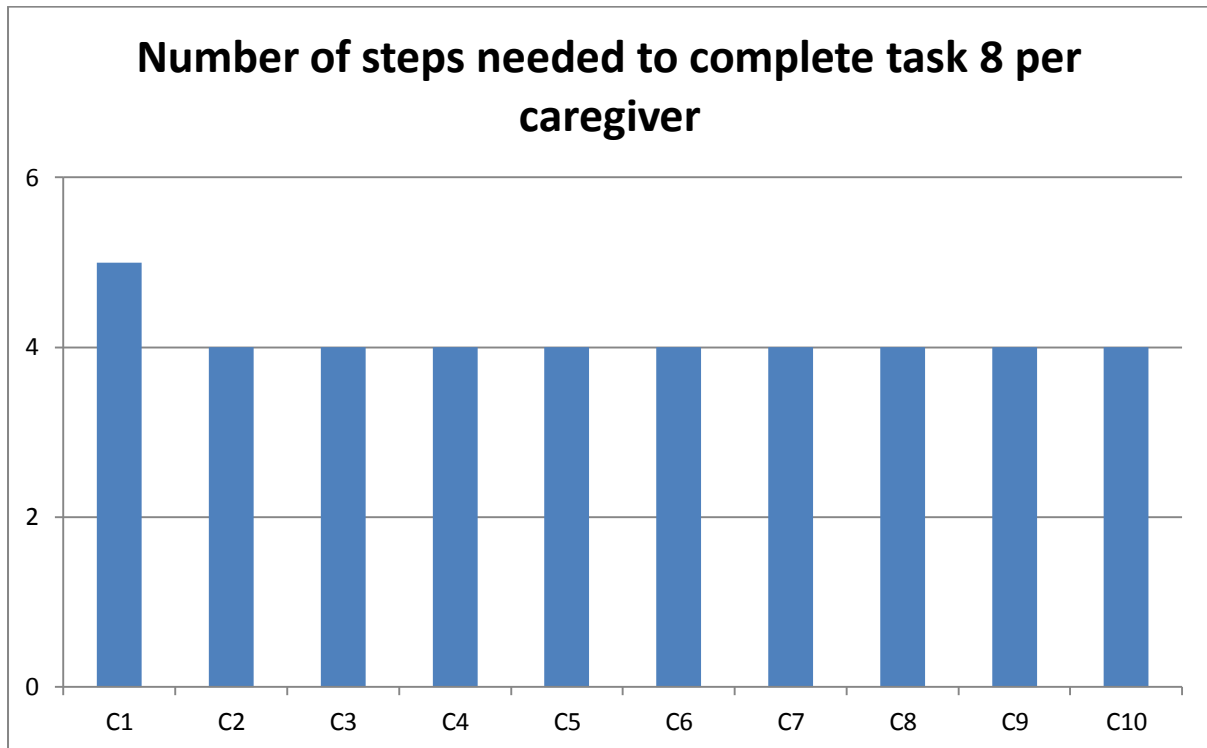


Chart 8 – Redesign phase: task 8 results.

Only one caregiver needed an additional step to conclude this task.

Two things deserve to be mentioned in this task:

- First, the caregiver who took an additional step first touched on the “Change Message” option. This was in part the facilitator’s fault because the task was not made very clear during the explanation. Nevertheless, it also outlined the problem of devising tasks and explaining them accurately. The person is also actively looking to the interface trying to achieve the desired result, so common terms get picked on and options are experimented with, which is not a bad thing.
- Second, as Figure 30 shows, the designed screen was a little crowded and could generate some confusion. One caregiver lost a bit of time trying to understand if the option was enabled or not. This was the facilitator’s fault.

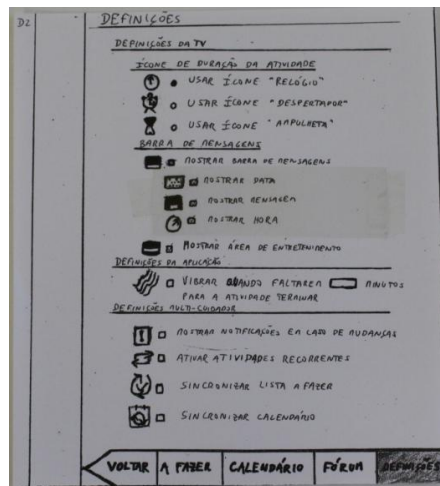


Figure 30 – The “Settings” screen’s low-fidelity prototype with the “Show Message Bar” option disabled.

5.1.3.2.2.3 Task 9 results

Task 9 was the final task. Caregivers should hide the entertainment options by going to the settings. This task required four steps to complete.

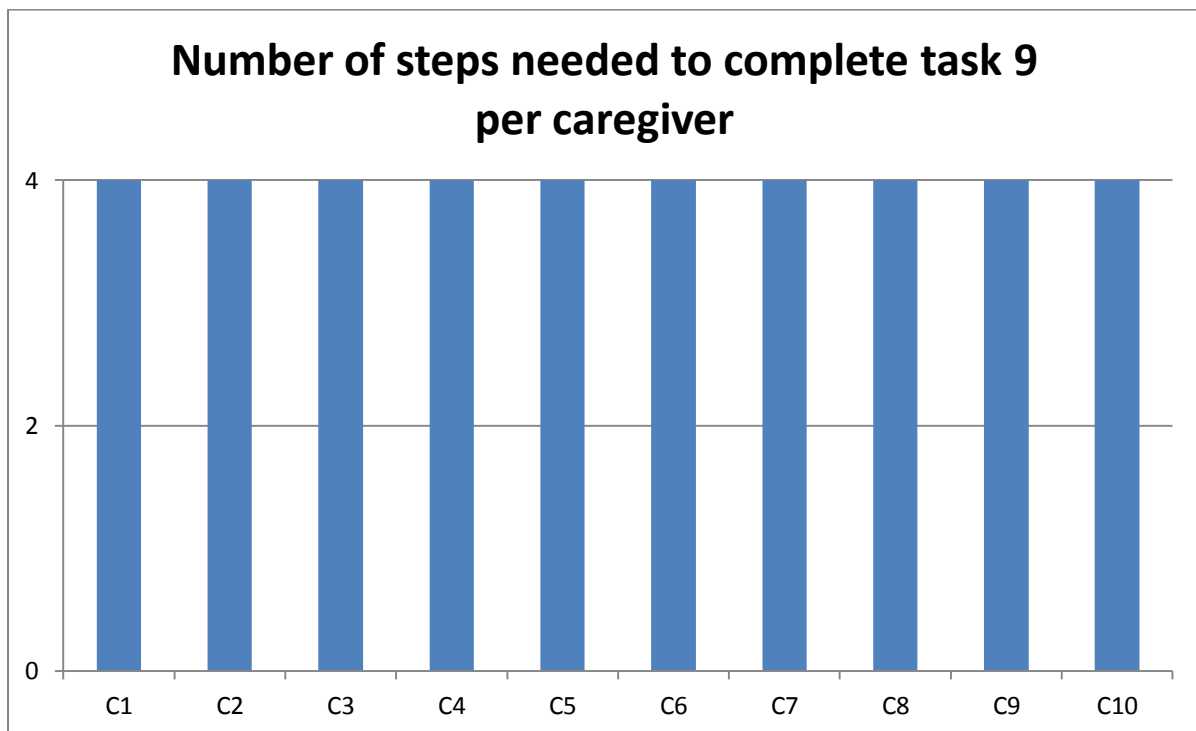


Chart 9 – Redesign phase: task 9 results.

No additional steps were needed to be taken by any caregiver to complete the last task. By this point, everyone was pretty sure of how to complete tasks and understood how the application worked.

5.1.3.2.2.4 Global task results analysis

All in all, the task results were positive.

Table 3 – Redesign phase: Minimum number of steps needed, maximum number of steps used and average number of errors per task.

Task	Minimum number of steps needed	Maximum number of steps used	Average number of errors
Task 1	10	11	0.1
Task 2	9	11	0.6
Task 3	14	15	0.7
Task 4	10	10	0
Task 5	6	6	0
Task 6	6	6	0
Task 7	4	4	0
Task 8	4	5	0.1
Task 9	4	4	0

Analysing the number of errors per task globally allows for the identification of the more problematic tasks. Tasks 2 and 3 were the ones where most errors occurred. The previous individual task analysis shows that task 2 had problems related to how the caregivers used technology and not exactly difficulties in using the system. Task 3 was indeed a tougher case. However, useful conclusions could be extracted from this task that served to provide a better designed application more in line with their expectations since caregivers gave valuable suggestions regarding the options' terminology. Of the remaining tasks, the first and eighth revealed to be mainly related to getting used to the application and the facilitator's fault, respectively. All of the tasks were successfully completed and even those that did not need additional steps from caregivers led to useful and important information.

As 15 errors were identified in total during the execution of all 90 tasks, on average it could be said that approximately two errors were made by caregiver. That value is encouraging and very positive regarding the usability of the application.

5.1.3.2.2.5 Questionnaire results

After performing the nine tasks, each caregiver was given a questionnaire with 14 questions to be answered. In the first eleven questions, caregivers had to choose from four options, the most positive being "Always" and the most negative being "Never". The questionnaire aimed at understanding the same concepts as mobileWAY v1's: the usability of the system (questions 1 through 3), the general appreciation of the system when using it (questions 4 and 5), how caregivers think the application will help the dementia-affected persons (questions 6 through 8)

and how it helps themselves in feeling more comfortable and relaxed regarding their relatives' situation (questions 9 through 11). The last three questions, 12 to 14, were open-ended to allow for caregivers to express themselves freely regarding what they liked, what they disliked and what could be improved on the system.

The following chart shows the global results of the quantitative measures (first 11 questions):

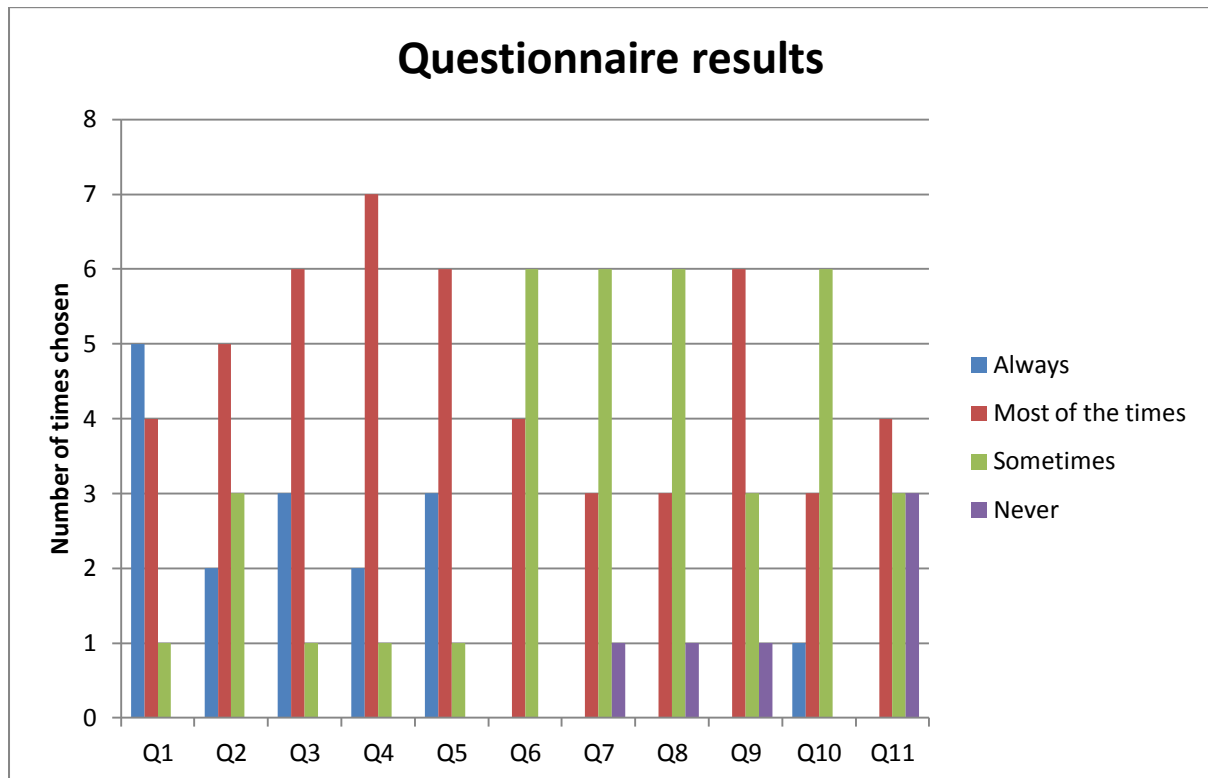


Chart 10 – Redesign phase: questionnaire results.

The first three questions were mostly answered positively. In general, caregivers thought that the application was usable. The second question had three caregivers answer “Sometimes”, most likely derived from the difficulties they had had regarding some terminology, as discussed previously.

Questions 4 and 5 were also positively evaluated. In general, caregivers expressed that they liked the application.

Questions 6, 7 and 8 display more conservative answers. As caregivers filled the questionnaire, many commented that it is impossible to know for sure if the dementia-affected person will feel safer and more relaxed although they believed it would help. The “Never” answers displayed in questions 7 and 8 had to do with the caregiver’s knowledge of the diseased relative. The caregiver knew that in the person’s current condition (a more advanced stage of AD), the system would not be capable of making the person feel more secure or calmer,

respectively. It is also worth noting that one of the caregivers answered question 7 as “Sometimes” but included a comment: “it depends on the person’s degree of discernment”. Globally, and considering this specific disease, it is understandable that participants are conservative while answering these questions.

The last three questions were answered similarly to the last group. The number of “Never” answers, particularly in the last question, is understandable as the system does not actively monitor the dementia-affected person. Of course, while it is true that mobileWAY can help caregivers and provide support in these contexts, it cannot substitute other kinds of support systems or human relationships and neither does it intend to do so.

Regarding the open-ended questions, generally the comments provided were positive. One caregiver was a bit harsher (C4), saying that the application is a bit limited in terms of practical use because it is dependent on the stage of the disease and also that the application is complex to use as not everyone has mastered the technology. Assessments of systems like these are naturally related to the difficult personal situation caregivers are experiencing. The person that this caregiver looks out for is in a more advanced stage of dementia so there are increased doubts regarding the capability of the system to be able to support in those cases. mobileWAY is a primarily intended for early-stage AD because of the extreme difficulties that these persons tend to go through in later stages.

Another example that reflects the personal situation can be seen on the most disliked option of C9. In this particular case it can be seen that the entertainment option is not very useful at all, since the dementia-affected person does not pay much attention to any of the entertainment provided by these functionalities. However, the positive side of allowing customisation ended up being reinforced in these cases.

Generally, people were positive about the application. The results reinforced the idea that the system can serve as good support in these contexts, thus validating its continued development.

5.1.3.2.3 Dementia-affected persons’ results

The results from the dementia-affected persons will be discussed in this section. The full tables of notes and commentaries can be found in appendix 11.5.

AP1 did very well in the two tested scenarios. The only thing that generated difficulties was the understanding of the clock icon. However, this difficulty ended up revealing something that was not considered previously. This was one of the tests where a formal caregiver was present,

and this person not only knew the dementia-affected persons but also knew quite a lot regarding the disease. One of the things that surfaced when the person was struggling to understand the clock was that it was missing the indicative numbers (3, 6, 9 and 12). By drawing these on the icon, the person made a connection instantly. This representation was therefore used in all remaining tests. Another thing that was important was that in this test it was found that testing three slides made the task rather long. As a result, and because it would have minimal impact on new tests, from this point on only the two clearer slides (one with a picture of Santa Claus and the other with a picture of the Christmas crib) were used.

AP2 also displayed good results. The clock was once again a point of difficulties but the combined elements (numbers, circular shape, activity duration that could be read in the text) ended up successfully indicating the icon's intended representation.

AP3 was more problematic. The more advanced stage of AD in this case showed some difficulties in reading from too far (two meters) and understanding pictures, including the daughter's one. However, two things were positive: first, reading the text was not a problem at all, the main difficulty was the distance; and second, the picture that was a photograph of a church revealed a very good reminiscence potential just because of the trademark cross.

AP5 performed a successful test generally, with the only downside of the clock icon's late recognition. The test showed, however, that the numbers were a huge help when the person was trying to figure out what it was.

The last tested person, AP6, was another problematic case. This was yet another case of a more advanced stage of AD. The person had great difficulties understanding the text and pictures from far away. In this sense, it was a lot like the test with AP3. However, just as with AP3, partial success could be seen in both the reading of text and partial picture understanding.

Overall, the tests were positive. Early-stage AD persons could more easily understand the information while more advanced-stage AD persons had greater difficulties. However, the potential found for reminiscence and short-term memory stimulation indicates that the application can serve as a means of support even in these more complicated situations.

There is one thing that deserves to be mentioned regarding the clock as a final observation: although the clock was recognized by most people, it is true that in some cases some time or help was needed. However, this was also a shortcoming of low-fidelity prototyping. In the working system, the clock icon will be updated in real time as the minutes go by. This could not be conveyed in paper, and it is expected that this added help will make identification even easier and faster.

5.1.4 Final design of mobileWAY v2

The good test results and the amount of observations allowed for some changes that were very important before starting implementing the system. The changes as collected from the usability tests that were considered in the implementation phase were as follows:

- In the main screen, the word “Change” was removed from every option regarding accessing a given resource type (caregiver, activity, activity duration and message) after at least one had been added to the application.
- When adding a resource type to the TV, the option to do so no longer had “Change to” in its terminology. Instead, that was replaced by “Confirm”.
- The settings screen was given a “Save Settings” option.
- In the settings screen, the suggestion given by C6 of placing check boxes and radio buttons on the right edge of the screen was followed. Even though this was a suggestion given only by this caregiver, none of the other caregivers paid much attention to this element’s placement and did not seem to mind a different one because everything would work in the same way. Being so, and because the implementation was in fact going to be done on the Android OS, following its general look and feel seemed completely right and adequate as in this way the application becomes easier to use and more adapted to a wider age range.

There was one thing that was observed in the tests that did not make it to the final redesign after being evaluated: the possibility of touching directly on the TV screen fragment of the application to directly place a caregiver, activity and activity duration on the TV. There are various reasons for this decision:

1. First, by allowing this, a disconnect would exist between the tablet application’s TV screen fragment and the TV interface itself (e.g., in the tablet a caregiver picture appeared but in the house, no caregiver was being seen by the dementia-affected person).
2. Second, this behaviour would conflict with the original zooming idea of the TV screen fragment.
3. Lastly, this behaviour would involve the design of new screens as this would bring about an entirely new workflow.

Of course, these problems could be addressed in different ways. For instance, a way to tell caregivers that the TV was not yet updated could be via a faded-out display of the pictures (reason 1), and zooming could coexist with direct picture input by making sure that it activated

only when the interface was touched outside of the resource-input options (reason 2). However, such solutions involved many considerations and further testing with caregivers (in some cases, only with high-fidelity prototypes and various would be needed to assess the best way). Since these resources are very difficult to find and time was limited as well, this idea had to be dropped in the current implementation.

Finally, one last change had to happen because of technology limitations. As usability tests progressed, work on the final application was already underway. One of the available options in the settings allows caregivers to make the device vibrate when a customisable amount of minutes remain to the end of the caregiver's activity. Because the application was tested on a device without vibration capabilities, this option was changed to play sound instead of vibrating. This happened merely to avoid displaying a useless option, and eliminating it entirely would not make much sense. It is very simple to change this option to accommodate both kinds of feedback (although it would need to be renamed) or even just show the vibrate option if the device supports it.

As the redesign of the application was concluded at this point, the following chapters will focus on the specification, implementation and final evaluation of the system.

6 Technical Specification and Implementation of mobileWAY v2

6.1 Technical Specification of mobileWAY v2

In this section, the full specification of mobileWAY v2 will be detailed, where requirements, both functional and non-functional, will be listed as well as the main use cases of the application. Lastly, the system architecture will be presented.

As was already described earlier, mobileWAY is a system directed at both dementia-affected persons and their respective caregivers. Caregivers use a tablet application to display very simple information on the TV watched by dementia-affected persons, such as who they are, what activity they are going to do, the duration of that activity as well as optional messages and entertainment aimed at the dementia-affected persons. These persons, on the other hand, are able to see what caregivers display on the TV screen at home.

Since caregivers can use the system from anywhere and multiple caregivers can use it, there exists a central server that knows where the TV is so it can receive information from the tablet application(s) and push it to the TV.

6.1.1 Requirements Specification

In this section, the main requirements will be specified. It contains both functional requirements – that specify functions that the system will perform – and non-functional requirements – that specify how the system will perform those functions.

6.1.1.1 *Functional Requirements*

6.1.1.1.1 Tablet Application

6.1.1.1.1.1 *User Requirements*

6.1.1.1.1.1.1 *Caregiver*

Caregivers can:

1. Manage resource information, where they are able to:
 - a. Add themselves to the application by entering a name and taking a picture or selecting one from the picture library.

- b. Access a list of all caregivers added to the application.
 - c. Edit caregiver information.
 - d. Delete caregiver information.
 - e. Push caregiver information to the TV.
 - f. Add activities to the application by entering a name and taking a picture or selecting one from the picture library.
 - g. Access a list of all activities added to the application.
 - h. Edit activity information.
 - i. Delete activity information.
 - j. Push activity information to the TV.
 - k. Add activity durations to the application by choosing the amount of hours and/or minutes.
 - l. Access a list of activity durations added to the system.
 - m. Edit activity duration information.
 - n. Delete activity duration information.
 - o. Push activity duration information to the TV.
 - p. Add messages to the application by entering a name.
 - q. Access a list of all messages added to the application.
 - r. Edit message information.
 - s. Delete message information.
 - t. Push message information to the TV.
 - u. Access a list of available entertainment in the TV's set-top box.
 - v. Play slides, audio or video in the TV's set-top box.
 - w. Stop playing slides, audio or video in the TV's set-top box.
 - x. Change playing slides, audio or video with another entertainment, regardless of type, in the TV's set-top box.
2. Zoom in on what the TV screen is currently showing to the dementia-affected person.
 3. Manage settings, where they are able to:
 - a. Choose from three different activity duration icons.
 - b. Show/hide the message bar part of the TV's interface entirely or show/hide any combination of the following:
 - i. Date;
 - ii. Message;
 - iii. Time.

- c. Show/hide the entertainment area of the TV's interface, which hides the entertainment option on the application as well.
 - d. Play a sound when a configurable amount of minutes remain to the end of the caregiver's activity.
 - e. Enable/disable notifications when changes occur⁴.
 - f. Enable/disable recursive tasks⁴.
 - g. Enable/disable to-do list synchronisation⁴.
 - h. Enable/disable calendar synchronisation⁴.
4. Access multi-caregiver functionalities that enable management of that functionality. Three multi-caregiver functionalities can be accessed:
- a. To-do;
 - b. Calendar;
 - c. Forum.

6.1.1.1.1.2 *Interface Requirements*

- Text fields accept all characters.
- Number fields such as those found when defining the activity duration only accept numeric characters.
- Activity duration hours can go to a maximum value of 23 and a minimum value of 0. Default value is 0.
- Activity duration minutes can go to a maximum value of 59 and a minimum value of 0. Default value is 0.
- On the settings screen, the option to play sound when a given amount of minutes remain to the end of the caregiver's activity has a number field that can go to a maximum value of 1439 (23 hours and 59 minutes) and a minimum value of 0. Default value is 0.
- Font size depends on the screen and its organization but must always be readable by its target audience.

6.1.1.1.1.3 *Business Requirements*

- The application can run only in portrait orientation; however, both portrait orientations must work (every tablet device has two portrait orientations and two

⁴These options can be toggled but do not actually do anything in the final application. This will be explained in chapter 6.2.2.

landscape orientations, depending on how the user uses it, e.g., upside down). There is an exception to this: the TV screen zoom interface must run in both landscape orientations but not in portrait mode.

- Caregivers and activities need both a name and a picture before they can be added to the application.
- Activity durations must at least be equal to one minute before they can be added to the application.
- Messages must have a name before they can be added to the application.
- When taking pictures, the following cameras will be used:
 - Frontal to take a picture of the caregiver;
 - Rear to take a picture of an activity;
 - If the device only has one camera, it will be used by default for every picture.
- Before asking caregivers whether they want to push information (including entertainment) to the TV, they must have previously confirmed three core elements: caregiver, activity and activity duration.
- The TV screen fragment of the application never actually shows videos or slides and neither does the tablet play audio. When entertainment is playing, only an icon identifying the type of entertainment is displayed alongside a sentence letting the caregiver know that it is playing.
- Internet access is required to communicate with the server and thus send information to the TV, as well as accessing multi-caregiver functionalities.
- The application should give proper feedback to the caregiver when something happens successfully, such as adding or eliminating information, or fails, such as when there is no Internet connection.
- When deleting a resource, the application should ask the caregiver for confirmation.
- On the settings screen, when the “Show Message Bar” option is disabled, its related options – “Show Date”, “Show Message” and “Show Time” – should not be accessible.

6.1.1.1.4 Hardware/Software Requirements

- A tablet device with Android 3.1.x or newer.
- The device must have at least one camera.

6.1.1.1.2 Server

6.1.1.1.2.1 *Business Requirements*

- The server must be accessible through its Internet Protocol (IP) address and a port number by a device connected to the Internet.
- The server must receive information from the tablet application and store it in its database.
- Information received and stored must be sent to every detected set-top box inside the home network.
- Three sets of information must be individualized to allow for flexible updating of the TV information:
 - Caregiver, activity and activity duration information as well as the respective pictures;
 - Entertainment information (with “play” and “stop” commands);
 - Message bar information.

6.1.1.1.2.2 *Hardware/Software Requirements*

- A server with the Ruby language installed, with the gems required to support Ruby on Rails 3.1 or newer.
- An SQLite3 database.
- Ports 1337 and 1338 open on the network, to send and receive information.

6.1.1.1.3 TV Side of the System

6.1.1.1.3.1 *Interface Requirements*

- Everything must be displayed and visible on the screen (no scrolling).
- The caregiver, activity and activity duration information must always be displayed.
- Font size must always be readable by its target audience.
- If there is entertainment displaying on the TV, the interface content should be dynamically arranged so that it shares about half of the screen with the message bar information (if present).

6.1.1.1.3.2 *Business Requirements*

- The application must run in landscape orientation for the TV interface.
- Entertainment only appears when the caregiver tells it to. As soon as it is stopped or ends, the interface is cleared of this information.
- The message bar is optional and any of the elements that compose it (date, message and time) can be hidden.
- When one of the three sets of information mentioned in 6.1.1.1.2.1 is updated, only that set changes.
- The clock must update every second as time passes. The clock hand moves clockwise and the elapsed time will be depicted with a progressive green-coloured filling. Accordingly, the number of minutes shown in the sentence that accompanies the resources' pictures must decrease every minute, going no lower than 0.
- When an activity ends, nothing happens. The interface simply shows "0 minutes remaining" along with all previously posted information and sits there waiting for the caregiver to clear it.

6.1.1.1.3.3 *Hardware/Software Requirements*

- A TV.
- A Google TV set-top box supporting Android 3.1.x or newer.

6.1.1.2 *Non-functional Requirements*

- Usability – Usability is one of the most important qualities of the system. mobileWAY v2 targets the context of dementia that involves both older and younger people, as well as people with severe disabilities. Many usability tests were done having end users at the centre of design and development to try and best adapt it to their needs and knowledge. A clean, consistent and intuitive interface with visible and understandable information should be hallmarks of the system so that users can quickly engage in its usage. Using the platform's usability guidelines is also something that should happen whenever possible.
- Performance – The system should be smooth and avoid stuttering. The result of a given action on the tablet application should be immediate when possible and something should always happen to let users know that they did something. Long

tasks that are likely to freeze the system or make it unresponsive should always be relegated to the background. Resource optimisation is crucial since it's important to ensure that only necessary resources are being used. Resource processing such as the one that happens on the server and TV should be as fast as possible to keep information as synchronised as possible as well as being displayed in a timely manner to dementia-affected persons.

- Reliability – the system has to do its best to be reliable as it is important that it does not fail nor provide wrong information to both caregivers and dementia-affected persons.
- Extensibility – the system should allow for a relatively easy implementation of new features and expansion of others. By being modular and separating functionality, new integration with other applications can occur as well as new customisations and optimisations. Additionally, new tables can be created on the server database to allow for more useful information as well as new possibilities regarding the system's feature set.
- Recovery – the system should do its best never to fail or perform errors. If they do occur, though, the system should not just crash and disappear; it should try to recover and continue operating as normal. If possible, these recoveries should happen without the user noticing. They also should not interfere with what the user was doing and should try to save what they can.
- Robustness – in general, the system should be sturdy and inform users of the impossibility of doing something if the need arises (e.g., tell them that sending information to the TV is not possible at that moment).

6.1.2 Main Use Cases Definition

Use Cases are a description of how users (actors) will perform actions on a given system and thus show the collection of possible interactions between a system and its users.

In mobileWAY v2, there is only one actor that interacts with the system: the caregiver. Dementia-affected persons are passive users that only watch, in the comfort of their homes, what caregivers pushed to their TV.

In the following figure, the caregiver's use cases diagram can be seen:



Figure 31 – Caregiver's use cases diagram.

6.1.3 System Architecture

In the following figure, the physical system architecture diagram can be seen.

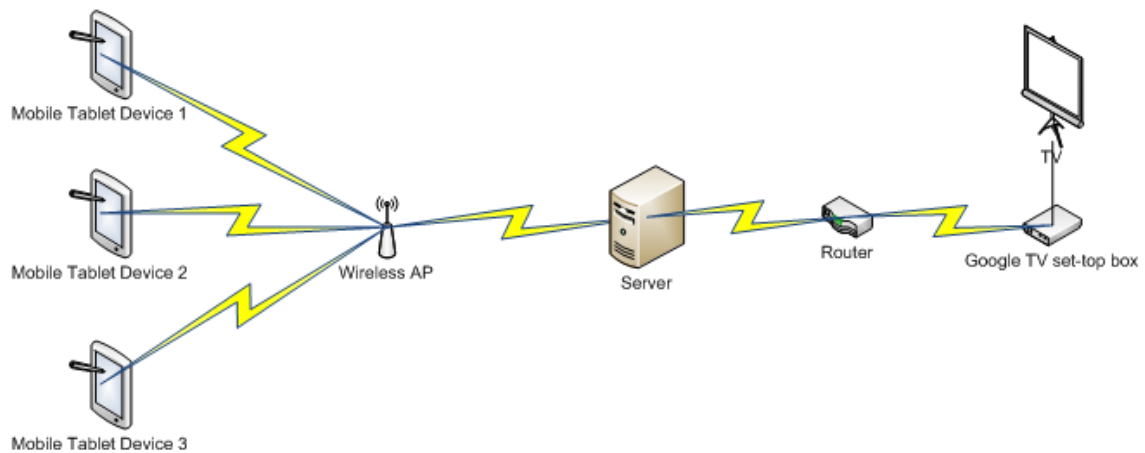


Figure 32 – mobileWAY v2’s physical system architecture diagram.

Multiple Android-powered mobile tablets (owned by different caregivers) can push information to the TV via the Internet. Information passes through a central server and is then forwarded to the correct Google TV set-top box, which is connected to the TV at home and displays the information to the dementia-affected person.

mobileWAY v2 has a variety of modules which will be detailed next. The application modules will be presented first, followed by the server modules.

6.1.3.1 Application

Although the tablet application is different from the TV’s interface, in reality there is only one single application that is installed both on the tablet and on the Google TV. This application comprises various modules.

6.1.3.1.1 Application Management Module

The application management module is responsible for the cohesion of the whole application. This module is central and every other module communicates with it or impacts it in one way or another.

In a first stage, this module controls whether the application should display only the TV interface (if it is launched from a Google TV) or the full-fledged tablet application (if it is launched from a mobile tablet).

On the TV side, this module is mostly responsible for keeping the interface updated as it receives commands and manages layouts. On the tablet side, this module is responsible for controlling a variety of interface elements such as fragments and inter-module passing of information. This module provides an interface to the application's internal database where important resource information is kept, and controls user settings and preferences as well.

6.1.3.1.2 Service Management Module

This module is only in full effect on the TV side. It is responsible for the creation and maintenance of a background service that is application-independent. This module listens to any intention of displaying or changing information on the TV that the dementia-affected person is watching. This intention is sent by caregivers using the tablet application. As soon as that intention is detected, the module will either:

- Launch the application if it is not currently displaying, as well as activate and inform the necessary processes to update the information on the screen; or
- Activate and inform the necessary processes to update the changed information on the screen.

This module communicates with the application management module to ensure interface updates.

6.1.3.1.3 Resource Management Module

This module is very important as it is responsible for the creation, edition, listing and deletion of resources in the system. Resources are caregivers, activities, activity durations, messages and entertainment (slides, audio and video).

This module manages each resource in accordance with its requirements. For instance, caregivers and activity durations are composed by different elements. The resource management module makes frequent calls to the application's database (therefore interacting with the application management module) to retrieve, add, update or delete resource information.

It is important to note that entertainment is a special case of resource because currently it can only be listed and cannot be created, altered or eliminated.

The resource management module is also responsible for initiating the sending of resource information to the TV, communicating with the network management module.

6.1.3.1.4 Network Management Module

This module gives life to the true goals of this system by making sure that requests to update the TV interface are honoured. This module receives requests from the resource management module and processes them, encapsulating information in a JSON (JavaScript Object Notation) structure where applicable. Information is then sent through the network and processed when it arrives at the Google TV. This module is responsible for ensuring all network operations and as such includes various checks to prevent errors, such as guaranteeing that there is an available Internet connection.

This module is also used to a lesser degree by the multi-caregiver functionality management module.

6.1.3.1.5 Multi-caregiver Functionality Management Module

This module manages multi-caregiver functionalities, namely the to-do, calendar and forum functionalities, that are provided by Google's own services. This module uses the network management module to verify the availability of a working Internet connection.

6.1.3.2 Server

The server acts as a broker between the caregivers' tablet application and the Google TV in the dementia-affected persons' houses. The following figure shows the server's model diagram:

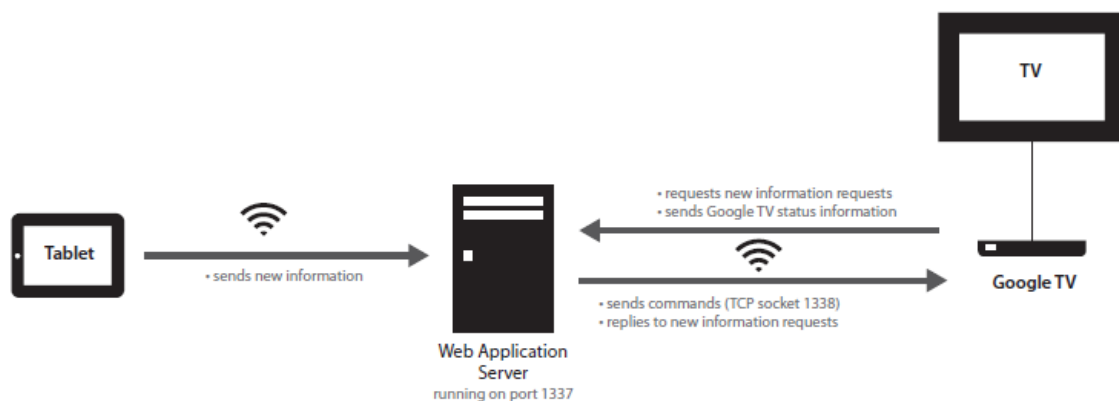


Figure 33 – The server's model diagram.

The server has four main modules.

6.1.3.2.1 Google TV Registration Module

This module is responsible for registering the activation and deactivation of Google TV sets. Activated sets will receive commands and be able to communicate with the server while deactivated sets will no longer be part of the application's environment.

6.1.3.2.2 Information Acquisition Module

This module is responsible for receiving and storing the information sent from the tablet application, which happens whenever caregivers want to display information on the dementia-affected person's home television.

6.1.3.2.3 Information Update Module

This module is responsible for telling the Google TV clients that new information is available. It sends update commands to clients informing that they can retrieve new information.

6.1.3.2.4 Information Serving Module

This module is responsible for serving information upon the requests of Google TV clients.

6.2 Implementation of mobileWAY v2

This chapter details the implementation of mobileWAY v2. It will present the methods and tools, the system functionality and some examples of using mobileWAY v2.

6.2.1 Methods and Tools

mobileWAY v2 is a system built in the following way:

- The application itself, which is installed on a tablet and on a set-top box, was developed for the Android OS using the Android software development kit (SDK).
- The server, where the database that receives and stores important information that must be passed from the tablet to the TV-connected set-top box is located, uses the Ruby on Rails web framework and an SQLite3 database.

These decisions had to be made when defining the requirements and it is important to explain them.

6.2.1.1 *The application*

The application side of mobileWAY v2 was intended to be developed on mobile devices, namely smart phones and slate tablets (which do not have a visible means of input and are generally used by interacting with the touch screen). The iPhone changed the landscape of modern smart phones (Kim, 2011) and the iPad, launched in 2010, was the first tablet that really popularised the tablet concept for the mainstream market (Strickland, 2011). From these points forward, as was mentioned earlier, these types of devices gained incredible adoption and they presently continue to grow and evolve at surprisingly fast rates. As a result, they have enormous and increasing potential in this work's scope.

mobileWAY v1 was tested on a low-fidelity tablet prototype. In mobileWAY v2 both the redesign and the implementation targeted a tablet (the TV component will be explained further down); smart phone work was not thoroughly conducted in the development of this dissertation. Besides time constraints, this decision was supported based mainly on two factors:

1. The tablet has advantages for both caregivers and the elderly. They feature touch screens that are larger and thus easier to use (Center for Technology and Aging, 2009). Option buttons can be bigger and more content can be seen and consumed. Since in reality caregiving is an activity performed both by younger and older people, these characteristics mean that tablets are more suited to encompass a broader range

of users in this context. Hence, they are a good option to showcase how these technologies can effectively be used to improve the quality of life of diseased people and those who care for them.

2. Tablet and smart phone applications cannot be approached in the same way. They need to be designed having the target device in mind (Apple Inc., 2011). Larger screens can have information separated in multiple columns whereas in a smaller screen it has to be compacted and divided across different application screens, for example. Adapting and optimising the interface for a smart phone would require a significant effort. Because the interface was designed with the specifications of a tablet in mind, as a first step, the prototype was redesigned and implemented on a tablet device.

Of course, and despite these reasons, it is important to say that redesigning the interface to fit on a smart phone screen remains a very big point of interest. These smaller devices have a variety of advantages that should not be ignored nor undermined and they share a lot with tablets in terms of potential and capabilities. However, in the current project, time and resource constraints made it impossible to actively pursue and go deeper regarding this work component.

Having decided the device type, it was important to know how the application would be implemented. mobileWAY is an application that aims to be used by as many people as possible. The idea of having it be as platform-independent as possible was heavily studied. However, in this project, it was developed for Android due to a variety of reasons.

One of the first studied possibilities was the use of HTML5. HTML5 is the fifth revision of HTML that started as a specification copyrighted by Opera Software. It was proposed to the World Wide Web Consortium (W3C) – a global community that develops Web standards – and rejected. Apple, Mozilla and Opera joined forces and worked on the evolution of HTML5's draft in a community called the Web Hypertext Application Technology Working Group (WHATWG). Later, in 2007, the W3C decided to work together with this community (W3C, 2012).

HTML5 is a working draft that “contains powerful capabilities for Web-based applications with more powerful interaction, video support, graphics, more styling effects, and a full set of APIs” (W3C, 2011). It basically uses the Web potential and technologies to provide richer applications to any device, including mobile devices and TV. This is appealing: in theory, HTML5 can position itself in a privileged condition in terms of platform independence and as

such diminish the validity or necessity of native solutions. However, as with any technology, it has various limitations. The following prevented it from being chosen for this project:

- Security – HTML5 applications are Web applications. This has serious implications security-wise. While users interact with the application, scripts could be altered and important data could be compromised more easily than in a native application (Wayner, 2011).
- Synchronisation – Web applications can be used offline thanks to local data storage. However, this can lead to very problematic synchronisation issues, e.g., users may switch browsers or computers (Wayner, 2011).
- User content – user data is kept in servers that may disappear with no guarantees of data recovery. This means that in essence, content created and provided by users is often out of their reach and control (Wayner, 2011).
- Forced updates – Web applications are not managed by users because they live on the Web. As a result, any update will be global and obligatory. While this has advantages, it also removes choice. In some situations, users may have valid reasons not to use the latest version of software (Wayner, 2011).
- No true global support – although HTML5 positions itself as a platform-independent solution, not every technology is supported globally. In fact, developers often have to adapt applications to different browsers. This is of course hindered by the fact that as a working draft, HTML5 is always evolving and things may change (and possibly break) very fast (Wayner, 2011).
- API access – native applications can leverage hardware in ways that Web applications cannot. For instance, accessing hardware buttons and the camera on a mobile device can be done with greater flexibility and results by the deeper hardware and platform integration (Mahemoff, 2011); (Meier & Mahemoff, 2011). While frameworks such as PhoneGap⁵ provide Web services that can be used to expose hardware features, they are more limited. Furthermore, relying on code developed by other third parties means that developers will have to trust that they are updated timely to coincide with the fast advances of native API possibilities. When this does not happen, developers will have to support their own needs, and this can lead to more fragmentation and work.

⁵ <http://www.phonegap.com>

- Performance – native applications are faster. While the Web is making serious progress in this area, it remains an important issue that needs to be addressed (Mahemoff, 2011).
- Look and feel – native applications can use native controls and functionality adapted and optimised to the platform. A Web application will possibly have to be adapted to various devices and even then it is possible that it will not replicate the user experience (Mahemoff, 2011).

HTML5 is without a doubt evolving and in certain cases can match the possibilities of native applications. However, for mobileWAY its advantages are outweighed by its disadvantages. As an application to support dementia contexts, factors like performance, user content and security are essential. Currently, HTML5 cannot offer many benefits of native applications, and so it was not used.

Developing a native application on a modern mobile device leaves the choice to essentially four players: Apple and iOS, Google and Android, Research In Motion (RIM) and BlackBerry OS and Microsoft and Windows Phone 7 OS.

Windows Phone 7 is currently, essentially a smart phone OS, so from the beginning it could not be chosen to target a tablet.

iOS, Android and BlackBerry Tablet OS were valid choices. Out of these, Android was chosen because of the following:

- Market share – Android is on the rise as a viable OS whereas RIM's devices are on a steady decline (Gartner, Inc., 2011). Android had 52.5% of market share in the third quarter of 2011 followed by Symbian (Nokia's former OS) at 16.9% and iOS at 15%. The huge success of Android continues to grow and it is predicted that by 2015 it will have a market share of 48.8% (Gartner, Inc., 2011). These figures make Android a very suitable choice as a platform capable of widespread reach.
- Flexibility – Android is open source and very flexible. Third-party tools can be used freely and there is a lot of dynamism in terms of customisation. The core applications use sets of API that are available to developers, which means custom applications can replace core ones entirely (Google, 2011). Since the development environment is not as strict it makes it a very suitable choice for adaptation of user interfaces and functionalities for given segments of the population, such as the work developed in

this thesis. All of this also culminates in an environment that eases the process of developing new applications.

- Google TV – mobileWAY involves a specialised TV interface that also needed to be explored as development would be required for it. In the scope of this project, the Google TV was one very important part of choosing Android. Google TV is a smart TV platform offered by Google that is powered by Android and integrates with existing televisions, making them smarter by offering access to a plethora of applications, enabling Internet access, and so on (Google, 2011). Because this platform runs Android, applications can be developed just as they are for smart phones and tablets using all known underlying concepts of the OS. Other devices or Internet-enabled TV would have various limitations or use proprietary SDK which would fragment the components required for this project and so were not chosen.

All the aforementioned reasons made Android the best choice and as such, it was chosen to support the application's implementation. A variety of concepts and components are important in the scope of Android, so the next sections will delve further into what Android is and how to work with it.

6.2.1.1.1 The Android ecosystem

Android is a software platform developed by the Open Handset Alliance, a group of 84 technology and mobile companies (Google, 2011). It is an open-source project led by Google. Android is currently very successful in the smart phone market and is expanding its reaches to tablet devices and even televisions.

Android is based on Linux and uses a customised version of the Java programming language that is adapted and optimised to leverage mobile devices' system resources (Google, 2011).

There are various versions of Android, each of which building upon the last. As of this writing, the latest version is 4.0.3, codenamed Ice Cream Sandwich (ICS). However, version 3 was special. It was codenamed Honeycomb and was a version released specifically for tablet devices. This project was tested on a tablet device running Android 3.1. The used Google TV set-top box also received an update to this version, so the code could easily be deployed on it.

To develop Android applications, in this project the Eclipse Integrated Development Environment (IDE) was chosen. The Android team made available a plug-in called ADT (Android Development Tools) for the Eclipse IDE that expands on it and provides an integrated

environment specifically for Android development; it adds a custom XML editor, debug output, wizards to execute common operations quickly, among others.

6.2.1.1.2 Android development

Applications in Android separate the user interface from application logic. Layouts are written using XML while the application logic is written in Java. Java and XML are widely known languages. Starting developing applications for Android is therefore relatively simple.

There are a number of important Android concepts that must be introduced because of their predominant usage in this project:

- Activities – an activity is basically a single screen with which the user interacts. An application typically has various activities that the user navigates through. Activities can start other activities and are kept in an activity stack. Each activity has a lifecycle with a variety of states, such as “Created”, “Paused”, “Resumed” and “Destroyed”, that developers need to understand and control to create flexible and powerful applications adapted to the reality of these devices’ features, such as multitasking (Google, 2011).
- Services – a service is a background component that can be application-independent and thus be used to perform a wide range of tasks such as downloading information from the network or even launching applications. Services also have their own lifecycles (Google, 2011).
- Broadcast receivers – a broadcast receiver allows developers to receive system-wide broadcast announcements. These announcements can be launched from the system itself or from applications. Broadcast receivers are very simple yet very useful because developers can use them to implement a variety of functionalities in a given application. For instance, developers can try to save important information when a low-battery announcement is made or they can even use a service to receive an announcement and do something after it is received (Google, 2011).
- Fragments – the fragment concept was introduced in Android 3.0 to cater to the management necessities of larger screens. A fragment is a portion of a user interface that lives in an activity. An activity can have multiple fragments that basically represent modules to achieve given goals. For instance, in a tablet an activity can be divided in two different lists that would be displayed in two different activities in smaller screens. These two lists can be further broken down into two fragments. This

way, the lists can be independently managed and even reused in other parts of the application without the need for new or repeated code. Fragments have their own lifecycles but since they are bound to activities, what happens to the activity where they are attached happens to them too. Fragments can be added and removed easily and they have their own stack (Google, 2011).

- Intents – an Intent is an abstract description of an operation to be performed. Intents are very important because they are what connects everything inside an application. Intents can be used to launch activities, pass data between application components, communicate with services and they are the objects received by broadcast receivers (Google, 2011).

Android is known for its usage in a very wide variety of devices. Inevitably, not every device will have the same specifications. One will exhibit a larger screen, another will have two cameras, a third device will have additional sensors and so on and so forth. Because of this, in Android application resources can and should be organised so that multiple kinds of configurations can be supported. This includes user interface layouts, application icons and localisation files. The following figure illustrates this concept:

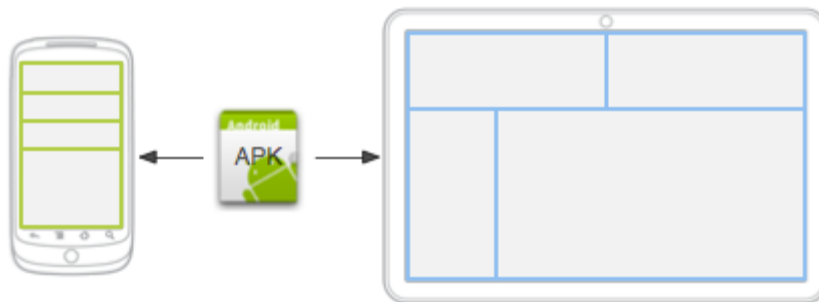


Figure 34 – An example of a different user interface layout structure for different devices, made possible by Android's resource separation. An APK is an Android package file that contains all of the application's code and resources and is used to install it. Source: (Google, 2011).

Because for this project the application was implemented on a tablet device and on a Google TV, the provided resources target both tablets with a 7" display or larger and a television display. Smart phone displays, for instance, are not supported. However, this kind of modularity makes it extremely easy to adapt the application to them; all that is needed is writing the code for the new layout arrangement as much of the application logic can be reused.

Another point of interest regarding application resources has to do with localisation. Currently, mobileWAY v2 supports both English and Portuguese languages. Supporting a new language is very simple because the strings of text used throughout the application are available in specific files. So, as long as these are translated, support for a new language happens as if it

was always there. The language used is based on the system's language. English is used by default for a non-supported system language.

The last important file that deserves to be mentioned is the `AndroidManifest.xml` file. This file is an essential part of an application as it tells the system important information. Among other things, this file is used to specify application components, such as activities and services, system permissions that are needed to run the application and system features used by the application. In mobileWAY v2, for instance, the used activities are declared here. Since a camera, Internet access and external storage access are needed, the application also declares so in this file. This file is very important as it is both a security mechanism (when users install an application, they can see what system features it needs and have to explicitly allow it to access them) and is used as a means of filtering applications: for example, the Android Market reads this file and knows that it should not list an application that needs a camera to a device without one; likewise, applications that are only meant for certain versions of Android cannot be used in others (Google, 2011).

6.2.1.1.2.1 Development and design practices

mobileWAY v2 is a mobile application that also has a TV component. While this section is by no means exhaustive, it is important to refer some important considerations that were had when implementing the application with regard to development and design practices.

In the initial version of mobileWAY, as was already shown, high-fidelity screen examples do exist that show the general look and feel and ideas of the final application prototype. However, it is important to keep in mind that interface elements such as colour and graphics were not thoroughly tested prior to the implementation itself. Additionally, the information collected from tests, both from mobileWAY v1 and the redesign developed in this work, led to some important interface changes that were already outlined. Because of these matters, as research was conducted and work progressed into the stage of implementation where visual design is vital, interface considerations related to this aspect had to be explored further.

The original design was followed as closely as possible and many elements were maintained. However, the new elements and additions in mobileWAY v2 required adjustments in some cases and new guidelines in others. In the following sections the most important considerations interface- and development-wise will be shown.

6.2.1.1.2.1.1 Colour

The colour schemes depicted in mobileWAY v1 were generally followed during the implementation. The TV and respective TV fragment in the application have a lighter gray as background while the application displays a darker gray. Interface elements follow similar principles regarding state colours and overall look.

6.2.1.1.2.1.2 Icons

Icons were kept as close to the originals depicted in mobileWAY v1's high-fidelity prototypes as possible.

mobileWAY v2 added new functionalities that needed new icons and graphics. These were investigated and created by following the same visual aesthetics laid out in the original design.

6.2.1.1.2.1.3 Buttons and options

Buttons and options are meant to be used by users, so it is important that they stand out. To achieve this, techniques such as looking like a typical button, having a border and displaying text to “touch here” as a means of guiding the user were employed. Furthermore, because users need to resort to using these elements in order to activate functionalities and achieve goals, having feedback is very important. When users touch such elements, mobileWAY v2 provides feedback by means of a colour change or other visible indications – for example, when an element such as a picture can be touched and selected, the application applies a colour filter that darkens it but maintains its understandability so that users know they have successfully selected it.

mobileWAY v1's high-fidelity prototypes are not very detailed regarding buttons' and options' feedbacks – mostly, the only clear ones are related to the use of an orange colour when users select buttons. However, the general look and feel of the application and these indicators were taken into account and they, along with literature recommendations of smart colour usage such as those present in (Dix, Finlay, Abowd, & Beale, 2004), paved the way to the final application results.

6.2.1.1.2.1.4 Feedback and confirmation dialogs

mobileWAY v2 has a variety of dialogs that help users understand what happened, whether operations were successful or not, whether certain operations were indeed wanted or not, etc. The literature and well-known references in the area of mobile design and usability such as

(Apple Inc., 2011) and (Nielsen, 2009) recommend adequate feedback in user interfaces. In terms of general layout, this led to one important change.

In the right screen of Figure 15, it is possible to see that the button to delete a resource in mobileWAY v1 is red. This can be easily explained by understanding that colour codes can be used to represent conventions in user interface design. Red and green are colours commonly associated with “stop” and “go”, respectively. Red can also be associated with “danger” (Dix, Finlay, Abowd, & Beale, 2004). As such, and because “delete” is a dangerous option that should not be used carelessly, the red colour serves as a warning to the user.

The addition of confirmation dialogs downplayed the importance of such an indicator, however, because if the user accidentally touches the “delete” button, the system will ensure that this action was in fact wanted by explicitly asking so to the user. Thus, the red colour was eliminated and this button was coloured like every other. This also helped diminish the presence of many different colours which is not recommended (Jacko & Sears, 2003).

In addition to this, it is also important to say that dialogs have a custom layout to keep the look and feel of the application intact.

6.2.1.1.2.1.5 The tab bar

The lower bar of the application where the multi-caregiver options and the settings can be accessed was called the tab bar and it suffered an important change with regard to the initial version of mobileWAY in terms of representation.

In mobileWAY v1, the “Back” option always appears highlighted in the high-fidelity prototypes (Figure 13 shows various examples of this). This was changed in mobileWAY v2. Now, this option only highlights when the user touches it. This was decided because of two key points:

1. The appearance of being selected may give users the wrong impression that this option cannot be used.
2. This appearance conflicts with the multi-caregiver and settings options. To enable users to better understand where they are in the application and because the tab bar is always displayed, whenever the user is located in the “To-do”, “Calendar”, “Forum” and “Settings” functionalities, the corresponding button stays selected and cannot be used.

6.2.1.1.2.1.6 *Animations*

Animations are very useful to communicate effectively with users by providing feedback and enhancing sense of manipulation. However, animations should be used sparsely and should never act as impediments to the smooth flow of an application (Apple Inc., 2011). Android provides activity transition animations that are fast, smooth and comprehensible, so nothing was changed in this regard. However, the animation possibilities for the switching of fragments were more limited and seemed very quick and static, which could cause a user to not realize that a fragment had just been replaced. Because of this, custom animations were applied in these cases. When a fragment is replaced, it will slide to the left and out of view as the new fragment slides into place from the right side of the application. Similarly, the reverse is applied when the user is returning to a previous fragment.

Another user interface element that exhibits animation is the clock icon on the television interface and on the corresponding TV screen fragment in the tablet application. As time passes, the clock is gradually filled to represent a countdown.

6.2.1.1.2.1.7 *Orientation*

mobileWAY v1 and v2 were primarily designed for the portrait orientation of tablets. While some devices will not evidence big differences if they are used in landscape or portrait orientations, some smaller tablets may do so, and that may lead to inappropriate or unexpected layout presentation. As such, currently the application can be used in either variant of the portrait orientation but not in landscape mode. The only exception to this rule is the activity that zooms in on the TV display, which runs in both variants of the landscape orientation but not in portrait. It was designed to behave like this.

The TV part of the interface however is the complete opposite. The particular activity that is used on the TV is designed to be used in landscape orientation as that is how televisions always display information (Google, 2011).

6.2.1.1.2.1.8 *No vertical scrolling on the TV*

One of the important requirements and design decisions was that the TV interface should not ever scroll. On a TV, scrolling may be slow and hide important information (Google, 2011). Since the TV is watched by people affected with AD, this was extra important, so each element that partakes in this particular interface, while dynamically sized, is always displayed in the available screen space and never hidden from view.

6.2.1.1.2.1.9 *General design and development guidelines*

In general, the development of mobileWAY as a whole followed design guidelines that try to ensure the consistency of the user interface, an appealing visual style and overall usability.

The use of a module-based development methodology as well as its related best practices helped in achieving the non-functional requirements. mobileWAY targets mobile devices that have limited resources yet are increasingly used to perform a wide range of everyday tasks that used to be limited to traditional computers. Restrictions associated with factors like battery life and the reality of multitasking increases the importance of adequate resource management, good integration and increased security. Because of this, striving for better performance, solid fault prevention and global application cohesion was a central part that guided the project's implementation as a whole.

6.2.1.2 *The server*

In order to communicate between the tablet application and Google TV clients, a server application was developed to serve as a broker between the two. As was said, its main modules take care of:

- Registering the activation and deactivation of Google TV sets;
- Receiving information from the tablet application;
- Sending update commands to the Google TV clients when new information is available for retrieval;
- Serving information in accordance with Google TV clients' requests.

The server also logs information for development and debug purposes. In the following sections, a quick overview of the technologies and implementation details will be described.

6.2.1.2.1 Description of the server technologies

Ruby on Rails is a Web application framework built on the Ruby programming language. It abstracts common functionalities of a Web application, based on the MVC (Model-View-Controller) pattern, enabling rapid development of Web applications. For the server application, version 3.1 of the framework was used.

SQLite is a lightweight relational database management system. It was chosen for the data store as the application did not require a great number of requests being served per second,

having a light load, for which SQLite is ideal; it is small in size and is great to spare server resources when compared with other databases such as MySQL and PostgreSQL.

The information is exchanged using JSON. JSON is an open-standard data interchange format that is both human-readable and text-based. It can be easily generated and parsed by machines and is a perfect format to pass structured data between machines through networks. As such, it was used in mobileWAY v2.

6.2.1.2.2 Implementation details

The mobileWAY v2 Web application runs a server in port 1337, listening to HTTP requests.

The Web application database has 4 tables, with no relationships between them. They are as follows: entertainments, information, messagebars and tvs. The following figure shows each table's fields:

entertainments	
PK	<u>id</u>
	status created_at updated_at entertainment_type entertainment_id

information	
PK	<u>id</u>
	text caregiver_tv_picture activity_tv_picture activity_duration created_at updated_at icon

messagebars	
PK	<u>id</u>
	message show_message show_date show_time show_messagebar created_at updated_at

tvs	
PK	<u>id</u>
	ip status created_at updated_at

Figure 35 – The server's database tables.

Each of the server's models is served by a controller, which supports the REST (Representational State Transfer) pattern, with POST, GET and PUT requests, to receive new information from the tablet and make it available for retrieval from the Google TV.

An API is provided for interaction with tablets or Google TV set-top boxes. A description with examples can be found in appendixes 11.6 and 11.7.

Information is sent from the tablet via a JSON POST except when sending images, where a reference to their locations in the database and in the disk is used instead.

When the server receives new information from the tablet it sends one of the following commands to the active Google TV, via a TCP socket on port 1338:

- "UPDATE INFORMATION" when new information regarding the caregiver, activity and activity duration is available.

- “PLAY [ENTERTAINMENT_TYPE] [ENTERTAINMENT_ID]” instructs which entertainment to play (slides, audio or video) and gives the ID of that entertainment so that the application knows what to play.
- “STOP” stops the currently playing entertainment, if available.
- “UPDATE MESSAGEBAR” when new message bar information is available.

Google TV are listening on port 1338 for the aforementioned commands, and upon receiving one will send a request to the server for the latest information update or in the case of the “STOP” command will just stop the currently playing entertainment. The server will reply to the request with a JSON-formatted document with the information. An example of a JSON document can be found in appendix 11.7.

The Web application has a simple Web interface for debug purposes where information can be inserted directly. The following figure exemplifies it:

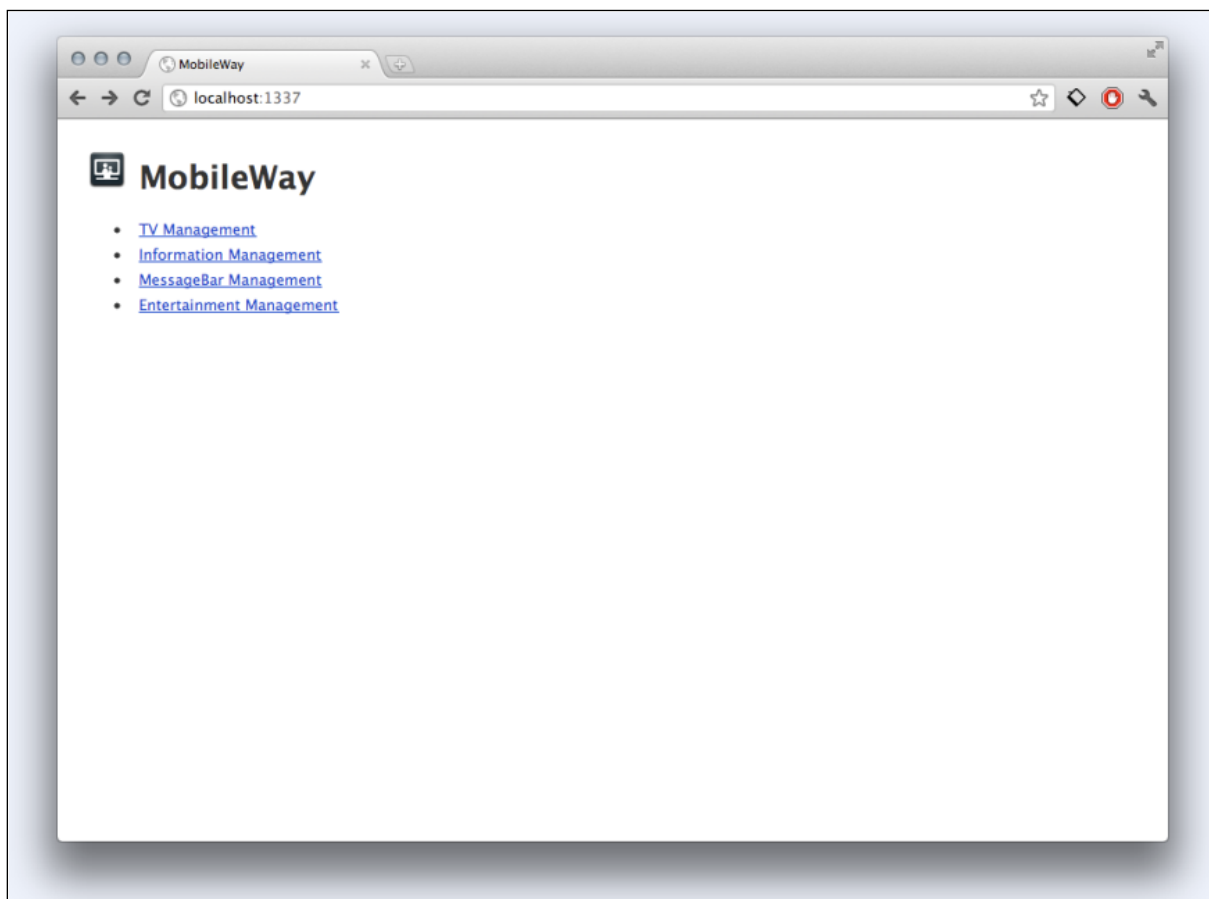


Figure 36 – The server’s Web interface.

6.2.2 System Functionality

In this section, the system functionality will be described.

In terms of organisation, mobileWAY v2's source code is divided into seven packages:

1. mobileway – this is the main application package. It is here that all activities are located. Since each activity represents a screen that the user will see and interact with, the various activities contained within this package will be explained further down in the document as they outline the functionalities of the system.
2. database – this package houses the classes that provide an interface to interact with mobileWAY v2's internal SQLite database.
3. dialogfragments – this package contains all the different classes responsible for each dialog used in the application regarding its contents and behaviours. The package name stems from the DialogFragment class introduced in Android 3.0. It is a subclass of the Fragment class and represents a fragment that displays a dialog window.
4. fragments – this package stores every class responsible for a given fragment. Fragments represent parts of the user interface and are used in activities.
5. network – this package contains a class that is responsible for managing the creation and sending of JSON objects through the network to the TV as well as parsing them. This class also deals with the transmission of the caregiver and activity pictures as they are multipart/form-data. Because a MIME multipart encoder is needed to handle this and Android does not support it out of the box, the HTTPMime 4.1.2 library from the Apache Software Foundation⁶ was used.
6. service – this package is used exclusively by the TV side of the application. It stores the classes related to the background service that is initialized after the first launching of the application and listens to incoming connections on socket port 1338 to launch the application if it isn't in the foreground already or update its information with the newly provided resources.
7. utils – this package houses various classes that provide useful utilities that other classes need. Examples of such utilities include methods to easily access the application's preferences, bitmap processing functions and declaration of constant variables which are used throughout the application.

For the full application to work, all of these classes serve their purpose and are used whenever needed. As was already pointed out earlier, there are also many other files composing the application as a whole, including the application resources such as icons, user interface layouts and localisation files. In the following sections, each activity of the application, found in the mobileway package, will be described and implementation decisions related to it will be outlined.

⁶ <http://hc.apache.org/httpcomponents-client-ga/httpmime/index.html>

The last section will briefly describe some important functions and Android elements that were used in the application to achieve its goals functionality-wise. Each activity can be seen in the application's workflow displayed in chapter 6.2.3.

6.2.2.1 *Launcher Activity*

The Launcher Activity is the very first activity that runs when the user starts the application from scratch. This activity is never actually seen nor does it have a user interface. The main purpose of this activity is to identify the device on which the application was launched so that it can correctly display the adequate user interface. If the device is a Google TV, then only the television-specific user interface will be displayed. Otherwise, the tablet application user interface will appear.

Google TV has a specific feature – `com.google.android.tv` – that is only available in the Google TV platform. By querying the package manager and detecting if this feature is present, an application can successfully determine whether it is running on a Google TV device. The following code was used to do so:

```
public static boolean isGoogleTV(Context context) {  
    final PackageManager pm = context.getPackageManager();  
    return pm.hasSystemFeature("com.google.android.tv");  
}
```

The returned value tells the application where it is currently installed and allows it to start the correct activity in accordance with the device.

6.2.2.2 *Google TV Activity*

The Google TV Activity is launched only on the Google TV device as it is a television-specific activity. This is the activity that is being watched by the dementia-affected persons while at their homes.

There is a service associated with this activity that listens for changes brought about through the network; these changes are sent by the users of the tablet application (caregivers). The application needs to run once in order for the service to activate. Typically, people who install the application will launch it after the installation process.

The activity displays information regarding the Caregiver, Activity and Activity Duration as well as entertainment and message bar choices. The running service will ensure that this activity is launched if caregivers update any kind of information. The interface will adapt in accordance with the kinds of options chosen by caregivers. For instance, the message bar information can be hidden or entertainment can be played. Essentially, this activity will have the following information:

- Caregiver, Activity and Activity Duration pictures as well as a sentence above them in the following format: “[Caregiver’s name] [Activity’s name] and comes back in [Activity Duration]” where each bracketed element is replaced by the information provided from the tablet application. The activity duration is represented by one of three icons and the number of hours and/or minutes in the sentence decreases as time passes. Currently, the only icon that dynamically fills as time passes is the clock icon as that was the recommended icon to be used by caregivers (since it had the most potential to be well understood by the dementia-affected persons) and therefore chosen to exemplify this functionality.
- Entertainment if chosen by caregivers. Slides and video types play as normal, while music types, besides being played, display a standard music icon along with the following sentence: “Music “[Music’s name]” playing”. Entertainment will share interface space with the aforementioned caregiver, activity and activity duration information when playing, and disappear entirely when not.
- Message bar information regarding date, message and time are shown at the bottom of the interface if caregivers choose to display it.

As soon as the activity duration reaches zero, the activity will remain on the television. This behaviour was decided as closing the activity would be strange and most likely confuse the dementia-affected persons. Additionally, since the caregiver is expected to be home by then, the activity can be manually closed.



Figure 37 – An example of the Google TV Activity's interface (on the television).

6.2.2.3 Main Activity

The Main Activity is presented to the user when the application is launched from a tablet device. This is the most predominant activity in the application as it manages various fragments.

The activity is divided into three different fragments: the TV screen fragment, which is the upper section of the screen; the content fragment, which is the middle section of the screen; and finally, the tab bar fragment, which is the set of options along the bottom part of the screen.

The TV screen fragment shows what the TV is showing. If information was not sent to the TV yet, it will display default placeholder icons. This means that the application is not running on the Google TV as after installation and consequent first run on this device, it will only be launched whenever users select core information on the tablet and choose to display it on the TV when they are given the option to send it over. The TV fragment section can be touched anywhere and doing so will launch an activity that zooms in on it. This activity, called the TV Screen Zoom Activity, will be explained later.

The content fragment is rather varied and can change. When the application is opened, this fragment will have an instance of a Main Menu Fragment. This fragment can be used to access and manage important resources, namely caregivers, activities, activity durations, messages and entertainment. Every option dynamically changes as needed taking the current state of the application into account. For example, if no resources of the type “Activity” were added or kept in the application, then the label for that respective option will read “Add Activity”. However, as

soon as at least one activity is added, the label will change to “Activity”. The only option that does not follow this labeling pattern is the option to access entertainment. Entertainment cannot currently be managed in the same way as other resources; it cannot be added nor deleted and the application already contains it by default. But the label of entertainment is not static. If users did not choose to play anything on the TV, this option is labeled “Select Entertainment”. But, if something is currently playing, it will be altered to “Change Entertainment”.

Functionality-wise, the application does not simply control the label names of its options regarding the content fragment. When resources are yet to be added, selecting their option will launch another activity dedicated to fulfilling that action. However, when resources of a given type exist in the application’s database, touching the appropriate option will trigger a fragment replacement. The fragment that will replace the Main Menu Fragment depends on the selected option:

- If the option is one of “Caregiver”, “Activity”, “Activity Duration” or “Message”, then an instance of Change Resource Fragment will occupy the content fragment section.
- If the selected option is “Select Entertainment” or “Change Entertainment”, then the Main Menu Fragment will be swapped with an instance of Select Entertainment Fragment. This fragment is very similar to the previous one and its main purpose is to allow the user to select (or change) the entertainment displaying on the TV. There are three types of entertainment – slides, audio and video –, each of which with its respective option. The labels here are dynamic too, and they will either start with the “Select” or “Change” keywords to reflect the current status of the system. Tapping one of the options will set off another fragment replacement, which substitutes the Select Entertainment Fragment with the Change Resource Fragment.

The Change Resource Fragment is an important fragment that lets users manage the information that is present in the system. This fragment is divided in two sections: the upper and lower halves.

The upper half loads a horizontal list with the available resources of a given type. This list can display up to a maximum of three elements at a time in accordance with the design: the first two are resources available to be managed while the third element allows users to add a new resource (when the resource is of type “Entertainment”, there is no “add” option – all three elements are resources). To the left and right of this list are arrows that can be used to traverse it. The arrows only appear when they are needed; so, if the list cannot be moved further to the left, then the left

arrow is cleared, and this is applied to the right arrow too. Of course, in a given list position, the three element positions may not be filled if there are not enough resources of that type.

The lower half is reserved for the context menu whenever a given resource is selected. This context menu is displayed on a separate activity, called Translucent Activity for Change Resource Fragment Menu, which will be explained in a later section.

Each fragment used in the content portion of the Main Activity is kept in a fragment stack. This means that when users use the “Back” option, if fragments were navigated through, the application will retrace these steps and pop them out of the stack in reverse. This is deliberate as the user expects to navigate backwards through fragments as if they were their own activity.

Finally, there is the tab bar fragment on the lower part of the application. This fragment displays multi-caregiver options as well as the option to access the settings. Furthermore, it displays two additional options in the Main Activity depending on the currently displaying content fragment: “Exit” or “Back”. “Exit” appears when the content fragment is an instance of Main Menu Fragment, and “Back” appears in every other case. Whenever users tap the “Exit” option, a dialog fragment appears and asks whether this was the intended action. The tab bar fragment is used throughout the whole application.

Various other dialog fragments are created from the Main Activity and its elements. These include, but are not limited to, confirming the sending of resources to the TV and success or failure of that operation.

It is also important to mention that the Main Activity reads the application preferences to know what users changed in the settings and adapts itself according to their needs. So, for example, if users disabled the entertainment options, these will be hidden from the interface; likewise, when users configure the TV interface, this activity will communicate with the TV screen fragment and ensure that it is correct. Fragments have a plethora of methods that let them know important aspects such as when they will be associated with an activity and which activity they are attached to. In this way, they function independently and can take care of their own logic.

6.2.2.4 TV Screen Zoom Activity

The TV Screen Zoom Activity is presented to the user after touching the TV screen fragment of the Main Activity. This activity is landscape-only. It can be used on either variant of the landscape orientation but not in portrait.

The TV Screen Zoom Activity, as the name implies, zooms in on the TV interface. All TV elements grow to fit the expanded interface. The tab bar fragment is displayed at the bottom of this activity. Since the mechanism to zoom in and display this activity revolves around selecting any part of the TV screen fragment, this activity maintains this functionality in reverse; that is, aside from the tab bar fragment (which also allows for the use of the “Back” button), touching the screen anywhere will close the activity.

6.2.2.5 Add or Configure Resource Activity

This activity is used to add and configure resources of type “Caregiver”, “Activity”, “Activity Duration” and “Message”. The user interface that is displayed here varies depending on the resource type that is being worked on:

- “Caregiver” and “Activity” resources require two kinds of information: a name and a picture.
- “Activity Duration” resources require a time duration in hours, minutes or both.
- “Message” resources require a name.

The “Caregiver”, “Activity” and “Message” resources are very similar interface-wise. The picture is the only visible difference. Resources of type “Activity Duration”, however, have a distinct appearance. To change hours or minutes, users can tap the numbers to display a numeric keyboard, but the preferred method is to use the arrows placed to the right of each field. When working in projects related to older adults, the author noticed that people often use arrows through repeated tapping. Younger people, though, more familiar with technology, tend to let their fingers rest on arrows expecting that they will work as long as they do not let go. For this reason, in this interface, both interactions are supported.

This activity presents, for each resource, a set of options found above the tab bar fragment. These depend on what is being done:

- If the resource is being created, then the “Cancel” and “Save” options are available.
- If the resource is being configured, then the option to “Delete” the resource appears in addition to the two mentioned above.

The “Save” option has two states, enabled or disabled. It is not possible to use it unless each resource has every element it needs. To represent so, the option appears faded. When everything is correctly set up and the resource is ready to be save (or configured), then the option is displayed like every other, indicating that it can be used.

When saving, updating or deleting a given resource, this activity calls helper methods to communicate with the database.

This activity displays dialog fragments to let users know when operations were successful or when they failed. When the “Delete” option is used, a dialog fragment will ask the user to confirm the operation.

6.2.2.6 *Enter Resource Name Activity*

The Enter Resource Name Activity allows users to input a name for the “Caregiver”, “Activity” and “Message” resource types. It is called whenever users touch the appropriate option on the Add or Configure Resource Activity.

Upon entering, the keyboard is immediately brought into view and users can start typing. The cursor is automatically placed in the edit text element and there is no need for users to select it, therefore saving time. An important functionality of this activity is that when the keyboard shows up, it automatically brings the tab bar fragment along its top side. This is useful to ensure that users can always access the navigation options present in this location.

To confirm the data entered, or to cancel the operation, the options to “Cancel” or “Save” can be used.

6.2.2.7 *Choose Resource Picture Activity*

The Choose Resource Picture Activity is a very simple activity that appears after users touch the option to insert (or replace) the resource picture on the Add or Configure Resource Activity.

In this activity, two options are available; users can either select a picture from the library or take a new picture. The tab bar fragment is also available as usual.

6.2.2.8 *Picture Library Activity*

The Picture Library Activity allows users to select a picture from available pictures on the device’s external storage. This activity presents items in a grid, with three pictures per row, and their corresponding names. There are also two arrows available that allow users to navigate through the available pictures. Similarly to the previously explained arrows on the Change Resource Fragment of the Main Activity, these arrows can be used either by repeated tapping or continuous touching.

When a given picture is touched, a dialog fragment is presented to the user that allows for confirmation. The tab bar fragment is displayed on the bottom of the interface as well.

6.2.2.9 Take Resource Picture Activity

The Take Resource Picture Activity allows users to freely take a picture of their face or surroundings. When users enter this activity, the first thing that happens underneath is the choice of the camera to use. Only two resource types need pictures, “Caregiver” and “Activity”. If users are creating or editing a “Caregiver”, then the system will use the frontal camera. On the other hand, if the resource is an “Activity”, the rear camera will be used by default. As mentioned earlier, not every Android device has the same set of features. While having a camera is a requirement for the application to be used, a given tablet device may only have one camera as opposed to two (or more). So, if only one camera is found, the application will default to it regardless of resource type.

This activity's interface changes as users use it to take pictures. When entering the activity, the "Take Picture" option is available and can be used to take a picture. After doing so, the activity will display a dialog fragment to users letting them know that the picture is being saved. As soon as the new picture is ready to go, the interface changes to show two additional options: "Redo" and "Save". The former will revert the interface back to its initial appearance, while the latter will confirm the picture and thus allow users to move on.

There are two important things that happen in this activity code-wise:

- First, the device’s gyroscope is used to determine the device’s orientation. Because the application is meant to be used in both variants of the portrait orientation, users can change between them at will. Android will switch between these with a smooth animation. However, the camera preview must be adjusted in accordance with the current orientation so that the picture will always appear right no matter how users decide to use the device. Another consideration that was taken in this scope has to do with how to manage the camera surface when users position the device in landscape mode. Although the application will not switch to this mode, the camera preview will always follow the device’s orientation to appear right to the user. If users decide to take a picture when the device is in the landscape orientation, then it will be kept as is (thus appearing as though it is lying down when used elsewhere in the application).
- Second, if the device’s camera supports auto-focus, then the application will attempt to focus the picture a maximum of two times before saving it.

The tab bar fragment is also available in this activity. It is important to note that “Back” will not do the same as “Redo” in this particular activity because that would cause confusion to users. When the “Back” option is selected, this activity will be finished and no changes will be made; it does not matter if a picture was taken or not.

6.2.2.10 Translucent Activity for Change Resource Fragment Menu

This activity was mentioned before in the Main Activity section. The main purpose of this activity is to show the context menu of a given resource when it is selected in the Change Resource Fragment of the Main Activity. This activity was created to allow for the faded effect displayed whenever a context menu is shown. This was achieved both by applying a transparent theme to the activity and using the `dimAmount` property of the Window as shown in the following code snippet:

```
getWindow().getAttributes().dimAmount = 0.7f;

getWindow().setFlags(WindowManager.LayoutParams.FLAG_DIM_BEHIND,
    WindowManager.LayoutParams.FLAG_DIM_BEHIND);
```

The context menu has a clearly defined border and an arrow is displayed pointing to the selected element so that users do not lose track of what they were doing and their selection. Depending on the resource type, this menu displays different options. If the resource’s type is one of “Caregiver”, “Activity”, “Activity Duration” or “Message”, then three options can be used here: “Configure”, which will open the Add or Configure Resource Activity; “Cancel”, which will close the context menu; and “Confirm”, which allows users to confirm their will to send this information over to the TV (it can only be sent when the three core resources – “Caregiver”, “Activity” and “Activity Duration” – are confirmed). If the resource is a type of entertainment (“Slides”, “Audio” or “Video”), then only two options will be displayed: “Cancel” and “Select”. If the selected entertainment is currently displaying on the TV to the dementia-affected person (and this can only be achieved after the three aforementioned core resources were confirmed and sent over), then the “Select” option will change to “Stop”.

This activity fades everything behind it concerning the application, including the tab bar fragment. So it cannot be used while here.

6.2.2.11 Multi-Caregiver Functionality Activity

The Multi-Caregiver Functionality Activity is used to display the three existing multi-caregiver functionalities – to-do, calendar and forum – to the user. When thinking about implementing the multi-caregiver functionalities, various considerations needed to be made.

It was possible to design new applications to meet the desired goals. However, this would have led to new designs and further testing with end users, which was not possible in the allotted timeframe for this project. Because of this, compromises had to be made. Since these functionalities are already available by third parties, in this project it was decided that Google services would be used as they are widely known and could successfully be used for a working prototype. So, the following Web applications were used:

- To-do: Google Tasks;
- Calendar: Google Calendar;
- Forum: Google Plus.

The Multi-Caregiver Functionality Activity uses a WebView to display online content. Depending on the selected functionality, the tab bar fragment will highlight it and the corresponding Google service will be displayed. Users only need to set up an account and they can use it to coordinate tasks and communicate with each other. The “Back” button functionality in the tab bar fragment was changed to meet users’ normal and expected use of the application. Although no location bar is shown in the WebView and users make use of optimised versions of the sites for mobile devices, the behaviour of the “Back” button allows pages to be navigated in reverse order as it is important to ensure that users feel that these applications are part of mobileWAY v2 and thus have a cohesive and integrated experience.

6.2.2.12 Settings Activity

The Settings Activity is dedicated to the settings of the application. Here, users can change various options regarding the application and the system as a whole.

The tab bar fragment highlights the “Settings” option to let users know that they are located there. There are various behaviours present in this activity that should be mentioned:

- Each white row represents an option that can be touched anywhere; doing so will select or toggle it, depending on the type of option.
- The “Activity Duration Icon” option section uses radio buttons as these are mutually exclusive options; therefore, selecting one will deselect the previous choice.

- The “Message Bar” section has an option that includes sub-options called “Show Message Bar”. While each sub-option can be toggled individually, this one acts as the “master”. If it is off, then all sub-options will darken and cannot be toggled. Their states will remain untouched, however.
- In the “Application Settings” section, there is one option allowing the playing of sound. There is an edit text box that allows users to input the number of remaining minutes to the end of the activity when the sound should be played. Touching this particular edit text box will make a numeric keypad appear. Since the interface is already full, the keypad will not bring the tab bar fragment up with it; additionally, no arrows were placed in this layout as there is not enough space for them to be able to adequately be used. Users cannot input anything other than numbers in the edit text box and the maximum value of minutes is 1439, which corresponds to 23 hours and 59 minutes. A value of zero in this edit text box is ignored even if the option is turned on. When a valid value is placed here, the alarm manager is used to play the system-wide sound that the user chose.
- The “Multi-Caregiver Settings” section is not used in this version of mobileWAY. The options are listed and can be toggled but do not affect anything in the system. There are two main reasons for this:
 - Because third-party solutions were chosen to be used in this version of mobileWAY, it is of utmost importance that they be tested in order to see if they do, in fact, meet the end user’s needs and if they are easy enough to use. Pursuing further integration with these services regarding these settings is a task that can end up not being useful and wasteful if the applications do not adequately suit the users’ needs.
 - When the implementation took place, some tasks were not yet officially possible to do normally with Google’s services, such as launching a notification whenever a new calendar entry was made.

The Settings Activity provides the “Save Settings” option to save the new preferences in the system.

6.2.2.13 Android elements and tools

Throughout the application, there are various tools and elements of Android that were used to achieve the desired goals. While some of these were already explained in the previously

detailed activities (since they are more specific to the corresponding activity), some of them are broader in scope yet very important, and were used heavily to achieve some functionalities that were explained in the previous sections. As these are more general and applied in a larger context regarding the application as a whole, they were combined in this section.

6.2.2.13.1 Data passed through Intents

Intents, as was already explained, glue together activities of an Android application. They are messages that activities can use to pass data amongst themselves. This is a pretty important concept that deserves to be expanded upon since mobileWAY v2 uses Intents heavily to adjust itself in accordance with the data sent and received. The previous sections explained the various activities of the application and their functionalities. In some cases, certain activities, such as “Add or Configure Resource Activity” and “Choose Resource Picture Activity”, exhibit a variety of user interfaces depending on the resource they are dealing with. This is possible due to the powerful capabilities of Intents.

Android starts activities by means of the `startActivity(Intent)` method. When an Intent object is created, data can be easily passed through it via its `putExtra()` method. To better exemplify this, the following code excerpt from the `AddOrConfigureResourceActivity` class is shown:

```
// create a new Intent defining the context of the
application package implementing this class and the component
class to be used

Intent        chooseResourcePictureIntent        =        new
Intent(AddOrConfigureResourceActivity.this,
ChooseResourcePictureActivity.class);

// pass a String that identifies the resource type along
chooseResourcePictureIntent.putExtra(Constants.INTENT_EXTRA_
RESOURCE_TYPE, this.resourceType);

...

// start the new activity with the created Intent
startActivity(chooseResourcePictureIntent);
```

The above code outlines how data is passed to other activities. Following the above example, here is how the ChooseResourcePictureActivity class acts upon the activity's creation:

```
// obtain the Intent that started this activity

this.intent = getIntent();

// assign the String passed via the Intent to the
appropriate variable that controls the resource type

if
(this.intent.hasExtra(Constants.INTENT_EXTRA_RESOURCE_TYPE)) {

    this.resourceType =
intent.getStringExtra(Constants.INTENT_EXTRA_RESOURCE_TYPE);

}

...

// set the appropriate content view (a layout resource) for
this activity based on the resource type

this.setAppropriateContentView();
```

As pillars of Android applications, Intents are very interesting because they allow for a wide variety of operations and they can be combined with a plethora of tools to enable very significant achievements.

6.2.2.13.2 AsyncTask

AsyncTask is an Android class that is meant to execute background operations and thus relieve the main user interface's thread (Google, 2011). AsyncTasks are used in many places throughout mobileWAY v2's application to ensure that heavy tasks do not interfere with the smoothness of the main interface nor hinder execution of other smaller operations.

AsyncTasks are used to perform operations such as database interaction (creation, updating and deletion of resources) and bitmap processing.

6.2.3 Using mobileWAY v2

As was described, mobileWAY v2 has a plethora of functionalities and screens that support them. In this section, the workflow of the tablet application will be shown, followed by a figure that shows an overview of the system.

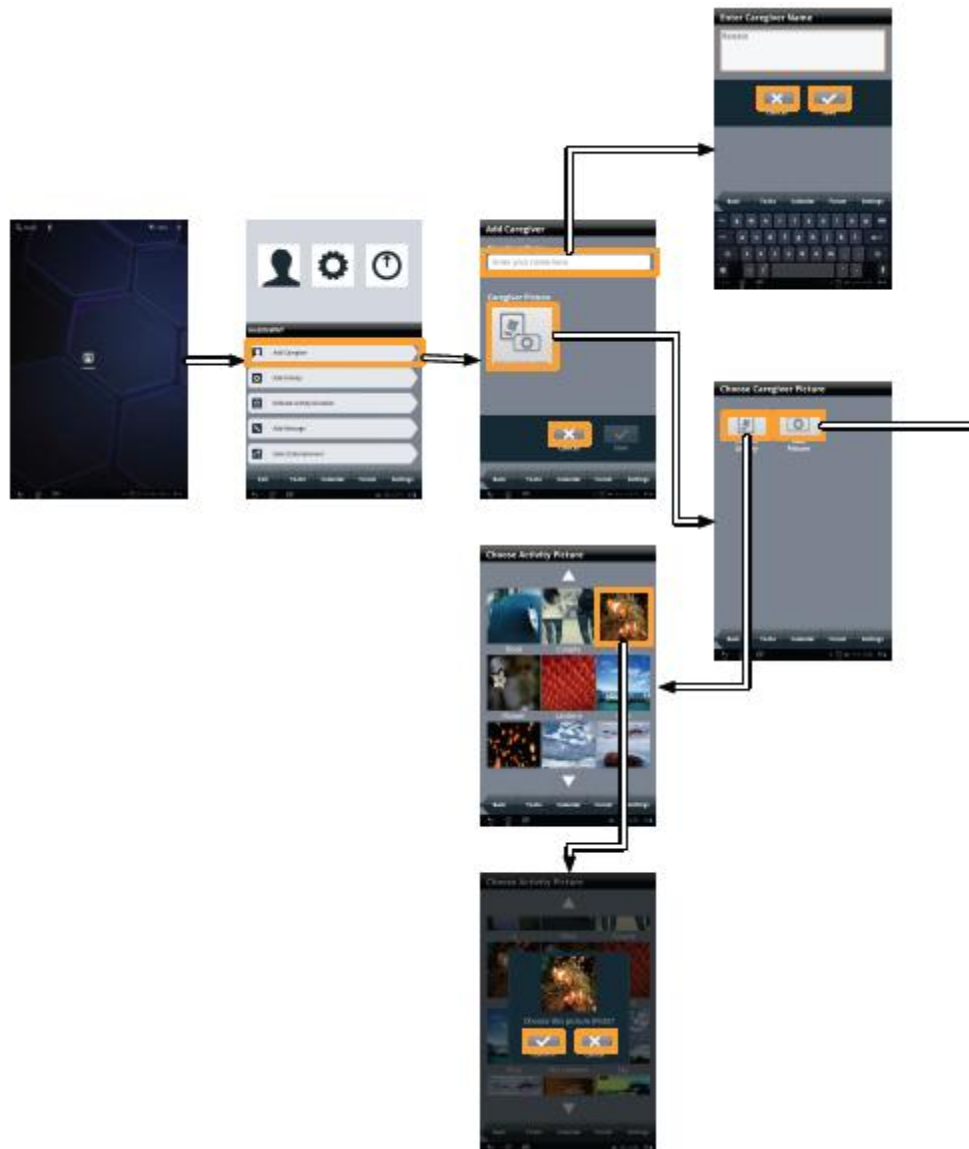


Figure 38 – Caregiver's workflow, part 1.

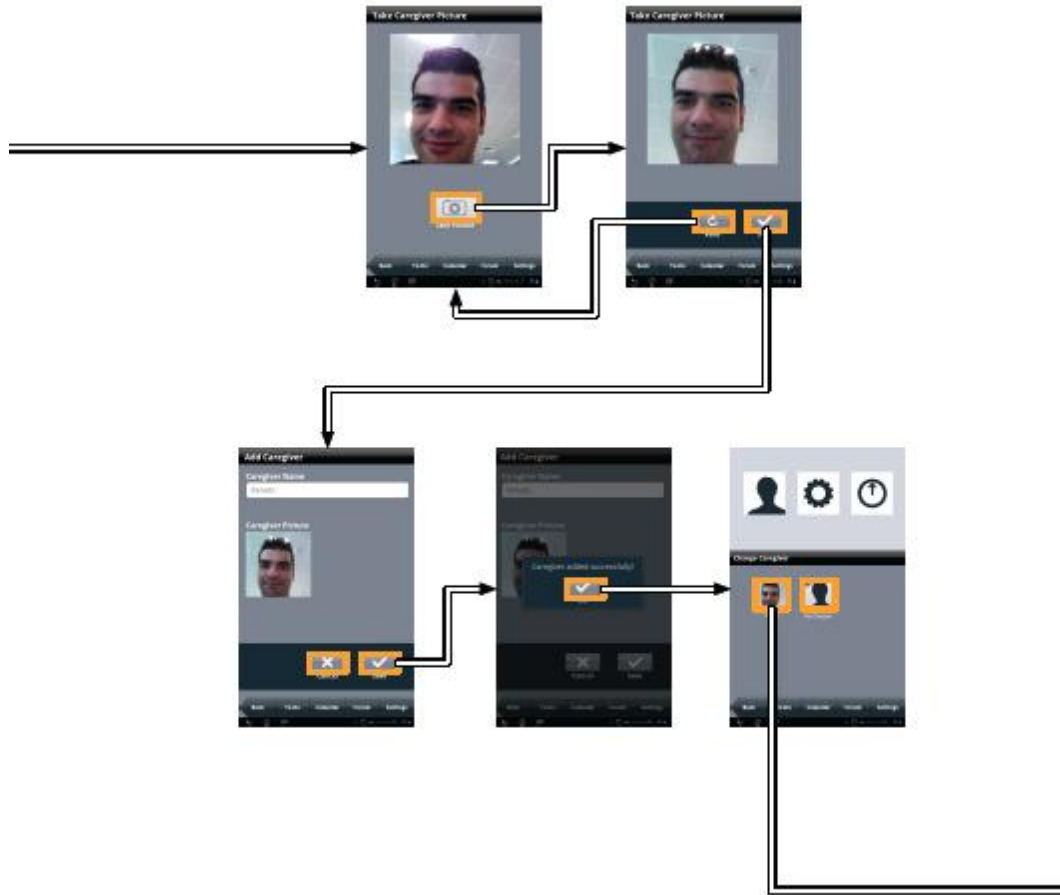


Figure 39 – Caregiver's workflow, part 2.

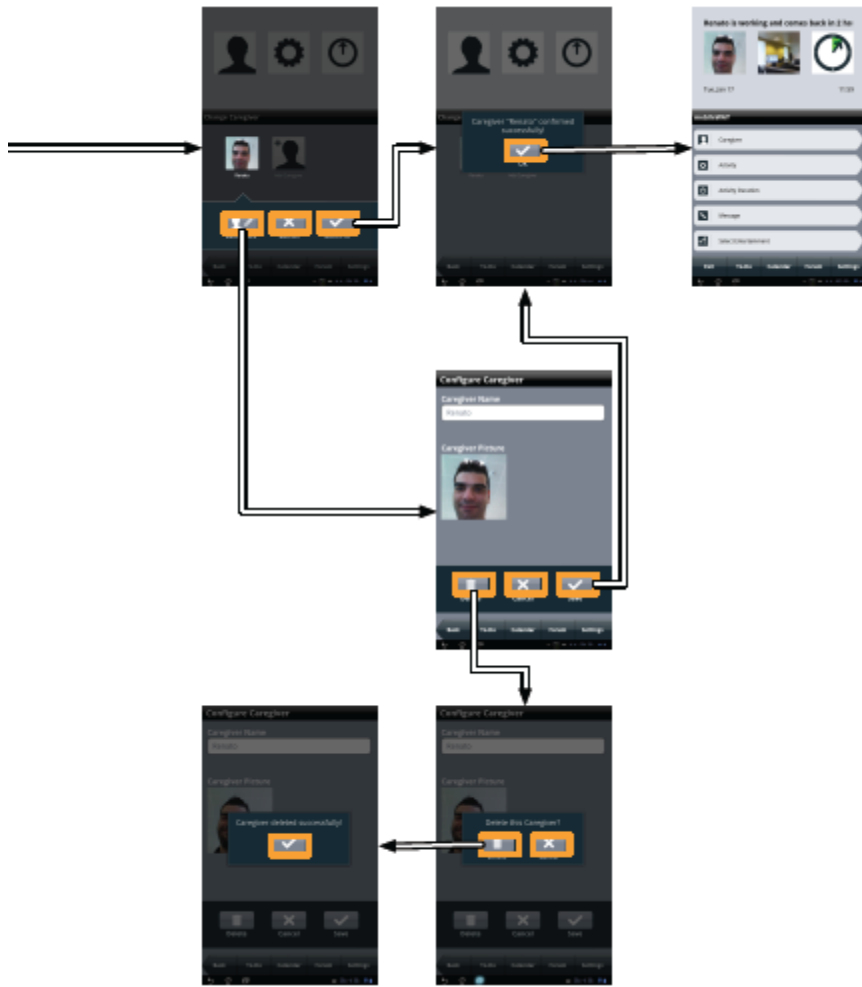


Figure 40 – Caregiver's workflow, part 3.

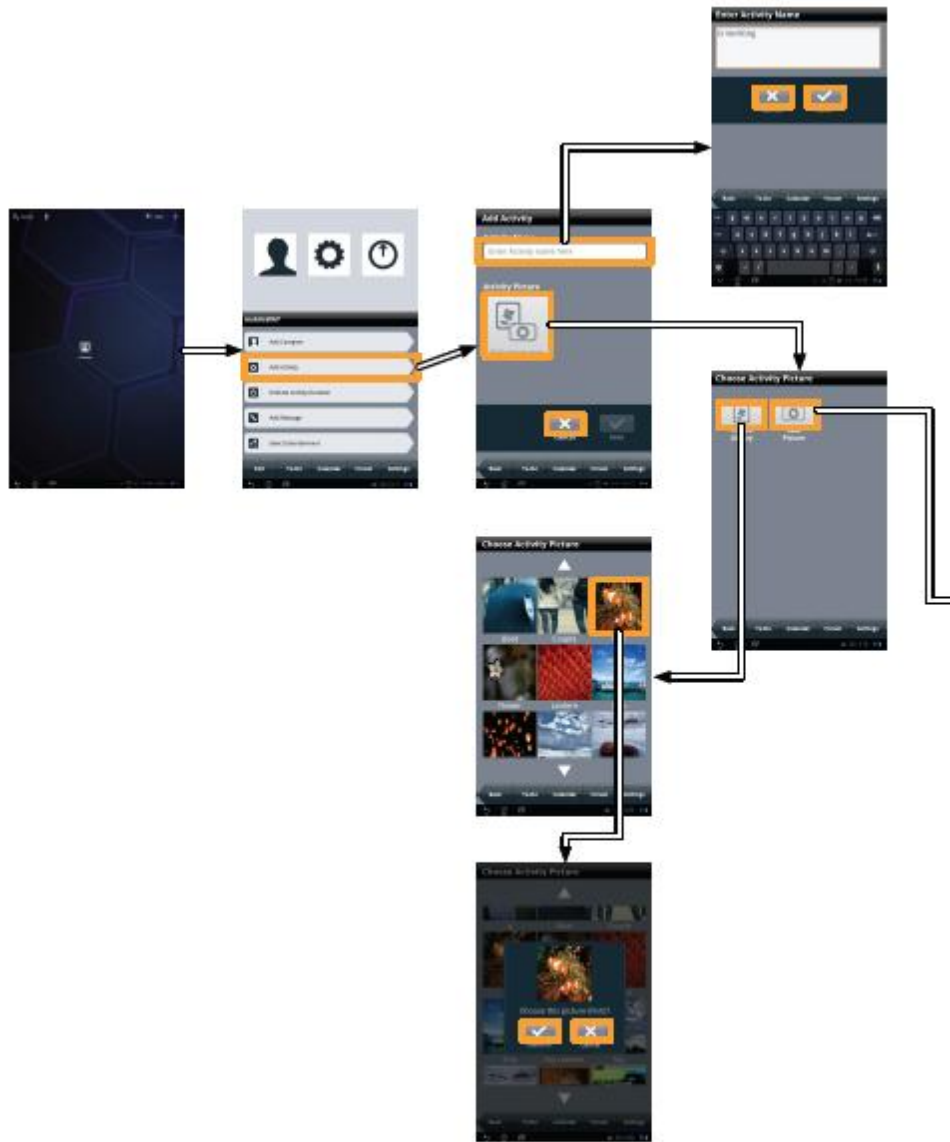


Figure 41 – Activity’s workflow, part 1.

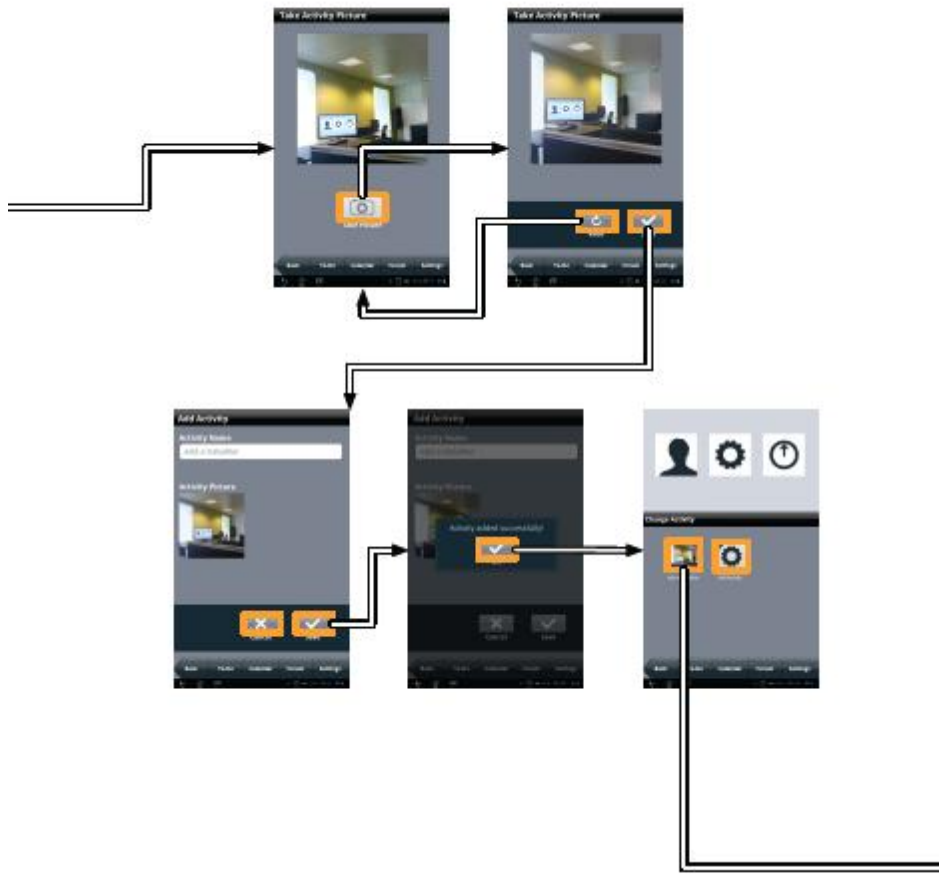


Figure 42 – Activity’s workflow, part 2.

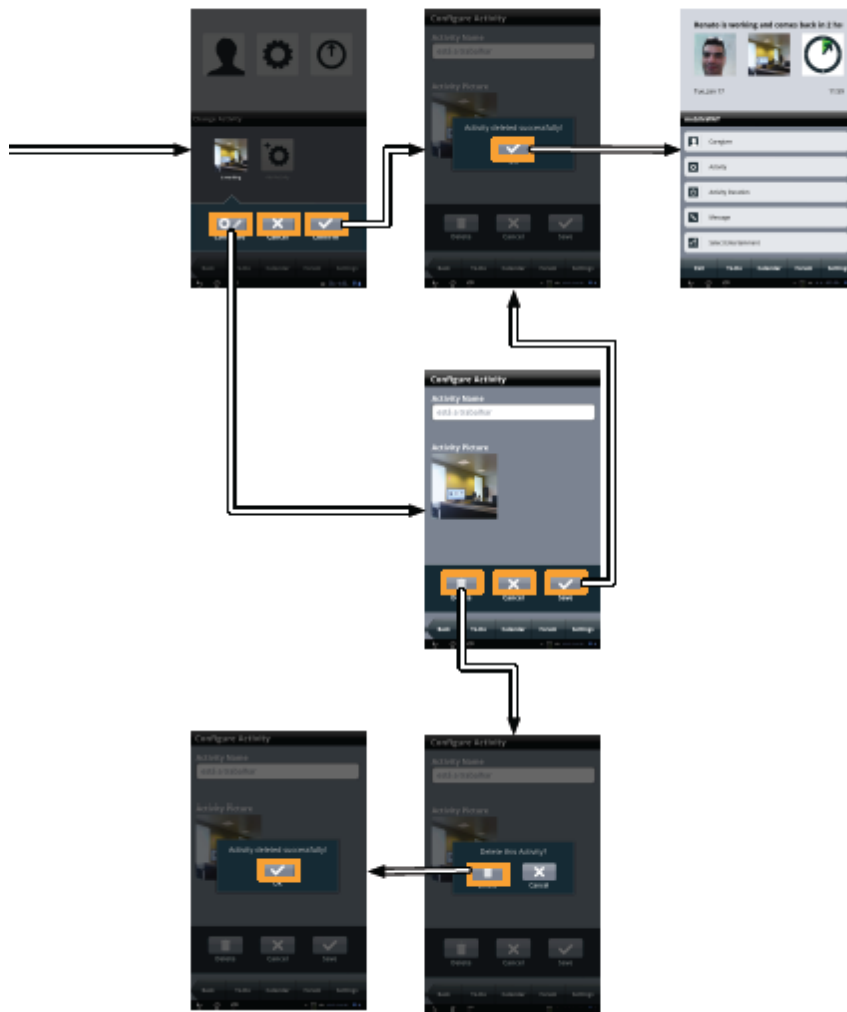


Figure 43 – Activity's workflow, part 3.

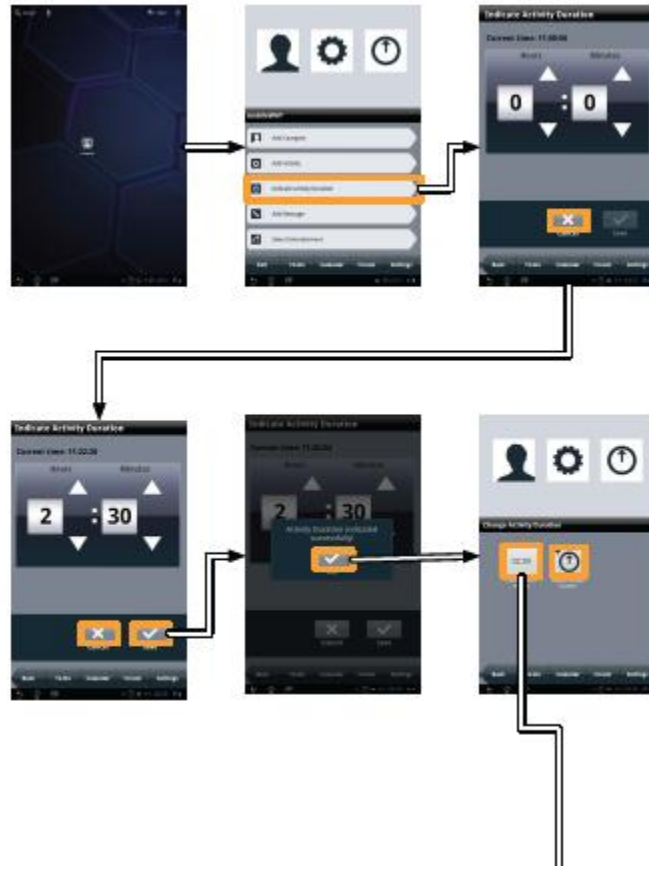


Figure 44 – Activity duration's workflow, part 1.



Figure 45 – Activity duration's workflow, part 2.

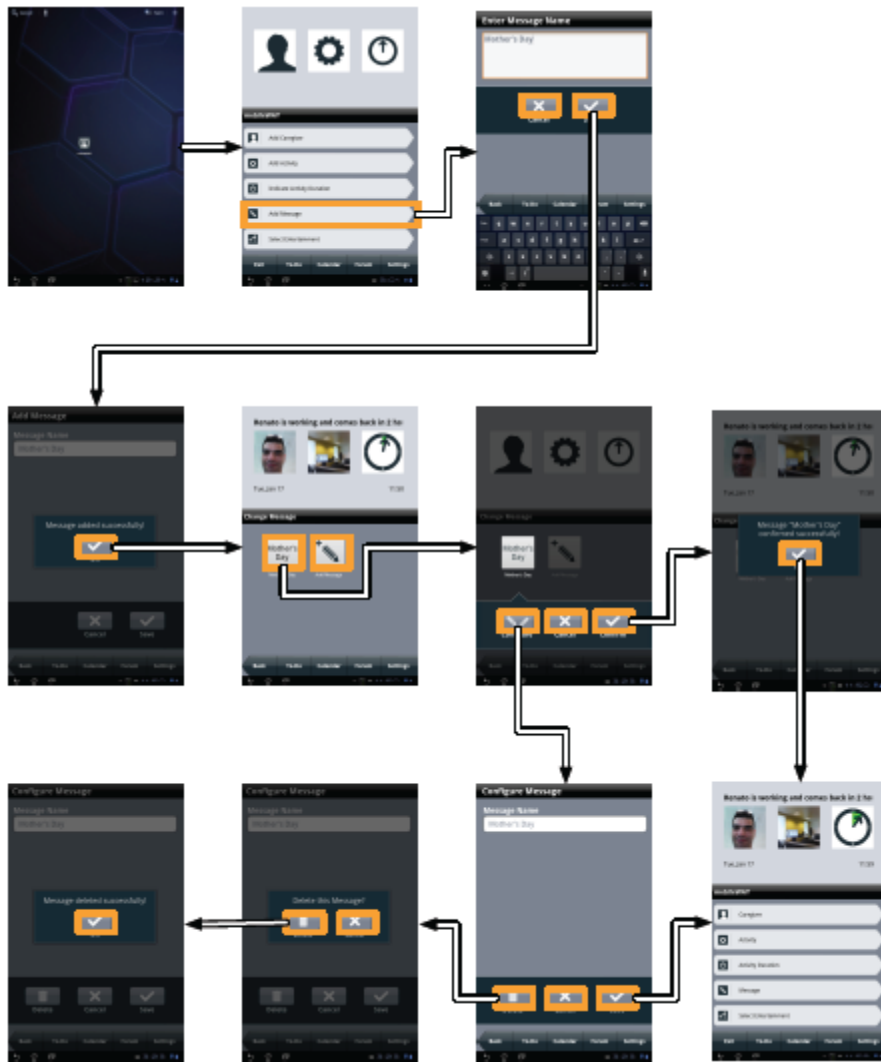


Figure 46 – Message's workflow.

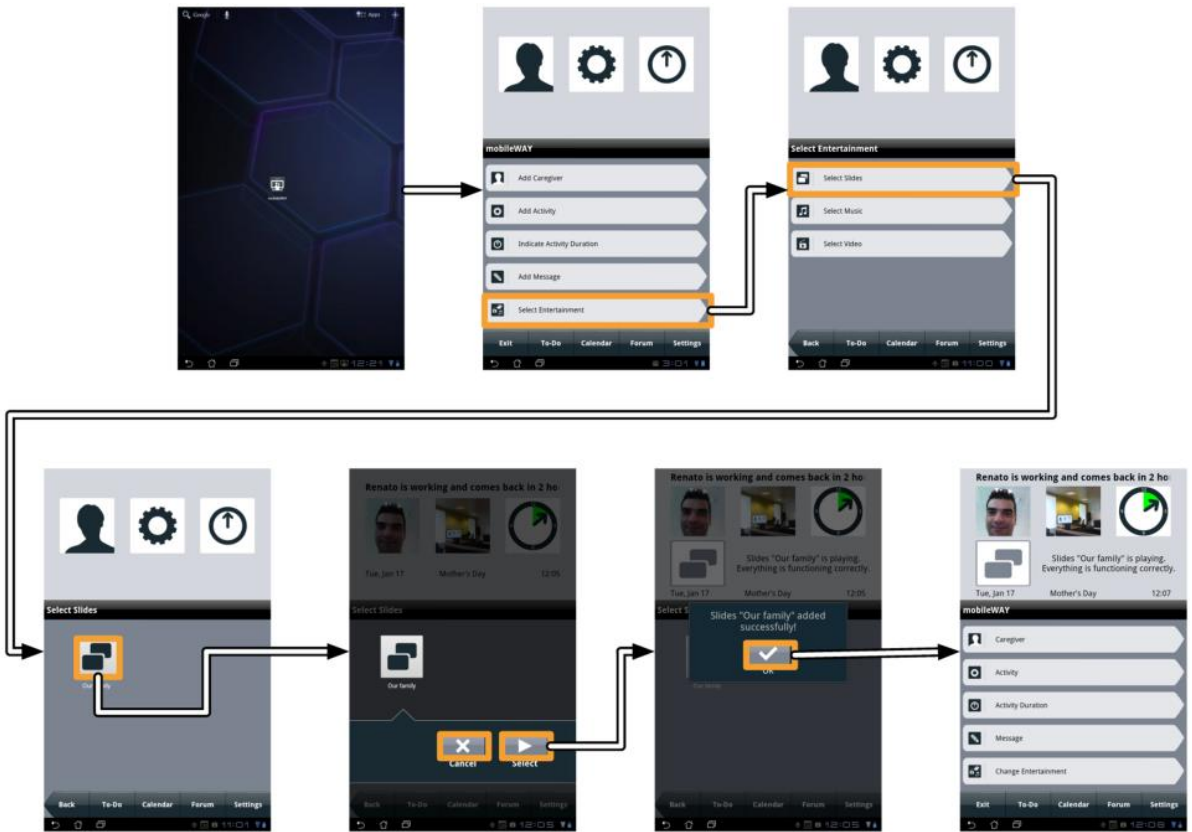


Figure 47 – Entertainment's workflow, part 1.

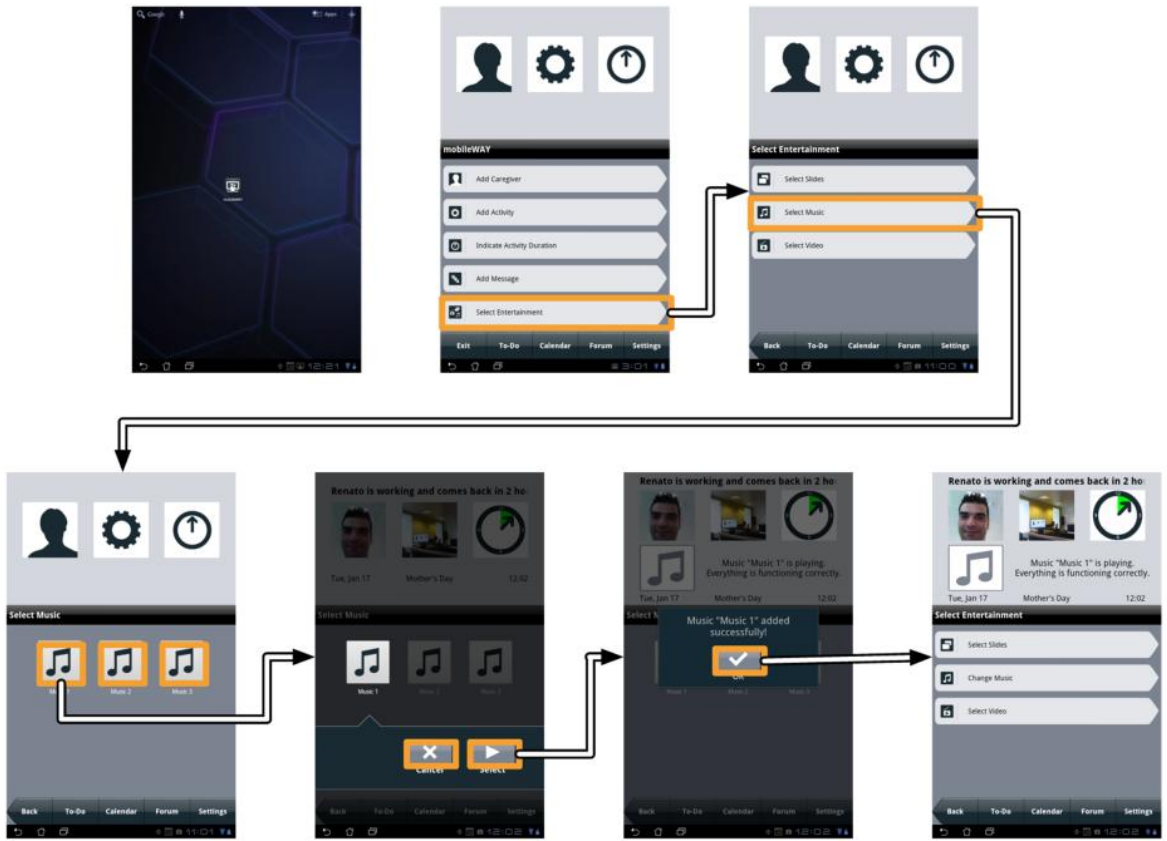


Figure 48 – Entertainment’s workflow, part 2.

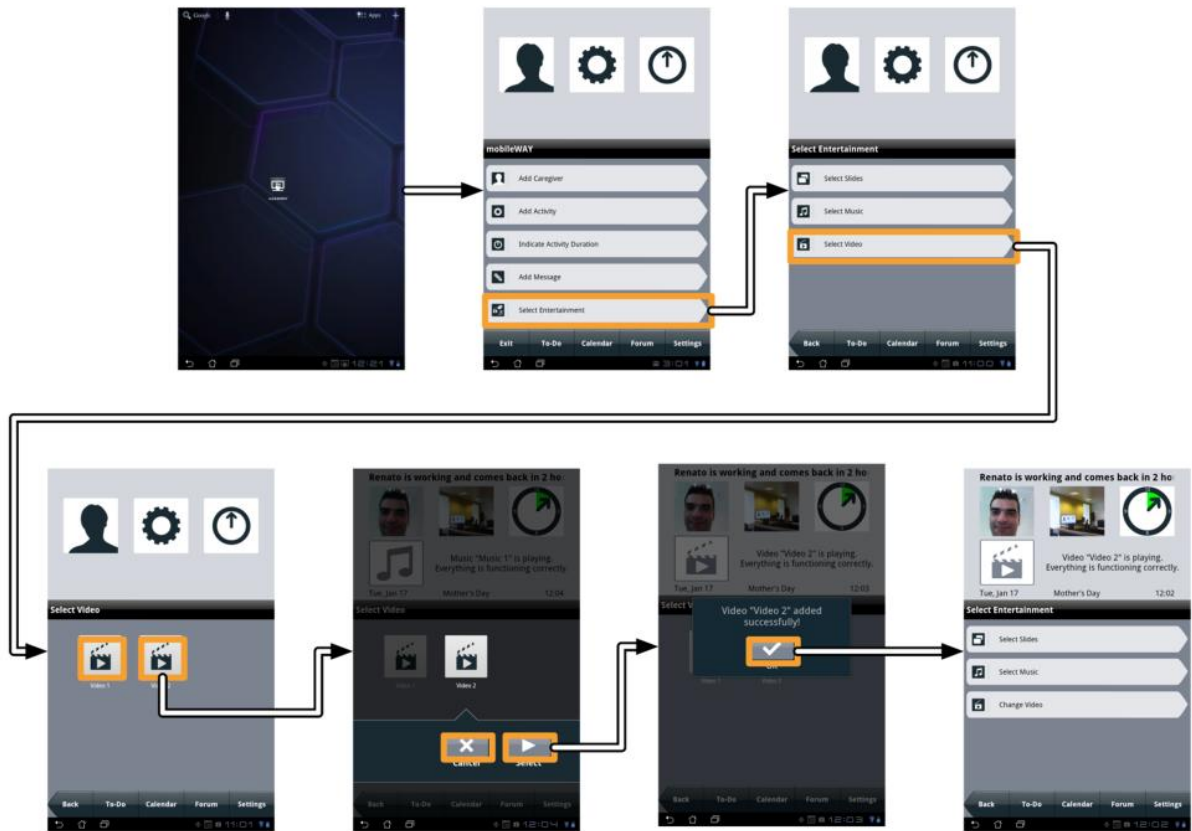


Figure 49 – Entertainment's workflow, part 3.

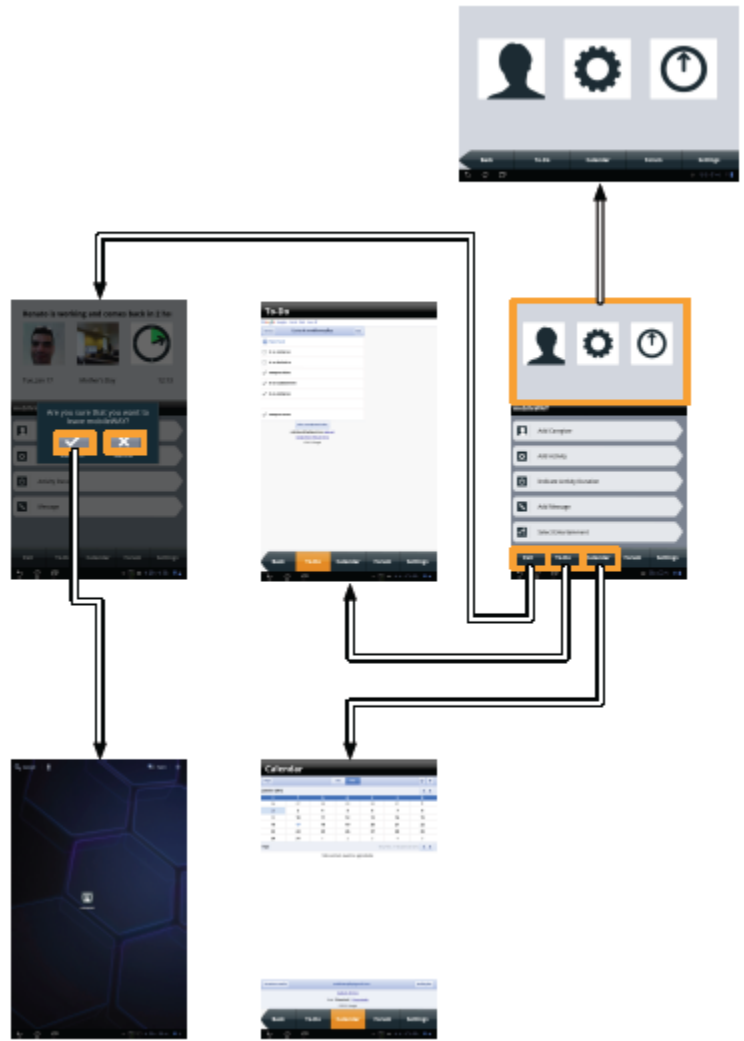


Figure 50 – TV screen zoom, application exit and part 1 of the multi-caregiver functionalities' workflow.



Figure 51 – TV screen zoom, settings and part 2 of the multi-caregiver functionalities' workflow.

The following figure shows the fully-working system with the tablet and TV for clarity:



Figure 52 – An overview of the fully-working system.

7 Validation and Tests of mobileWAY v2

After the implementation of the system was completed, it was important to test it again to understand if it was usable and adapted to users' needs.

The validation and testing phase had to focus on the caregiver-side of the application. This was because finding additional people suffering from AD to test the TV side was not possible as, like explained before, finding these types of users is extremely hard, and given the available time and resources, it was impossible to find new users. Moreover the TV interface had already been tested twice without having had been subject to changes. So, it considered to be sufficiently validated. Additionally, the participants who tested the system were not truly taking care of someone affected with AD. Unfortunately, finding new users different from those who participated during the redesign tests was impossible given the available time and resources.

The following sections give an overview of the participants, present the protocols for the usability tests and the results of the tests and questionnaires.

7.1 The participants

In total, six people tested the implemented system. Out of the six participants, four were more experienced with technology, and two were less experienced but still familiar with it.

None of the participants were looking after someone affected with AD. While this system is mainly targeted at these types of users, useful information can also be acquired from other types of users as there is a possibility that they will benefit from such an application sometime in the future and caregivers can be any type of person. There was an attempt to test the system with actual caregivers of dementia-affected persons, but under the available time window, it was not possible to arrange neither resources nor time to do so.

The following table outlines the data of each participant.

Table 4 – Participants' general data for the validation of the system.

Participant	Information	Gender	Age
C1		Female	27
C2		Male	29
C3		Female	24
C4		Female	28
C5		Female	24
C6		Female	52

Each participant tested the system regarding two major areas: the caregiver status setup, which is the implemented part of the system that was tested previously only on low-fidelity prototypes; and the collaborative tasks, which is the implemented part of the system that deals with the multi-caregiver functionalities.

The following sections will explore the protocols, usability tests and questionnaire results of both parts. The protocol and detailed results can be seen in appendixes 11.8, 11.9 and 11.10.

7.2 Evaluation of Caregiver Status Setup

In this section, the aspects involving the caregiver status setup tests will be detailed. The caregiver status setup set of tests involves the same tests that were previously performed with 10 caregivers using low-fidelity prototypes. These can be seen on chapter 5.1.3.1.1.

7.2.1 Evaluation Protocol

The evaluation protocol for these set of tests is the same that was followed previously. Each participant went through a process of three steps:

1. The system's purpose and functionalities were outlined to each participant so that people could understand how the testing would happen and what they could and should do as tasks were asked of them.
2. Each participant would perform a total of nine tasks. This time, the system was presented to them on a high-fidelity prototype (the tablet itself).
3. After every task was completed, participants filled in a questionnaire where they were inquired about what they thought of the system.

7.2.2 Results of Usability Tests

This section outlines the task results. Every task remains the same and that is also true regarding the minimum number of required steps. Every task had a 100% success rate.

7.2.2.1 Task 1 results

Chart 11 presents the results for the first task (the minimum number of required steps for this task was 10).

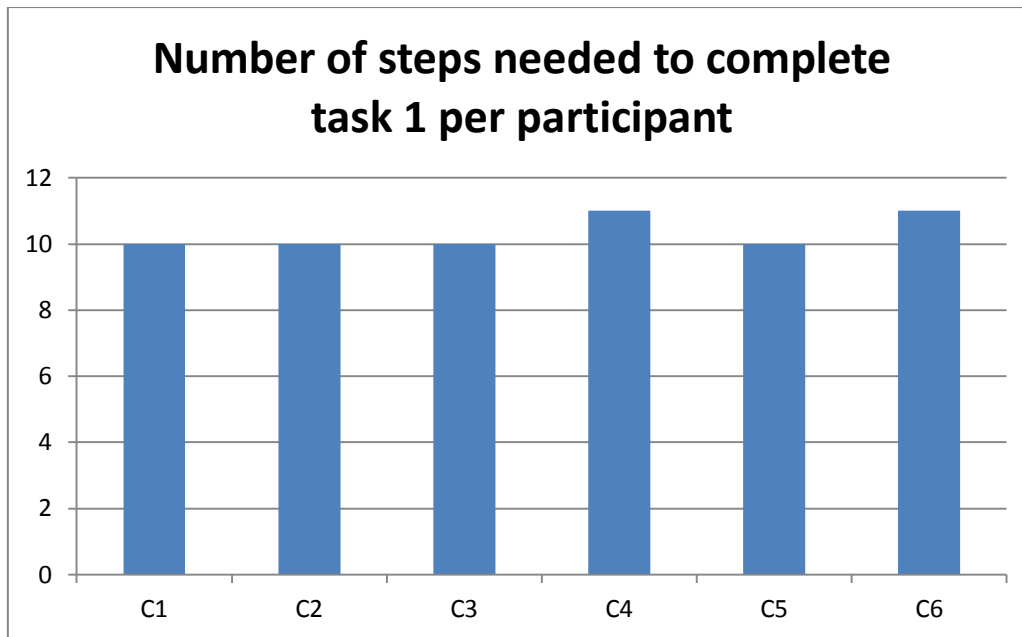


Chart 11 – Validation phase: task 1 results.

Only two participants needed an additional step in this task. Interestingly, both of them made a mistake in the same part: they tried to save the resource without taking a picture.

While the interface darkens the “Save” option if a given resource is missing a required element, the fact that people attempt to save means that probably this behaviour needs to be accounted for. There is in fact a chance that users can get lost and not understand why they cannot proceed. One thing that might be helpful here is to present a dialog telling users what is missing should they try to use the unavailable “Save” option.

Aside from this, users quickly grasped how to achieve the desired goal and had no questions or observations.

7.2.2.2 *Task 2 results*

The second task needed nine steps to be successfully completed. Here are this task’s results:

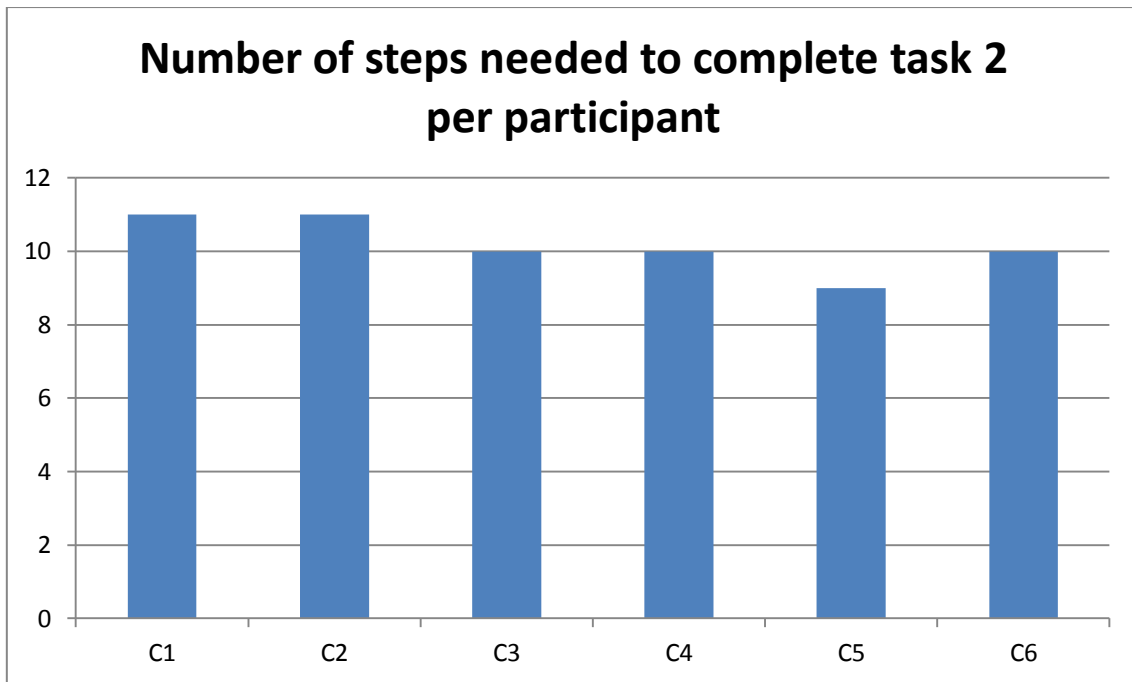


Chart 12 – Validation phase: task 2 results.

Only one participant was able to successfully complete this task using the minimum number of steps.

There are some conclusions that can be taken from the results of this task. First, one kind of error that was observed in two participants had to do with the fact that instead of directly configuring the intended activity resource, users tried to add a new one. This was remarkably similar to what was observed during the redesign tests. Again, while in this case participants did not follow the expected series of steps immediately, it is hard to consider this as a big mistake or error design- and implementation-wise; in fact, such an option is viable and could certainly be used in a real-case scenario. Another participant tried to delete the resource; however this also had to do with the fact that at first it was not clear to this person how to change the picture.

Second, three participants tried to access the “To-do” list. Although this might seem strange at first, it most likely has to do with the fact that, as technology-savvy people, they immediately associated the word “activity” with a task on the “To-do list” and went searching for it there. Additionally, this kind of problem also led to another conclusion: this might be caused by slight changes in the words used to communicate with users, which may lead them down a different path.

Third, along with the aforementioned participant, another participant took a while to understand how to change the picture and even suggested having an option to do so on the options’ bar. This was an interesting observation as it became clear that something should be

added to make the action “change picture” more visible. In order not to disrupt the existing organisation of options, one possibility would be to add a visual element such as a pencil to the picture to provide aid.

Lastly, one participant canceled the adding of the resource after having inserted information. This led to one important observation that could not really be observed with low-fidelity prototyping and was not enforced: the user will lose inserted information because no dialog will inform of that situation. This needs to be addressed in a further iteration of mobileWAY.

7.2.2.3 Task 3 results

The third task required 14 steps to complete. Its results are as follows:

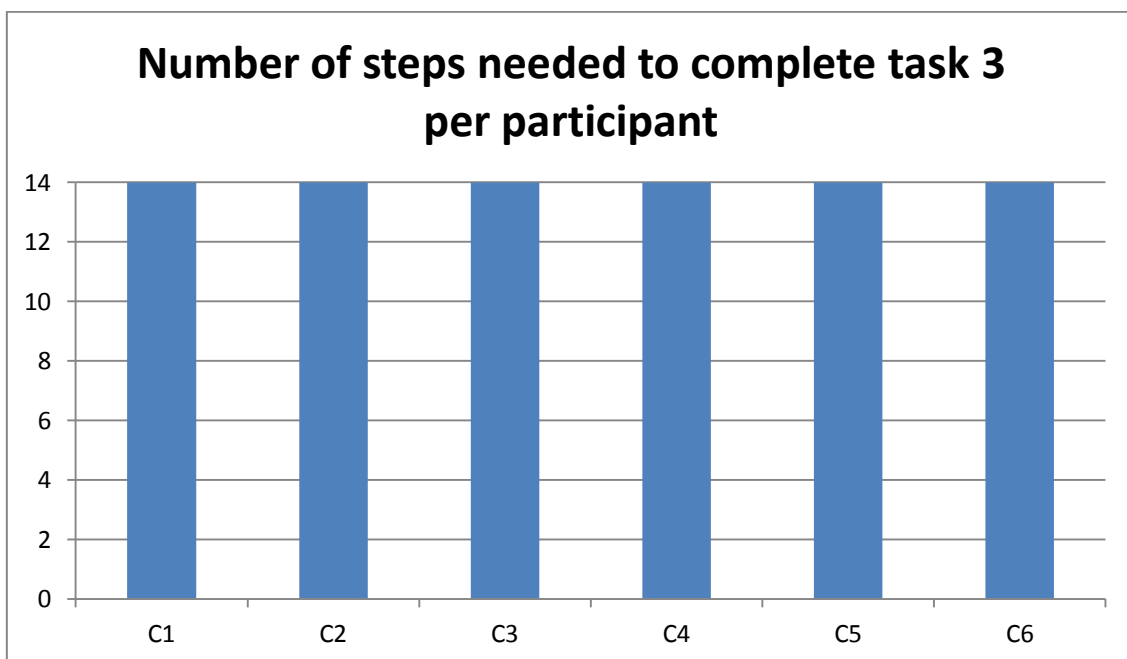


Chart 13 – Validation phase: task 3 results.

Every participant completed this task using only the minimum number of steps. Nevertheless, the results showed two important things.

First, two participants showed some problems regarding the difference between adding resources to the TV and defining (confirming) those resources to be shown on the TV. This shows that the terminology may not yet be perfect and could take further refining.

Second, two participants forgot to confirm a resource. As one of them commented during the test, currently the application provides no clear information on what resources are confirmed already. Even though caregivers are expected to select and send all core information over to the TV in a small amount of time (as they will not be displaying information way ahead of actually

going out to perform the given activity), it is still important to think of a way to tell them what kind of resources they have selected already. Since the interface does not follow a linear path (resources can be confirmed in whatever order caregivers decide), they may forget what they actually confirmed or not.

7.2.2.4 Task 4 results

Task 4 needed 10 steps to be completed. Here are its results:

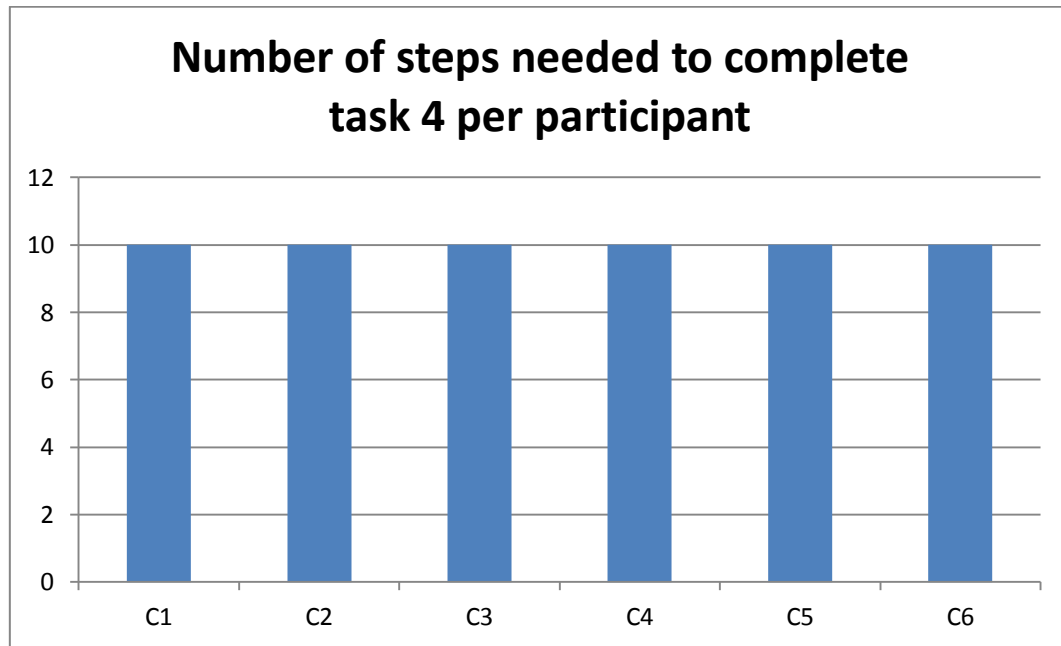


Chart 14 – Validation phase: task 4 results.

Every participant completed this task without problems. However, one participant raised an interesting point during the test.

When adding a message, there is one field where participants need to fill in its name. But this participant thought that this was simply an identifier that the caregiver would input, as opposed to the actual message displayed on the TV. The participant thought that after filling in this identifier, a new field would appear where the actual description of the message to send over to the TV would be inserted. This is an interesting idea that makes sense both from a terminology point of view (“description” may be better suited for this resource type, instead of “name”) and also from a functionality point of view. Using the “name” field as a tag of sorts could improve the usability of the application because caregivers might be able to use interesting forms of identifying given messages by using their experience of interacting and dealing with the dementia-affected person. For instance, the dementia-affected person may have a special way of

referring to the birthday. So, this name could be used as a tag so the caregivers immediately know that the message has to do with this special day.

Other than this, the execution of the task went perfectly for all participants.

7.2.2.5 Task 5 results

The fifth task required six steps to be completed. Its analysis follows.

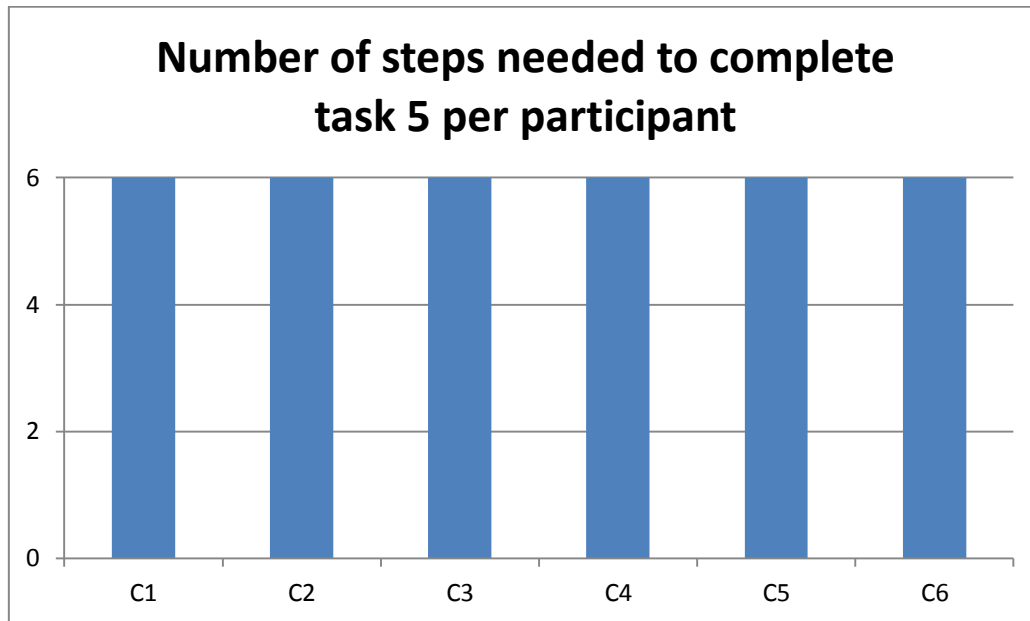


Chart 15 – Validation phase: task 5 results.

As with the previous tasks, every participant completed this task without needing additional steps. Since this task is similar in terms of workflow to previous tasks, this is positive with regard to the system’s usability.

One participant brought up a point that deserves further studying, which is the fact that when the caregiver selects an entertainment resource to play on the TV, there is no indication of whether it will play on the tablet as well. So, this option should be made clearer in a further redesign.

7.2.2.6 Task 6 results

Task 6 required six steps to be completed. Analysis follows.

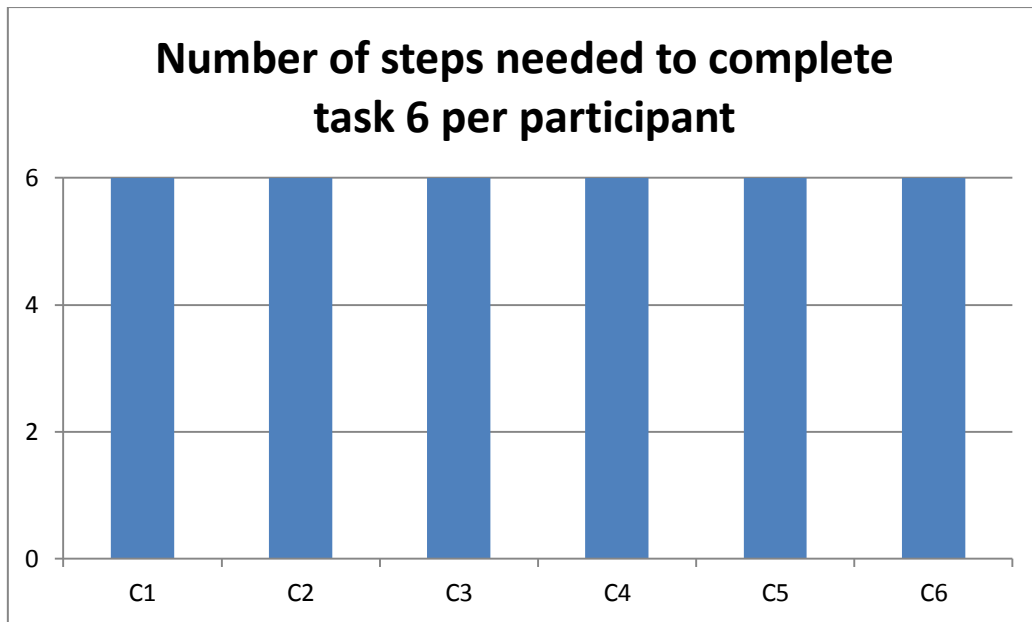


Chart 16 – Validation phase: task 6 results.

As with the previous tasks, this also was completed by every participant and with no additional steps.

The only observation here was that there was a little delay when the tablet communicated through the network to send the information to the TV. Although this delay can happen, it is mostly negligible. Nevertheless, it is important to consider an additional way of conveying to the user that the task is being processed in the background and will eventually report back (for instance, using a loading indicator mechanism) because when used in real-world scenarios, the complex amount of variables at play can turn this simple operation into something lengthier and harder.

7.2.2.7 Task 7 results

The seventh task needed a total of four steps minimum to be completed. The following chart shows this task's results:

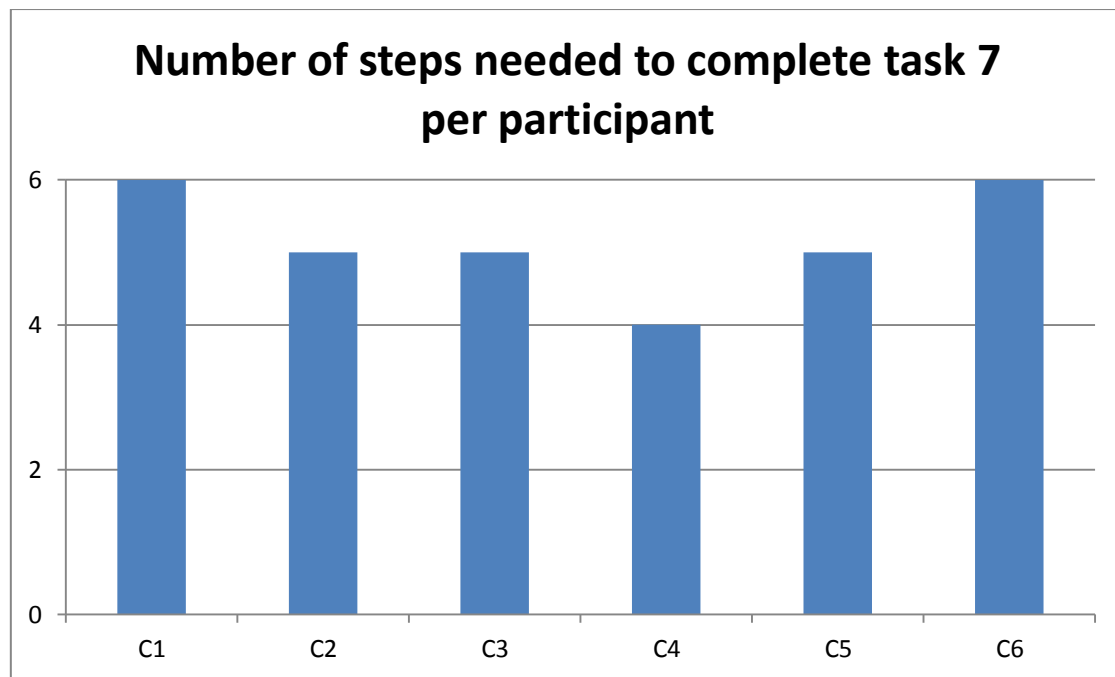


Chart 17 – Validation phase: task 7 results.

Only one participant managed to complete this task using the minimum amount of required steps.

A positive observation could be made here, related to the “Save Settings” option. Unlike before, only one participant showed signs of confusion regarding whether the new setting had been saved, but even in this case the “Save Settings” option was noticed and used.

The main problems here are different from what was observed during the redesign tests. There were two types of errors:

1. Participants used the “Activity Duration” option.
2. Participants touched the TV screen fragment.

Both errors are understandable as they can be thought to solve the problem. They do point, however, that the presence of a “Settings” option may often be overlooked and used as last resort. Since users may prefer for things to work out of the box, it is better to configure the application to suit their needs right from the start instead of making them customise things themselves.

7.2.2.8 Task 8 results

The eighth task could be completed in four steps. Its results are as follows:

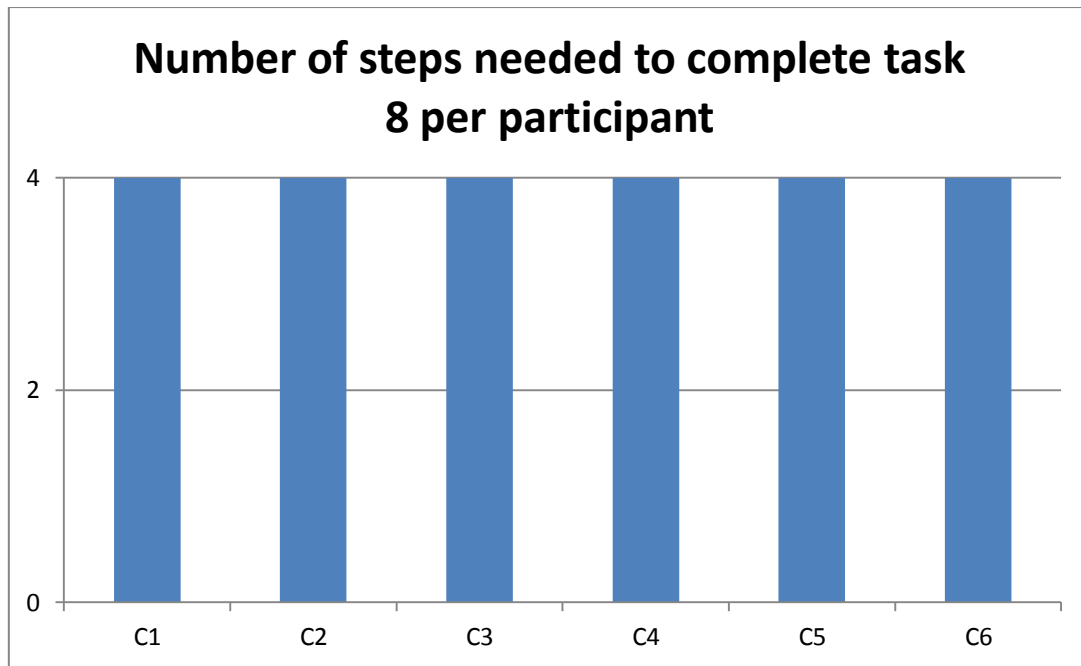


Chart 18 – Validation phase: task 8 results.

Every participant completed this task without additional steps.

No observations or comments were made here. Everything was completed smoothly and clearly.

7.2.2.9 Task 9 results

Task 9 is the last of the caregiver status setup round of tests and required four steps to be completed. Its results are the following:

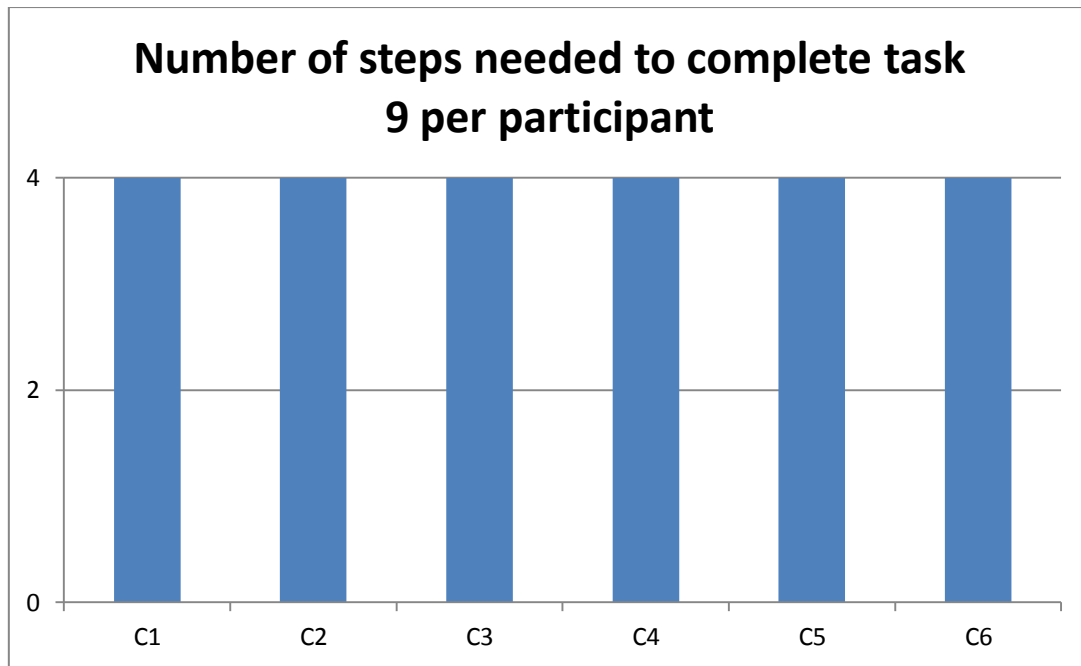


Chart 19 – Validation phase: task 9 results.

No additional steps were needed for any participant to complete this task. However, there were two things noted here:

1. One participant commented on how the term “entertainment” in this option was very broad. As a result, it could encompass more than desired. The facilitator wanted the participant to hide the entertainment area (and as a result, the entertainment-related options); however, since the term may be understood to mean more than slides, audio and video, caregivers may be unclear on what the option will actually do.
2. One participant mentioned that it was strange for this option to be inside the “Message Bar” group as they are unrelated.

Both these situations deserve further evaluation and assessment.

7.2.2.10 Global task results analysis

The following table shows the minimum number of steps needed, the maximum number of steps used and the average number of errors per task:

Table 5 – Validation phase: minimum number of steps needed, maximum number of steps used and average number of errors per task (caregiver status setup tasks).

Task	Minimum number of steps needed	Maximum number of steps used	Average number of errors
Task 1	10	11	0.3
Task 2	9	11	1.2
Task 3	14	14	0
Task 4	10	10	0
Task 5	6	6	0
Task 6	6	6	0
Task 7	4	6	1.2
Task 8	4	4	0
Task 9	4	4	0

Globally, the results are positive; however, there are various aspects that need to be further discussed.

First, in comparison to the first set of results during the redesign phase (presented on section 5.1.3.2.2.4), it can be seen that only three instead of four tasks needed additional steps. However, there is a greater average number of errors on the tasks that were performed. This also has to do with the fact that less people tested the system this time around, which increases the percentage for every error.

The first task’s errors were in fact different from what was observed during the redesign phase. They mostly had to do with missing information before saving.

The second task was, along with the seventh, the most problematic in terms of average number of errors. Although this task had people trying to solve the problem in a different way than that expected by the facilitator, much like the previous tests during the redesign phase, new problems were found here related to how users interpreted the information related to the task.

Task 3, which was the most problematic previously, was completed without problems here.

Task 7 was a new addition in comparison with the previous results and ranks highly with regard to the average number of errors. Users tried to solve the issue in different ways prior to accessing the settings.

Task 8, which registered an average number of errors of 0.1 in the redesign phase, was fine this time around.

The differences in the results might be explained by the fact that the participants of these tests were younger and more knowledgeable technology-wise so their expectations were also different regarding the system. These types of users are more likely to experiment with the application. Additionally, the facilitator was helped by a different person during this testing phase

as it was not possible to perform the tests with the same person as before for availability reasons. This can also impact the results as the way people communicate is different and so the users' understanding of tasks can slightly change.

However, even during the perfectly executed tasks, many useful observations were made that can further improve mobileWAY v2.

There were a total of 16 errors performed during the 54 caregiver status setup tests, which averages on 2 errors per person in total. This number is the same as before, however the problems were different and this also needs to be taken into account. This is expected when developing a system in an iterative and incremental way.

7.2.3 Questionnaires

The answers to the questionnaires were as follows:

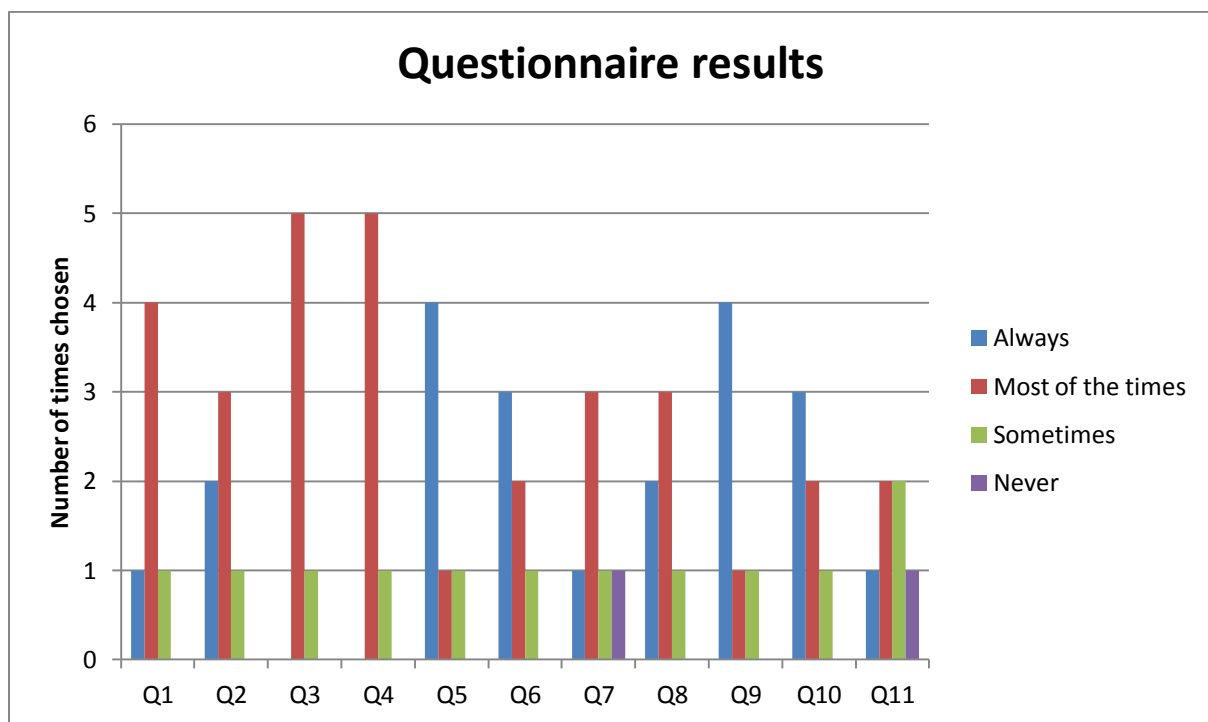


Chart 20 – Validation phase: questionnaire results.

Much in line with the previous questionnaire results, participants answered the first three questions positively, saying well of the application's usability.

Question 4 and 5 were also positive, reinforcing that they liked the application.

Questions 6, 7 and 8 were also very positive, however here it should be pointed out that none of the users were actually taking care of someone affected with AD. These opinions are based on

their knowledge of AD and are, in a way, simulated, so they obviously are not as impactful as those of people facing this situation.

The last set of options is similar to the previous one. The last question in particular was answered more negatively as the system does not monitor the dementia-affected person.

Regarding the open-ended questions related to these sets of tests, people were generally positive and liked the touch screen interface, the possibility of communicating with the TV, the clear terminology and the big buttons. However, some things such as better response times, better colours and necessity of further explanations and indications on how to send information to the TV were pointed out as well.

Some suggestions such as adding a dynamic background to the TV's interface based on a theme such as the current season and the addition of an option to delete pictures deserve to be further explored and tested in the following iterations of mobileWAY.

7.3 Evaluation of Collaborative Tasks

In this section, the collaborative tasks' results will be presented. These tests are related to the three multi-caregiver functionalities – To-do, Calendar and Forum.

7.3.1 Evaluation Protocol

The collaborative tasks were evaluated after the caregiver status setup tasks. They consist of three additional tasks and are thus numbered task 10, 11 and 12.

Since the system was explained to users during the caregiver status setup tests, here the facilitator focused the explanation on the multi-caregiver functionalities before users were asked to perform the tests. The questionnaire handed to users was the same as during the previous tests, so in this section only the usability tests related to these functionalities will be detailed.

7.3.2 Results of Usability Tests

In this section the three tests' results will be shown. The tasks involved using the to-do, calendar and forum, respectively. Every task had a 100% success rate.

It is also noteworthy to mention that these tasks were performed on the conventional Google-provided applications, as explained before, so the evaluated design in these tests is not the design of the author of this dissertation.

7.3.2.1 Task 10

The tenth task involved adding a new task to the to-do list. It could be completed in four steps. The following chart shows these tests' results:

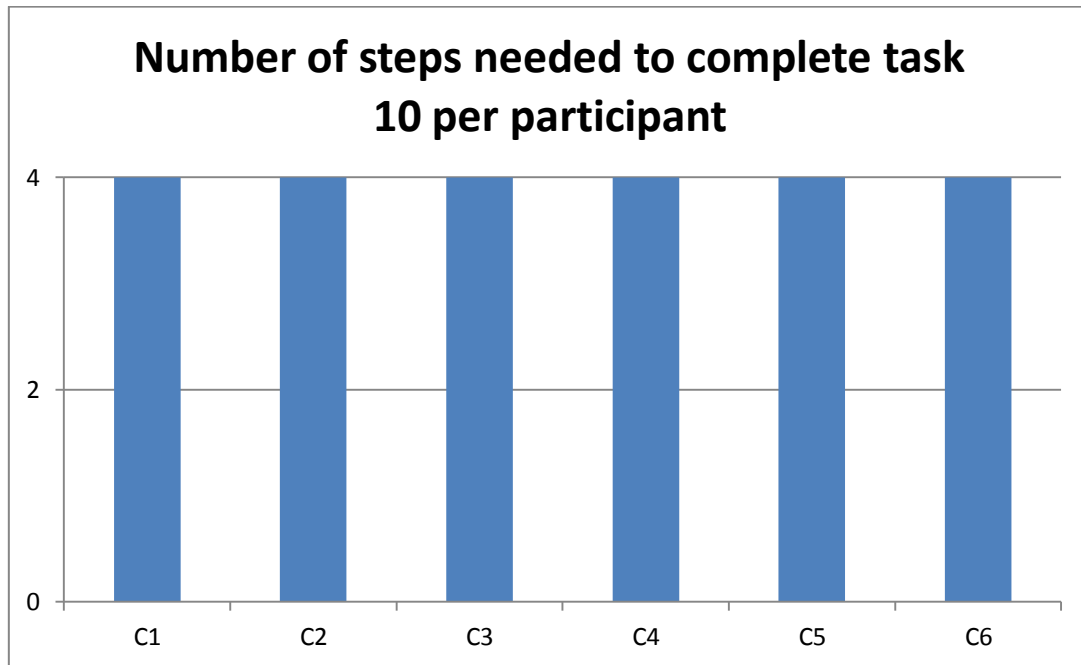


Chart 21 – Validation phase: task 10 results.

No participant needed additional steps to complete this task. However, there are various things that need to be said regarding this task.

One of the participants required the facilitator to use the “+” option, found in the Google Tasks interface, that allows for the adding of a new task. This option is not very clear at all.

Five out of the six participants experienced problems related to the interface and these add to the aforementioned “+” option point: they all had trouble saving the new task’s information after writing it. Google Tasks positions the cursor on a new blank field as a new task after the person uses the “+” option. However, to save the new task, users are expected to use the “Enter” button of the virtual keyboard. It is also possible to save by touching anywhere else on the interface, as long as it is outside of the new task’s text field. None of these were very well understood and caused many problems. Even though users managed to complete the tasks, the usability regarding this particular application revealed itself to be less than ideal.

7.3.2.2 Task 11

Task 11 involved adding a new event to the calendar. Like the previous tasks, four steps were required to complete the task. Here are its results:

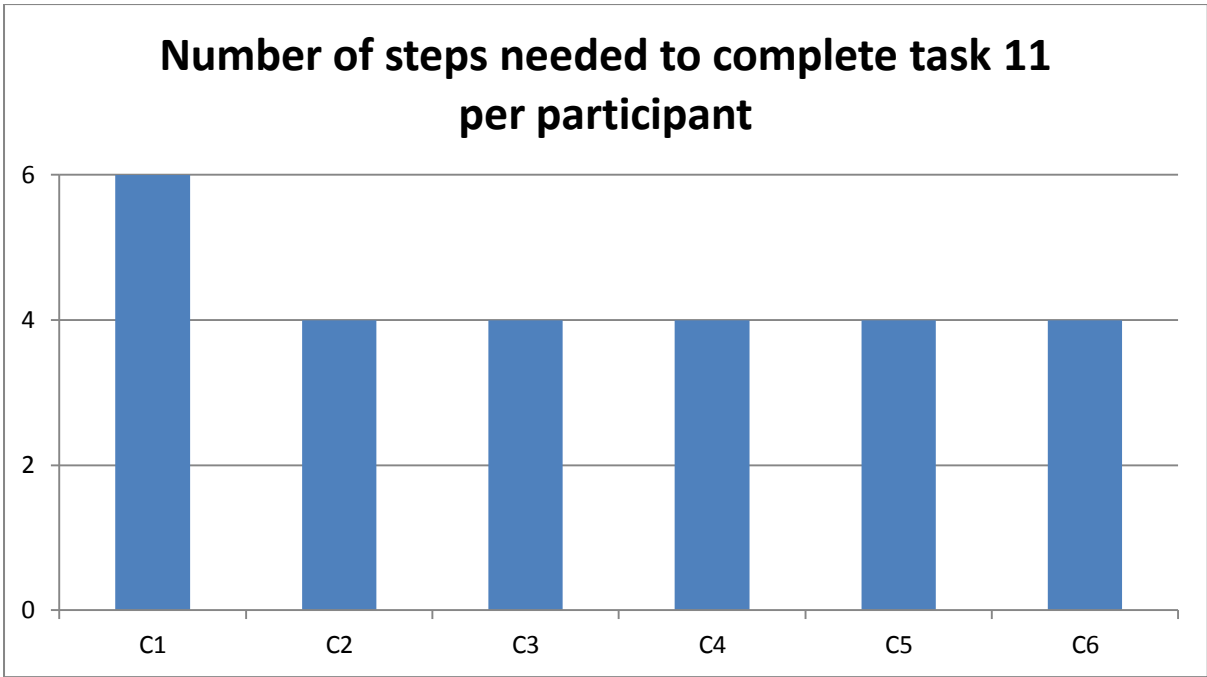


Chart 22 – Validation phase: task 11 results.

With the exception of one participant, everyone completed this task without needing additional steps.

This time, Google Calendar was the chosen service to support the calendar needs of caregivers. This application performed a bit better with the users who tested the system. However, both the participant who needed additional steps and another got a bit confused by the interface. Because of this, it has to be said that this service is not the best choice for mobileWAY.

7.3.2.3 Task 12 results

The twelfth, and last, task had participants adding a new message in the forum. The task required a minimum of four steps. The following chart displays its results:

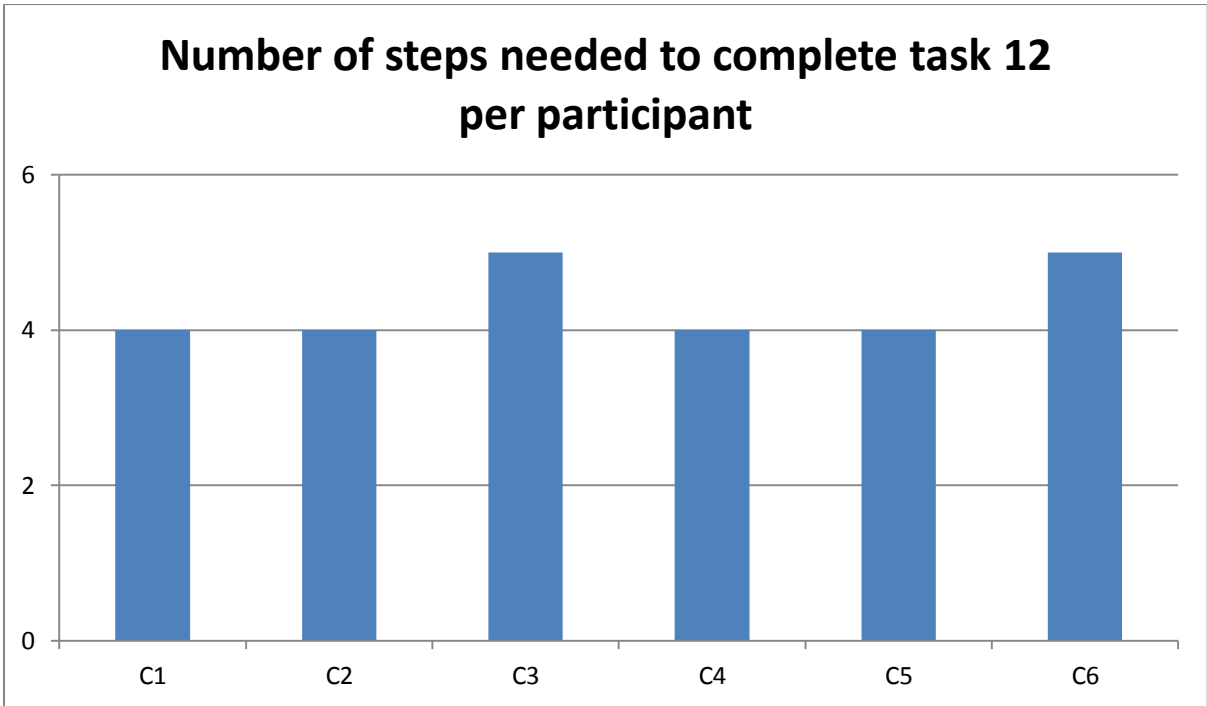


Chart 23 – Validation phase: task 12 results.

Two participants needed an additional step each to complete the final task.

Both errors were related to how to post information. Again, the Google’s application interface (in this case Google Plus) revealed itself to be relatively bad for the required purposes of participants. With the exception of one participant, who had no problems, for all others the interface was slow and in one case even seemed to reveal a bug where nothing could be done until a retry was performed.

7.3.2.4 Global task results analysis

In the following table, the minimum number of steps needed, the maximum number of steps used and the average number of errors per task can be observed:

Table 6 – Validation phase: minimum number of steps needed, maximum number of steps used and average number of errors per task (collaborative tasks).

Task	Minimum number of steps needed	Maximum number of steps used	Average number of errors
Task 10	4	4	0
Task 11	4	6	0.3
Task 12	4	5	0.3

Generally, the results are positive as only two errors were made on both task 11 and 12. But these results have to take the problems users had in mind. Unfortunately, the multi-caregiver functionalities, although they work and can be used for prototype purposes, will need to be

reevaluated as various usability problems were found during tests. This generally has to do with the different user interface design as it is not as clear or integrated as the rest of the application. More detailed results will be outlined in the following section.

Still, the possibility of using tools that are capable of providing information to many people at once should be praised.

7.3.3 Questionnaires

The questionnaire results can be seen on Chart 20 as the questionnaire was only one and involved the multi-caregiver tasks as well.

Looking at the results, users generally felt that these functionalities need additional improvements: the interface is a bit different from the rest of the mobileWAY's application, buttons and elements are generally small and usability needs improvements. One participant also suggested changing the name "To-do" to "Do Not Forget" which can be iterated and studied as well.

Overall, the multi-caregiver functionalities, while appreciated, need various enhancements.

7.4 Evaluation Results

Although the tests still have shown areas of improvement, the test results were mostly positive.

The users who tested the system were mostly younger, knew more about technology, and were not as knowledgeable regarding a real-life situation of AD caregiving. As users' expectations from the system were different and they were faster to experiment with the interface, new errors were made and the tasks yielded some new findings. Additionally, the fact that a new helper was providing assistance to the facilitator may explain the fact that in some situations the users may have tried to solve tasks differently.

Still, the application, while focused on the contexts of dementia and AD, can and should be usable by people of varying ages and backgrounds, especially since there is a possibility that these persons may need to look after a diseased relative later on in their lives. While the tests showed some new problems, they also enforced that the application is very usable and was well received functionality-wise. Furthermore, problems that were identified before disappeared or were mitigated in this round of testing, which is a very positive accomplishment.

More tests would be desirable involving first and foremost, people who are somehow involved in a dementia-related context. However, the results of these tests indicate the potential of mobileWAY which should continue growing and be developed further.

8 Discussion

This thesis focused on the redesign, implementation and evaluation of mobileWAY v1, a system to be used in dementia contexts, particularly those involving persons with early-stage AD and their caregivers. The system contains two components: the caregiver-side component, in which caregivers use a mobile application to send information about who they are, what activity they are performing outside the house and when they will return to the TV at home of the dementia-affected person; and the dementia-affected person-side component, who is at home watching the aforementioned TV and can therefore be updated on the caregiver's status.

Research and analysis of various technological projects culminated in the choice of mobileWAY v1 as an idea worth pursuing further, both because of its simple, focused approach in the context of dementia, a difficult and important area of research, and because of its intelligent use of connecting widely used and well-known technologies – mobile devices and the TV – which are on the rise and will continue to gain traction in the foreseeable future.

To further improve mobileWAY v1, the first phase consisted of a redesign and new evaluation performed with end users. As changes to improve the usability and clarity of mobileWAY v1 were identified, new functionalities were also included. Of particular note are the entertainment-related functionalities, which allow caregivers to play slides, audio and video on the TV to entertain the dementia-affected person. While tests were positive, it is worthwhile to mention that there were difficulties regarding the availability of users that filled the prerequisites of being a caregiver or a dementia-affected person. In the area of HCI, a UCD approach presents many advantages, however evaluation in this context is extremely difficult. This evidences that dementia contexts need a more dedicated set of practices and guidelines for this particular context. Finding users was a difficult endeavor and testing with people affected with AD was slow and challenging. Still, the positive achievements of this phase, which combine a good number of dementia-affected persons and their respective caregivers as well as a good acceptance of the redesigned system, deserve to be mentioned.

The next phase consisted of the implementation of the redesigned system, mobileWAY v2. Prior to the implementation, it was necessary to make important decisions regarding the methods and tools. An analysis of the current state of the art with regard to mobile platforms and their possibilities ended up paving the way for the choice of Android and Google TV to achieve the desired results. Complementing this, agile methodologies allowed for a rapid and systematic approach to development. The openness of the Android platform facilitated work and allowed a smooth integration of the tablet device (chosen as it was the target of the design) with

the Google TV by means of a server powered by Ruby on Rails and equipped with an SQLite database.

As the implementation progressed and the application got more complete, the multi-caregiver functionalities presented a few challenges. The available time and resources made it impossible to pursue new designs and evaluations of the required functionalities with users, namely the to-do, calendar and forum functionalities. As a result, the decision to use applications already available from Google was taken.

After implementing the system's prototype, the final validation and tests were performed. As explained before, it is very difficult to find users directly involved in dementia settings. This problem was emphasized towards the end of the thesis and final tests because it is important to perform the tests with different users from before and it was not possible to find more test participants with the desired characteristics. So, in this stage, regular, more technologically-savvy people performed the tests. However, it is important to point out that this situation does not detract from the validity of the testing. Any person can be a caregiver of a dementia-affected person at any point of their lives, regardless of age, kinship or gender. Since one part of mobileWAY is intended to be used by caregivers, it is important and useful to ensure that the system remains usable and pleasant to use for people in general. The only thing that could not be assessed as well was the section of the questionnaire that deals with the impact of the system in the life of dementia-affected persons, as the participants were not taking care of these types of persons, and therefore would not know how to reply to these questions. It is noteworthy to mention the fact that in these evaluations, some tasks were solved differently when compared with the tests during the redesign phase, introducing some new unexpected problems. This may be explained by: i) the fact that the users had different expectations of the system (which is natural as they are more familiar with technology); and ii) during evaluations, although the author attempted to use the same criteria to assess results, it is possible that communication with users, and therefore the resulting evaluations, may not have been exactly the same. Some problems with the interfaces of the multi-caregiver functionalities could also be identified, which can be explained by the fact that these external applications have designs that are not aligned with mobileWAY's interface and are therefore not tailored for optimal use in the contexts that the system aims for. Still, the overall positive results from the validation phase should be noted.

This thesis contributes a working prototype of a system that is targeted at dementia contexts, and the use of state-of-the-art technology to help solve this problem was an exciting undertaking. The challenges that needed to be overcome regarding the interconnection of devices and the use

of the recent Google TV allowed the acquisition of a great deal of knowledge and were very enriching.

As the results from the various tests were positive, there is a reinforced notion that mobileWAY should continue evolving. Although many evaluations of the system could be performed when both mobileWAY v1 and v2 are taken into account, the importance of further testing and refining of the system prevails. It is also important to highlight that going forward, more tests involving both actual caregivers and dementia-affected persons should be pursued.

9 Conclusions and Future Work

9.1 Conclusions

The second iteration of mobileWAY, developed in this work, culminated in a fully working prototype of mobileWAY, which was the main aim for this project. The system was implemented using the Android platform and can be used by caregivers on a tablet device to push information to the TV of the dementia-affected persons they care for.

The tablet application allows caregivers to:

- Add and manage information related to caregivers, activities, activity durations and optional messages.
- Send this information to the TV of dementia-affected persons.
- Control and display entertainment on the dementia-affected persons' TV screen in the form of slides, audio and video to keep them occupied and entertained while caregivers are out of the house.
- Access multi-caregiver functionalities – to-do, calendar and forum – that allows caregivers to communicate with each other and coordinate activities seamlessly.
- Customise various options to adapt everything to a given situation.
- Keep up to date on whatever the TV is showing as a means of letting caregivers control what their diseased relatives are seeing.

The TV interface, on the other hand, receives information from the tablet and displays it dynamically.

mobileWAY is a powerful system in that it can be customised according to various dementia contexts and avoids introducing costly or flashy equipment in the home of a dementia-affected person.

The tests performed throughout this work showed many positive aspects of the system and are without a doubt encouraging for its continued development.

The system was developed with scalability in mind, so it is possible to add new components and integrate them with the existing solution. Usability tests showed room for improvement and the addition of new functionalities can correct some problems. It is also important to keep testing the system with caregivers and dementia-affected persons as their input is very valuable and further developments can be researched and pursued.

9.2 Future Work

There are various areas that can be explored for further iterations of mobileWAY.

First off, a smart phone version could not be pursued in this work but is a very important continuation as smart phones are easier to carry around and currently more widespread than tablets. Since these devices' displays are smaller, it is important to adapt mobileWAY v2's interface having these restrictions in mind.

Further, the multi-caregiver functionalities should be worked on. New designs, evaluations and implementations of each of the multi-caregiver functionalities could be conducted to be truly optimised for the intended audience of the system. Integration of these with the placeholder settings regarding these functionalities is also desired.

New entertainment options could also be explored such as the addition of simple games that dementia-affected persons could enjoy. Additionally, the system could benefit from the use of a Web interface and/or functionality that allows caregivers to store and manage entertainment types such as videos and audio that the application would fetch and thus immediately make available to display on the TV.

The tests performed herein also present aspects that could be improved; for instance, exploring the possibility of using a wallpaper as background on the TV with something recognisable to the dementia-affected person, improving feedback on what information was confirmed, and trying to simplify the various processes even further.

Some possibilities that were suggested in mobileWAY v1 but could not be explored in this work include the possibility of auditory modalities on the TV (such as a timed reading of the displayed information) and integration of mobileWAY with the regular TV broadcast.

Other possibilities for a newer version of mobileWAY include the optimisation of the communication between the mobile device and the TV letting users know exactly how the process is faring such as a loading indicator. More work can also be put into further implementation of the animated countdown activity duration icons and more investigation can be done regarding new icons.

Finally, it is very important to test the system with a larger number of caregivers and dementia-affected persons. Although the system displays good results, adapting the interface and optimising the application as a whole for these target users continues to be one of the central aspects of mobileWAY.

9.3 Summary

This thesis focused, from the beginning, on the development of a system that would provide assistance in the contexts of dementia.

By conducting research and investigating the projects that were worked on around the scope, many interesting things were found. The population is getting older and as a result, many people are more likely to suffer from dementia. The most common form of dementia, AD, thus became a very important and central point of this work. Alongside this reality, it was possible to identify the growing potential of technology as a means of diminishing the gap between dementia contexts and the economically-choked reality that the world currently finds itself in. Since health care systems cannot currently give an appropriate answer to everyone who needs them, technology can do its part in helping given segments of the population in a helpful and effective way.

Various projects that could help people affected with AD and their caregivers were researched and looked into. Many of them involved complex systems and required various external tools such as sensors or other intelligent devices. One project however set itself apart for its approach in simplicity and focus: mobileWAY v1.

mobileWAY v1 is a project that attempts to support early dementia contexts, involving both dementia-affected persons and their caregivers, by tackling the problem with a two-sided solution:

1. Caregivers use a mobile device application to send very simple information to the TV of the dementia-affected persons, indicating who they are, what they are going to do and how long they will take until they are back at the house of the dementia-affected person.
2. Dementia-affected persons see on the TV what their caregivers displayed through the tablet application.

By making use of mobile devices and a TV, mobileWAY v1 uses state-of-the-art technology by identifying the growing trend of smart phone and tablet adoption and mixes it with an old yet well-accepted technology to create an environment in which caregivers can feel more at ease regarding their beloved ones while the dementia-affected persons will feel less anxious by knowing their caregivers' whereabouts, thus decreasing their sense of loneliness.

mobileWAY v1 was designed and tested by (Jordan, 2011). This thesis took it further by gathering the information from previous tests and iterating the design once achieved, resulting in

a better, more usable and richer system. The implementation of the system was also carried out. These were the tasks performed in this thesis. The main steps are described in the following paragraphs.

Firstly, the collected information and ideas from the initial version of mobileWAY were used to create a more usable and adapted system. This phase resulted in a redesign of mobileWAY v1 which embodies added functionality and an improved interface. This phase used a UCD methodology that involved end users of the system to ensure that it would meet their needs and goals. Many things changed, including revised workflows, improved terminology, more adapted user interfaces, confirmation dialogs and a whole new set of functionalities related to providing entertainment to the dementia-affected persons.

The system was then tested and evaluated with ten caregivers and five dementia-affected persons to understand if the changes improved the design and were well accepted.

Results from the first round of testing were very encouraging; people liked what they used, saw much potential within the application and a number of less ideal behaviours were pointed out together with other general suggestions regarding the interface. Further terminology enhancements were made and new options, like a “Save Settings” button, were included. By this point, tests implementation-wise were being performed and the addition of new functionalities, namely the multi-caregiver functionalities, was being studied and worked on.

The implementation phase came next. The specification was detailed and, as requirements were being specified and completed, the next step led to the choice of the Android platform and Google TV to support the needs of the system because of its open nature and wide adoption. All interfaces were constructed and functionalities were implemented. For the multi-caregiver functionalities, Google’s existing applications were chosen because of being well known and having the potential to integrate well with mobileWAY.

The second phase of testing, during validation, was performed with six users that were not caregivers of dementia-affected persons. Unfortunately, these types of users could not be found and as such the application was tested with regular users, more familiar with technology. Although the results did show that these users had different behaviours regarding their interface usage (for instance, they were more prone to experimenting with it), it was nevertheless possible to see that they accepted the system well and liked its motivations and goals. While some problems were identified, the major conclusions in this context had to do with the multi-caregiver functionalities.

There were some drawbacks from the usage of Google's applications regarding user interface and clarity of information. Ideally, going forward, the development of mobileWAY should focus on the design and evaluation of customised applications for the to-do, calendar and forum functionalities. In this way, a more integrated and uniform experience can be created.

There is also an important aspect that could not be tested in the validation phase of mobileWAY v2, which is the acceptance of the TV interface by dementia-affected persons. The extremely high difficulty of finding different and available people to test the system with prevented such evaluations, however it is very important to make sure that they understand the interface and are comfortable with it. Newer adaptations might be needed and some concepts such as the animated activity duration icons counting down can be further explored.

As pointed out by Jordan (2011), the available methodologies are insufficient regarding usability testing with people with dementia. These could also be explored and improved as a means of diminishing the needed time and effort such persons would require putting into when helping with evaluation of new systems.

Overall, it can be said that the positive feedback from the various tests and development conducted with users is very encouraging and can be stimulating in pushing this project to further refined iterations and developments. Many points can still be improved upon without sacrificing the tight focus of mobileWAY.

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11 Appendixes

11.1 Terminology Tests

11.1.1 Questions

Question A – As a caregiver of a dementia-affected person, you will be out of your house for a while to perform an activity (go to the supermarket, walk the dog, etc). What would you name the option that allows you to tell how much time you will take?

1. Define activity duration
2. Indicate delay time
3. Indicate activity duration
4. Add activity duration

Question B – As a caregiver of a dementia-affected person, you have the possibility of using an option that allows you to display a video, play audio or place slideshows so that the person can see/hear them. How would you name this option (note that besides the term you also need to choose between “show” and “select”)?

1. Show/select entertainment
2. Show/select occupation
3. Show/select pastime
4. Show/select distraction
5. Show/select diversion
6. Show/select multimedia

Question C – As a caregiver of a dementia-affected person, you have the possibility of defining who the caregiver(s) of the person are, which activity(ies) the caregiver(s) can perform, etc. For these possibilities, you can define elements such as the caregiver’s picture, the activity’s name, etc. How would you name the option that allows you to change these elements (if necessary)?

1. Configure
2. Adjust
3. Adapt
4. Tune
5. Perfect

- 6. Amend
- 7. Improve

11.1.2 Results

Total number of participants: 11.

Question A results:

Table 7 – Question A results.

Option	1	2	3	4
Number of times selected	5	2	6	0

Selected terminology: 3. Indicate activity duration.

Question B results (SHO – show, SEL – select):

Table 8 – Question B results.

Option	1		2		3		4		5		6	
	SH O	SE L	SH O	SE L	SH O	SE L	SH O	SE L	SH O	SE L	SH O	SE L
Number of times selected	2	3	0	1	1	1	0	1	0	0	3	1
Total	5		1		2		1		0		4	

Selected terminology: 1. Select entertainment.

Notes: The “entertainment” option was the most voted one. Looking at the results for “Show” and “Select” in that given term, it can be seen that “Select” was the most voted verb. As such, “Select entertainment” is the winner option.

Question C results:

Table 9 – Question C results.

Option	1	2	3	4	5	6	7
Number of times selected	9	2	0	0	0	0	2

Selected terminology: 1. Configure.

11.2 First round of usability tests – Protocol

11.2.1 Introduction

Hello, welcome to the “Using the mobileWAY application” session! My name is Renato. I would like to thank you for your participation in this session!

11.2.2 Session’s goals

This session to which I am asking for your participation arises in the context of the project that I am developing which consists in assessing and developing a tablet interface called mobileWAY. The application is intended to help dementia-affected persons that are in its early-stages as well as their respective caregivers. This application allows caregivers to display simple information to dementia-affected persons which will help them become more relaxed when they are alone at home.

It is very important to me to know if the application is comprehensible, simple and easy to use, and so your participation is fundamental. I thank you once again for your availability!

11.2.3 Session’s duration

The session should take no longer than 60 minutes.

11.2.4 Session’s organization

This session is divided in three parts:

1. First, I will briefly explain what the developed system consists of, what the motivations behind its development are and what its main functionalities are so that you can understand its main objectives.
2. Secondly, I will ask that you perform some tasks in the application interface that I have prepared.
3. Finally, I will ask you some questions regarding the functionalities that you tested so that I can understand your opinion of the interface you just used.

11.2.5 Privacy and security of collected data in this session

Data collected in this session will be used by me with the sole purpose of retrieving information that will help me improve the application. No data that identifies you personally will be provided to third parties.

11.2.6 Final notes

This session is by no means obligatory, which means you can interrupt or terminate it at any point and for any reason, if you so desire. Additionally, you can clarify any doubts that you might have whenever you need to.

Lastly, I want to remind you that **you are not being tested; you are testing the system.** Information collected during these tests will have the purpose of understanding what was done right and what was done wrong in the developed system.

11.2.7 Tasks

11.2.7.1 Task 1

Let us start by adding your profile to the application.

Add yourself to the application as the caregiver, write your name and take a picture of yourself.

11.2.7.2 Task 2

Now you can try to change the working activity.

As I previously said, the application places a message chosen by the caregiver in the television. I have used the prototype previously and added an activity that I called “is working”, but the picture is not a very good one. You can change that picture to one of your choosing that is located in the picture library.

11.2.7.3 Task 3

Great! You already added yourself to the system as the caregiver and changed the activity that shows that you are working.

Now try to imagine the following scenario: you need to go to work for the next 2 hours. I would like you to display that information on the television. To do so you have to:

- Define yourself as the caregiver;
- Define the activity “is working”;
- And define the amount of time you will be out of your house (2 hours).

11.2.7.4 Task 4

Very well! Now let us add a message to the lower part of the television letting the dementia-affected person know that today is Mother’s Day.

It is possible to optionally add a message to the bar appearing at the bottom of the television, which allows for the provision of useful information to the dementia-affected person. Add the message “Mother’s Day” to the television.

11.2.7.5 Task 5

Let us now add something to the television that allows the dementia-affected person to be entertained while waiting for your arrival.

Imagine the following: you are out of the house and want to help the dementia-affected person be entertained while you do not return. Make the television play the video “O Pátio das Cantigas”.

11.2.7.6 Task 6

Excellent! Let us try to change the dementia-affected person’s entertainment now.

Right now the dementia-affected person is watching the video “O Pátio das Cantigas”, but you know it is nearing its end and besides, you recalled that you had a new set of slides that the person really wanted to see. Replace the video with the slides “Our family”.

11.2.7.7 Task 7

Let us change the activity duration icon.

The activity duration icon that I configured is the hourglass. Let us change that to the clock icon. Go to the settings to do so.

11.2.7.8 Task 8

We are nearing the end! Let us hide the message bar.

You discovered that the dementia-affected person does not really need the message bar at the bottom of the television. Go to the application settings and hide it.

11.2.7.9 Task 9

Very good! Let us finish now. Hide the entertainment options.

Suppose that the dementia-affected person is not very interested in the television entertainment and would rather perform other activities while at home. In this scenario, having the entertainment options in the interface is not very important. Go to the settings and hide these functionalities.

11.2.8 Questionnaire

GENERAL INFORMATION

Caregiver no.

Age:

Gender:

Relationship to the dementia-affected person:

QUESTIONS

1. The application's organization makes it easy to understand the various tasks that it allows you to execute...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
2. The application's organization and content are clear...
 - a. Always
 - b. Most of the times

- c. Sometimes
 - d. Never
- 3. The way the content is presented allows you to know what to choose and how to execute a specific task...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
- 4. The application was easy to use...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
- 5. The application was pleasurable to use...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
- 6. The application will improve the dementia-affected person's quality of life...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
- 7. The application will enable the dementia-affected person to feel more secure...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
- 8. The application will enable the dementia-affected person to feel calmer...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never

9. The application will help you and other caregivers improve the dementia-affected person's quality of life...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
10. The application will enable you and other caregivers to manage the dementia-affected person's needs...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
11. The application will enable you and other caregivers to feel less concerned about the dementia-affected person's safety...
 - a. Always
 - b. Most of the times
 - c. Sometimes
 - d. Never
12. What did you like the most in the application?
13. What did you dislike the most in the application?
14. What would you improve in the application?

THANKS! Your help was very important!

11.3 First round of usability tests – Caregivers’ Task Results

11.3.1.1 Tasks’ Legend

Table 10 – Tasks’ legend.

Task 1 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
AC	Adicionar Cuidador	Add Caretaker
INC	Introduzir Nome do Cuidador	Insert Caretaker Name
EF	Escolher Fotografia	Choose Picture
TF	Tirar Fotografia	Take Picture
TF2	Tirar Fotografia (2)	Take Picture (2)
POPCAS	Pop-up "Cuidador adicionado com sucesso!"	Pop-up "Caretaker added successfully!"
ALC	Alterar Cuidador	Change Caretaker

Task 1 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[ADCU]	Adicionar Cuidador	Add Caretaker
[INA]	Introduza o seu nome aqui	Insert your name here
[GU]	Guardar	Save
[AFA]	Adicione a fotografia aqui	Add picture here
[TIPO]	Tirar fotografia	Take picture
[OK]	OK	OK

Task 2 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
ALA	Alterar Atividade	Change Activity
ALA2	Alterar Atividade (2)	Change Activity (2)
CA	Configurar Atividade	Configure Activity
EF	Escolher Fotografia	Choose Picture
BF	Biblioteca de Fotos	Picture Library
POPACS	Pop-up "Atividade configurada com sucesso!"	Pop-up "Activity configured successfully!"

ALA3	Alterar Atividade (3)	Change Activity (3)
------	-----------------------	---------------------

Task 2 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[ALAT]	Alterar Atividade	Change Activity
[EAT]	está a trabalhar	is working
[COAT]	Configurar Atividade	Configure Activity
[FOAT]	Fotografia da Atividade	Activity Picture
[BIBFO]	Biblioteca de Fotos	Picture Library
[NIA]	Nova imagem da Atividade	New Activity picture
[GC]	Guardar configurações	Save configurations
[OK]	OK	OK

Task 3 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
ALC	Alterar Cuidador	Change Caretaker
ALC2	Alterar Cuidador (2)	Change Caretaker (2)
POPCALS	Pop-up "Cuidador alterado com sucesso!"	Pop-up "Caretaker changed successfully!"
ALA	Alterar Atividade	Change Picture
ALA2	Alterar Atividade (2)	Change Picture (2)
POPAALS	Pop-up "Atividade alterada com sucesso!"	Pop-up "Activity changed successfully!"
ALDA	Alterar Duração da Atividade	Change Activity Duration
ALDA2	Alterar Duração da Atividade (2)	Change Activity Duration (2)
POPDAALS	Pop-up "Duração da Atividade alterada com sucesso!"	Pop-up "Activity Duration changed successfully!"
POPATV	Pop-up "Deseja atualizar a informação na televisão?"	Pop-up "Do you wish to change the information on the television?"
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 3 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[ALCU]	Alterar Cuidador	Change Caretaker
[ANA]	Ana	Ana

[ALPCU]	Alterar para Cuidador	Change to Caretaker
[OK]	OK	OK
[ALAT]	Alterar Atividade	Change Activity
[EAT]	está a trabalhar	is working
[ALPAT]	Alterar para Atividade	Change to Activity
[ALDUAT]	Alterar Duração da Atividade	Change Activity Duration
[2HO]	2 horas	2 hours
[ALPDUAT]	Alterar para Duração da Atividade	Change to Activity Duration

Task 4 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
AM	Adicionar Mensagem	Add Message
INM	Introduzir Nome da Mensagem	Insert Message Name
POPMA5	Pop-up "Mensagem adicionada com sucesso!"	Pop-up "Message added successfully!"
ALM	Alterar Mensagem	Change Message
ALM2	Alterar Mensagem (2)	Change Message (2)
POPMA5LS	Pop-up "Mensagem alterada com sucesso!"	Pop-up "Message changed successfully!"
POPATV	Pop-up "Deseja atualizar a informação na televisão?"	Pop-up "Do you wish to change the information on the television?"
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 4 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[ADME]	Adicionar Mensagem	Add Message
[INMA]	Introduza o nome da mensagem aqui	Insert message name here
[GU]	Guardar	Save
[OK]	OK	OK
[DDM]	Dia da Mãe	Mother's Day
[ALPME]	Alterar para Mensagem	Change to Message

Task 5 - Screens		
Abbreviation	Portuguese	English

HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
SE	Selecionar Entretenimento	Select Entertainment
SV	Selecionar Vídeo	Select Video
SV2	Selecionar Vídeo (2)	Select Video (2)
POPVSS	Pop-up "Vídeo selecionado com sucesso!"	Pop-up "Video selected successfully!"
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 5 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[SEEN]	Selecionar Entretenimento	Select Entertainment
[SEVI]	Selecionar Vídeo	Select Video
[OPDC]	O Pátio das Cantigas	O Pátio das Cantigas
[SEL]	Selecionar	Select
[OK]	OK	OK

Task 6 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
SE	Selecionar Entretenimento	Select Entertainment
SS	Selecionar Slides	Select Slides
SS2	Selecionar Slides (2)	Select Slides (2)
POPPVSS	Pop-up "Parar vídeo "O Pátio das Cantigas" para selecionar slides "A nossa família"?"	Pop-up "Stop video "O Pátio das Cantigas" in order to select slides "A nossa família"?"
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 6 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[ALEN]	Alterar Entretenimento	Change Entertainment
[SESL]	Selecionar Slides	Select Slides
[ANF]	A nossa família	A nossa família
[SEL]	Selecionar	Select
[OK]	OK	OK

Task 7 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
D	Definições	Settings
D2	Definições (2)	Settings (2)
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 7 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[DEF]	Definições	Settings
[UIR]	Usar ícone "Relógio"	Use "Clock" icon
[VOLT]	Voltar	Back

Task 8 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
D	Definições	Settings
D2	Definições (2)	Settings (2)
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 8 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[DEF]	Definições	Settings
[MBM]	Mostrar barra de mensagens	Show message bar
[VOLT]	Voltar	Back

Task 9 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
D	Definições	Settings
D2	Definições (2)	Settings (2)
EI2	Ecrã Inicial (2)	Initial Screen (2)

Task 9 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[DEF]	Definições	Settings
[MAE]	Mostrar área de entretenimento	Show entertainment area
[VOLT]	Voltar	Back

11.3.1.2 Results of Caregiver 1

Table 11 – Results of Caregiver 1.

Caregiver:	C1
Takes care of:	AP1
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	1	"Should I enter my name here?"	Before touching the correct option, the caregiver touched its label.
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		Caregiver gave clear signs of fearing doing something that could

					not be undone.
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		The question was repeated as the caregiver got confused.
3	ALA	[EAT]	1	"I am a bit confused."	The caregiver touched "Add Activity" first.
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALCU]	0		
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	1	"Change caregiver?"	The caregiver first touched on "Cancel".
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		

8	ALA2	[ALPAT]	0		The caregiver stopped a bit to think and then remembered how to do it correctly from the previous experience.
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0	"Oh, this is an hourglass? I see. But that means the time is indeterminate."	The hourglass was not very well understood at first.
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		

6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0	"Oh, that is nice. I much prefer the clock icon!"	
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	1		The caregiver first pressed "Change Message". The facilitator was not very clear so the task's goal was repeated.
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.3 Results of Caregiver 2

Table 12 – Results of Caregiver 2.

Caregiver:	C2
Takes care of:	AP2
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	1		The caregiver first tried to touch "Add Activity".
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		

7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0	"Wait, didn't I do that already?"	The caregiver thought at first that by fulfilling the first task, the application already had saved that information as the information that would later be pushed to the TV.
2	EI	[ALCU]	1		The caregiver attempted to touch the squared caregiver picture option present on the TV fragment part of the application.
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	0		The caregiver thought the words "Change to" were problematic; suggests using "Confirm" instead.
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		

12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPATV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		

7	EI2	-	0		
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Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.4 Results of Caregiver 3

Table 13 – Results of Caregiver 3.

Caregiver:	C3
Takes care of:	AP2
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		

4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	1	"When I am on my computer, if I need to change something, one option I have is to delete the unwanted item and create a new one."	The caregiver first touched "Cancel".
5	CA	[FOAT]	1		The caregiver touched "Delete Activity" instinctively. Refer to the commentary in screen number 4.
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		The task confused the caregiver at first because it seemed to already have been done

					in task 1.
2	EI	[ALCU]	0		
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	1		The caregiver did not understand very well how to complete the task at first; suggested changing "Change to" to "Confirm" instead.
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		When looking at the main screen, the caregiver was silenced while thinking for a bit, and then said that having the word "Change" behind a resource type was misleading as it seemed that it was intended to change the information on the TV. It was suggested that in this screen the word "Change"

					should not exist, just the resource type (e.g., "Caregiver", "Activity").
--	--	--	--	--	---

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		

2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0	"Where is the option to save the settings? Oh, I have to go back. That might be unclear. Did I actually save the changes?"	The settings screen should have a "Save Settings" button.
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.5 Results of Caregiver 4

Table 14 – Results of Caregiver 4.

Caregiver:	C4
Takes care of:	AP3
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	1	"OK, I see. To change this activity I will just delete this one and add another."	The caregiver touched on "Delete Activity".
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes

1	HA	[MW]	0		
2	EI	[ALCU]	0	"The caregiver is already added, right? So I do not want to change this."	The caregiver was reading the whole screen expecting to find something that could be used to complete the task. When asked if anything was wrong, the caregiver said that the only option that might allow doing what was expected was "Change Caregiver". However, after being motivated to access that option by the facilitator, the caregiver suggested eliminating the word "Change" from the main screen as it was misleading.
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	1		The caretaker first chose "Cancel" as "Change to" was not understood immediately. According to the caregiver, "Confirm" is a much better term.
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAAALS	[OK]	0		

10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		

4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.6 Results of Caregiver 5

Table 15 – Results of Caregiver 5.

Caregiver:	C5
Takes care of:	AP3
Kinship:	Son-in-law

Task no.	1
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Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALCU]	1	"Oh, this only zooms? It could be interesting to place the elements there directly."	The caregiver attempted to touch the squared caregiver picture option present on the TV fragment part of the application.
3	ALC	[ANA]	0		

4	ALC2	[ALPCU]	0		The caregiver suggested using "Confirm" instead of "Change to".
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		

6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.7 Results of Caregiver 6

Table 16 – Results of Caregiver 6.

Caregiver:	C6
Takes care of:	AP4
Kinship:	Son-in-law

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		When starting the tasks, it was apparent that the caregiver already had a lot of experience with technology.
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0	"I did this in the first task, right?"	The caregiver thought that he was already added to the TV.
2	EI	[ALCU]	1		The caregiver attempted to touch the squared caregiver picture option present on the TV fragment part of the application. After this, he caregiver scanned the screen and understood that the "correct" option was "Change Caregiver". However, the presence of the word "Change" was criticized for being misleading. It should not exist.
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	0	"The "check mark" image means "confirm", not "change to"."	The caregiver suggested "Confirm" instead of "Change to".
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		

13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0	"Check boxes and radio buttons should be on the right edge of the screen instead of being next to the option's picture".	The caregiver knew Android and it made more sense to follow the look and feel of the platform regarding settings screens.
4	D2	[VOLT]	0		The caregiver suggested having the option to save the settings.
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.8 Results of Caregiver 7

Table 17 – Results of Caregiver 7.

Caregiver:	C7
Takes care of:	AP4
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALCU]	0		

3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	0		
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.9 Results of Caregiver 8

Table 18 – Results of Caregiver 8.

Caregiver:	C8
Takes care of:	AP5
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALCU]	0		

3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	0		
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.10 Results of Caregiver 9

Table 19 – Results of Caregiver 9.

Caregiver:	C9
Takes care of:	AP6
Kinship:	Daughter

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		

2	EI	[ALCU]	0	"I understand the option, but "Change" is very misleading."	The caregiver understood the option "Change Caregiver" as being the correct one but pointed out that "Change" was a bad word to be there.
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	0		The caregiver took a while to understand what to touch on this screen. After understanding everything, the suggestion to change "Change to" to "Confirm" was made.
5	POPCALS	[OK]	0		
6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		

9	POPMALS	[OK]	0		
10	POPATV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0	"How do I save the settings? The only thing I can do here is go back... Does that retain changes?"	The caregiver suggested adding an option "Save Settings".
5	EI2	-	0		

Task no.	8				
-----------------	---	--	--	--	--

Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		
5	EI2	-	0		

11.3.1.11 Results of Caregiver 10

Table 20 – Results of Caregiver 10.

Caregiver:	C10
Takes care of:	AP6
Kinship (relationship to dementia-affected person, in this case):	Daughter's friend

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALAT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	1		The caregiver glanced first at the options below and tried to delete the activity.
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALCU]	0		
3	ALC	[ANA]	0		
4	ALC2	[ALPCU]	1	""Confirm" is much more explicit."	The caregiver tried to cancel first as none of the options appeared to do what was asked. After a more careful inspection, the chosen option was "Change to Caregiver", however it was criticized. "Confirm" was suggested instead.
5	POPCALS	[OK]	0		

6	EI	[ALAT]	0		
7	ALA	[EAT]	0		
8	ALA2	[ALPAT]	0		
9	POPAALS	[OK]	0		
10	EI	[ALDUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[ALPDUAT]	0		
13	POPDAALS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[ALPME]	0		
9	POPMALS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes

1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[VOLT]	0	"Hm... does going back save the settings? The screen should have that option."	The option "Save Settings" was suggested.
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		The paper prototype here made things harder to understand as check boxes were a bit rough. Facilitator's fault.
4	D2	[VOLT]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Caregiver's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[VOLT]	0		

5	EI2	-	0		
---	-----	---	---	--	--

11.4 First round of usability tests – Caregivers' Questionnaire Results

11.4.1 Caregiver 1

Table 21 – Questionnaire results of Caregiver 1.

Question	Answer
Q1	a
Q2	a
Q3	b
Q4	a
Q5	b
Q6	b
Q7	c
Q8	c
Q9	b
Q10	c
Q11	b
Q12	The possibility of "keeping in touch" with the diseased even when apart.
Q13	-
Q14	-

11.4.2 Caregiver 2

Table 22 – Questionnaire results of Caregiver 2.

Question	Answer
Q1	a
Q2	a
Q3	a
Q4	a
Q5	a
Q6	b
Q7	c
Q8	c
Q9	b
Q10	c
Q11	d
Q12	-
Q13	-
Q14	-

11.4.3 Caregiver 3

Table 23 – Questionnaire results of Caregiver 3.

Question	Answer
Q1	a
Q2	c
Q3	b
Q4	b
Q5	a
Q6	c
Q7	c
Q8	c
Q9	c
Q10	c
Q11	c
Q12	-
Q13	-
Q14	-

11.4.4 Caregiver 4

Table 24 – Questionnaire results of Caregiver 4.

Question	Answer
Q1	c
Q2	c
Q3	b
Q4	c
Q5	c
Q6	c
Q7	c (additional comment: "It depends on the person's degree of discernment")
Q8	c
Q9	c
Q10	c
Q11	c
Q12	I think that the application is a bit limited in terms of practical use because there is always a certain dependence on the stage of the disease in the dementia-affected person as well as as that person's capacities on all levels.
Q13	I consider the application to be complex to use because not everyone has mastered this kind of technology. On the other hand, the diseased person has to have a certain capacity of assimilation and association regarding imagery and messages.
Q14	The icons' presentation.

11.4.5 Caregiver 5

Table 25 – Questionnaire results of Caregiver 5.

Question	Answer
Q1	b
Q2	c
Q3	c
Q4	b
Q5	b
Q6	c
Q7	b
Q8	c
Q9	b
Q10	b
Q11	b
Q12	Innovative project.
Q13	A bit confusing.
Q14	-

11.4.6 Caregiver 6

Table 26 – Questionnaire results of Caregiver 6.

Question	Answer
Q1	a
Q2	b
Q3	a
Q4	b
Q5	b
Q6	b
Q7	b
Q8	b
Q9	b
Q10	b
Q11	b
Q12	I liked the integration with the TV. Menu access is effective to make the necessary changes.
Q13	-
Q14	On the settings screen, I would place the check boxes and radio buttons on the right of the option.

11.4.7 Caregiver 7

Table 27 – Questionnaire results of Caregiver 7.

Question	Answer
Q1	a
Q2	b
Q3	a
Q4	b
Q5	b
Q6	b
Q7	b
Q8	b
Q9	b
Q10	b
Q11	b
Q12	The TV integration is nice.
Q13	-
Q14	-

11.4.8 Caregiver 8

Table 28 – Questionnaire results of Caregiver 8.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	b
Q5	a
Q6	c
Q7	c
Q8	b
Q9	b
Q10	a
Q11	c
Q12	-
Q13	-
Q14	-

11.4.9 Caregiver 9

Table 29 – Questionnaire results of Caregiver 9.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	b
Q5	b
Q6	c
Q7	c
Q8	c
Q9	c
Q10	c
Q11	d
Q12	It is a relatively simple application.
Q13	The entertainment option.
Q14	Reduce the number of steps.

11.4.10 Caregiver 10

Table 30 – Questionnaire results of Caregiver 10.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	b
Q5	b
Q6	c
Q7	d
Q8	d
Q9	d
Q10	c
Q11	d
Q12	I liked the application in general.
Q13	The application does not entirely adapt itself to the specific diseased person's needs.
Q14	-

11.5 First round of usability tests – Dementia-Affected Persons’ Results

11.5.1 Results of Person 1

Table 31 – Results of Person 1.

Test no.	1		
Dementia-affected person:	AP1		
Place description:	In a small and quiet room, the person sat in a chair facing the wall where the TV paper prototype was placed. A formal caregiver was present and helped.		
Scenario	Information to test	Dementia-affected person's commentaries	Notes
Caregiver is out and will be back in 45 minutes	Caregiver's activity comprehension	-	The person fully understood the caregiver's activity and read the text without problems from about a 2-meter distance.
	Caregiver's activity-related imagery comprehension	[regarding the clock] "Is that the half-moon?"	The person recognized the caregiver and activity imagery. The formal caregiver placed numbers on the clock so as to make it more recognizable. The person understood it as being a clock immediately. After this, the new clock image complete with numbers was used in every test.
	Message bar comprehension	-	The person fully understood the message bar information and read it without problems from about a 2-meter distance.
Caregiver is out and will be back in 45 minutes, dementia-affected person is entertained watching Christmas-related slides	Entertainment slides comprehension	-	The person recognized Santa Claus and Jesus. The third slide which showed a Christmas's tree was a bit unclear but that was mainly the fault of the facilitator's image choice. Since by this point the test was getting a bit long, the person also started showing signs of being tired. So, the facilitator decided to eliminate this slide from further tests.
	Does the dementia-affected person still understand the information related to the caregiver?	-	Yes.

11.5.2 Results of Person 2

Table 32 – Results of Person 2.

Test no.	2		
Dementia-affected person:	AP2		
Place description:	In a small and quiet room, the person sat in a chair facing the wall where the TV paper prototype was placed.		
Scenario	Information to test	Dementia-affected person's commentaries	Notes
Caregiver is out and will be back in 45 minutes	Caregiver's activity comprehension	-	The person fully understood the caregiver's activity and read the text without problems from about a 2-meter distance.
	Caregiver's activity-related imagery comprehension	-	The person understood the imagery with the exception of the clock. The facilitator tried to ask about clock details to see if the person would understand. After a while, the combination of the clock numbers, the activity duration from the text and the green part of the clock were understood. As soon as the clock was understood, the association of the filled part of the clock to the 45 minutes remaining was immediately made.
	Message bar comprehension	"Oh, December 8! Our Lady of Conception's Day!"	The person understood the text and read it from a 2-meter distance. The person first read the "December 8" and quickly mentioned Our Lady of Conception's Day. The facilitator chose to use "Mother's Day" as the description for this day. Both are correct, and it was very interesting to see how fast and well the person read and understood the date.
Caregiver is out and will be back in 45 minutes, dementia-affected person is entertained watching Christmas-related slides	Entertainment slides comprehension	-	The person understood the image well, referring the Christmas crib and Santa Claus.
	Does the dementia-affected person	-	Yes.

	still understand the information related to the caregiver?		
--	--	--	--

11.5.3 Results of Person 3

Table 33 – Results of Person 3.

Test no.	3		
Dementia-affected person:	AP3		
Place description:	In a small and quiet room, the person sat in a chair facing the wall where the TV paper prototype was placed. A formal caregiver was present and helped.		
Scenario	Information to test	Dementia-affected person's commentaries	Notes
Caregiver is out and will be back in 45 minutes	Caregiver's activity comprehension	-	At first the person did not see quite well. The formal caregiver understood this situation and moved the person closer to about a meter from the wall. After this, the person fully understood the caregiver's activity and read the text without problems.
	Caregiver's activity-related imagery comprehension	"Who is that? I do not know... Oh, it is my daughter!", "That is Bonfim's church."	The person did not recognize the daughter at first, but the formal caregiver's questions regarding the daughter's hair, face, etc, led to the person recognizing who was represented. The represented church was incorrectly labeled in its locality (Bonfim instead of Antas), however the cross helped in immediately identifying that the person was in fact looking at a church. The clock was confused with a half-moon at first.
	Message bar comprehension	-	The text was correctly and easily read from the nearer distance.
Caregiver is out and will be back in 45 minutes, dementia-affected person	Entertainment slides comprehension	-	Neither Santa Claus nor Jesus was correctly identified. The pictures

is entertained watching Christmas-related slides			had to be brought to the person's hand to be recognized. The advanced stage of AD that this person had made it very difficult to discern all the pictures' colours from a distance.
	Does the dementia-affected person still understand the information related to the caregiver?	-	Yes.

11.5.4 Results of Person 5

Table 34 – Results of Person 5.

Test no.	4		
Dementia-affected person:	AP5		
Place description:	In a small and quiet room, the person sat in a chair facing the wall where the TV paper prototype was placed.		
Scenario	Information to test	Dementia-affected person's commentaries	Notes
Caregiver is out and will be back in 45 minutes	Caregiver's activity comprehension	-	The person fully understood the caregiver's activity and read the text without problems from about a 2-meter distance.
	Caregiver's activity-related imagery comprehension	-	All images were understood with the exception of the clock. At first, the person associated the green part as being a total of what was bought in the supermarket (this happened from association of the shopping cart in the activity image). However, after a few aids, the person understood the clock - one of the things that helped most for that was the presence of the numbers in the clock.
	Message bar comprehension	-	The person fully understood the message bar information and read it without problems from about a 2-meter distance.
Caregiver is out and will be back in 45 minutes, dementia-	Entertainment slides comprehension	-	The two slides were perfectly understood.

affected person is entertained watching Christmas-related slides			
	Does the dementia-affected person still understand the information related to the caregiver?	-	Yes.

11.5.5 Results of Person 6

Table 35 – Results of Person 6.

Test no.	5		
Dementia-affected person:	AP6		
Place description:	In a small and quiet room, the person sat in a chair facing the wall where the TV paper prototype was placed. A formal caregiver was present and helped.		
Scenario	Information to test	Dementia-affected person's commentaries	Notes
Caregiver is out and will be back in 45 minutes	Caregiver's activity comprehension	-	At first the person could not really read very well. The formal caregiver placed the person closer to the wall, at about 1-meter distance. After that, the person could read perfectly.
	Caregiver's activity-related imagery comprehension	"It is me!... No, it is my daughter! She is so beautiful!"	Since at first the person was a bit far and the pictures were already on the wall, the person only saw the daughter after being placed in a closer position. The person confused the hospital picture with a palace. Regarding the clock, the person identified it as both the sun and the letter "o". Even with help, it was very difficult for the person to see a clock there. The formal caregiver explained that the advanced stage of AD made it very difficult for this person to understand the icon.
	Message bar comprehension	-	The person could read the text perfectly but it was difficult to understand the time.
Caregiver is out and will be back in 45 minutes, dementia-affected person is entertained watching Christmas-related slides	Entertainment slides comprehension	-	The person understood the slide with the Christmas crib, but could not identify Santa Claus very well.
	Does the	-	Yes, but only as far as it

	dementia-affected person still understand the information related to the caregiver?		was understood before.
--	---	--	------------------------

11.6 Server – Tablet API example

SERVER: 192.168.30.13

PORT: 1338

#####

MessageBar

#####

http://192.168.30.13:1338/messagebar.json

POST

application/json

Example:

```
{
  "messagebar": {
    "message": "Renato",
    "show_date": false,
    "show_message": true,
    "show_messagebar": false,
    "show_time": true
  }
}
```

#####

Entertainment

#####

http://192.168.30.13:1338/entertainment.json

POST

application/json

Example:

```
{
  "entertainment": {
    "entertainment_id": 10,
    "entertainment_type": "video",
    "status": true,
  }
}
```

#####

Information

#####

While the others are JSON this is to be posted as a multipart/form-data.

http://192.168.30.13:1338/information

POST

Header: Content-Type

Header-value: multipart/form-data

Param Key: text

Value:

Param Key: activity_duration	Value:
Param Key: icon	Value: (integer)
File Key: caregiver_tv_picture	Value:
File Key: activity_tv_picture	Value:

11.7 Server – Google TV API example

SERVER: 192.168.30.13

PORT: 1338

```
#####
```

```
## TVs ##
```

```
#####
```

- To register a Google TV
- Has two fields: IP and STATUS (true or false)

<http://192.168.30.13:1338/tv.json>

POST

application/json

Example JSON to register a TV:

```
{  
  "tv": {  
    "ip": "192.168.1.1",  
    "status": true  
  }  
}
```

- To deactivate a TV send to:

<http://192.168.30.13:1338/tv/update.json>

PUT

application/json

Example JSON to deactivate a TV:

```
{
  "tv": {
    "ip": "192.168.1.1",
    "status": false
  }
}
```

#####

MessageBar

#####

- Server sends a socket message to GoogleTV_IP:1337 with the text 'UPDATE MESSAGEBAR'

- Google TV makes a request to receive the last update to:

<http://192.168.30.13:1338/messagebar/last.json>

GET

application/json

Example JSON output:

```
{
  "show_messagebar" : false,
  "id" : 5,
```

```
"created_at" : "2011-11-30T19:28:09Z",
"show_time" : true,
"message" : "Renato22222",
"show_message" : true,
"show_date" : false,
"updated_at" : "2011-11-30T19:28:09Z"
}
```

```
#####
## Entertainment ##
#####
```

- Server sends a socket message to GoogleTV_IP:1337 with the text 'UPDATE ENTERTAINMENT'
- Google TV makes a request to receive the last update to:

<http://192.168.30.13:1338/entertainment/last.json>

GET

application/json

Example JSON output:

```
{
  "status" : true,
  "id" : 8,
  "created_at" : "2011-11-29T17:31:01Z",
  "entertainment_id" : 23,
```

```
"updated_at" : "2011-11-29T17:31:01Z",  
"entertainment_type" : "photo"  
}
```

```
#####
```

```
## Information ##
```

```
#####
```

- Server sends a socket message to GoogleTV_IP:1337 with the text 'UPDATE INFORMATION'

- Google TV makes a request to receive the last update to:

<http://192.168.30.13:1338/information/last.json>

GET

application/json

Example JSON output:

```
{  
  "caregiver_tv_picture" : "/uploads/eu_colorshift.jpg",  
  "activity_tv_picture" : "/uploads/eu_contraste_145px.jpg",  
  "created_at" : "2011-11-30T20:37:20Z",  
  "id" : 14,  
  "activity_duration" : "10 minutos",  
  "text" : "Renato",  
  "updated_at" : "2011-11-30T20:37:20Z"  
  "icon": 3
```

}

- Append server's IP and port address to images URL

11.8 Second round of usability tests – Protocol

The protocol used in this round of usability is the same as the one found in appendix 11.2, with the following additional tasks:

11.8.1 Tasks

11.8.1.1 Task 10

OK! Now, let us add a task to the “To-do”.

Add the task “Buy eggs” to the to-do list.

11.8.1.2 Task 11

We are almost finished! Add an event to the calendar.

In the calendar, say that the 25th of December is Christmas.

11.8.1.3 Task 12

Excellent! Let us wrap up now. Add a message to the forum.

Let us write in the forum that the dementia-affected person loves watching “O Pátio das Cantigas”.

11.9 Second round of usability tests – Participants’ Task Results

11.9.1.1 Tasks’ Legend

Since the results from the first round of tests led to the change of some options, it is important to display the things that were altered.

Table 36 – Tasks’ legend.

Task 2 - User Interface options		
Abbreviation	Portuguese	English
[AT]	Atividade	Activity

Task 3 - Screens		
Abbreviation	Portuguese	English
POPCCS	Pop-up "Cuidador confirmado com sucesso!"	Pop-up "Caretaker confirmed successfully!"
POPACS	Pop-up "Atividade confirmada com sucesso!"	Pop-up "Activity confirmed successfully!"
POPDACS	Pop-up "Duração da Atividade confirmada com sucesso!"	Pop-up "Activity Duration confirmed successfully!"

Task 3 - User Interface options		
Abbreviation	Portuguese	English
[CU]	Cuidador	Caretaker
[CONF]	Confirmar	Confirm
[AT]	Atividade	Activity
[DUAT]	Duração da Atividade	Activity Duration

Task 4 - Screens		
Abbreviation	Portuguese	English
POPMCS	Pop-up "Mensagem confirmada com sucesso!"	Pop-up "Message confirmed successfully!"

Task 4 - User Interface options		
Abbreviation	Portuguese	English
[CONF]	Confirmar	Confirm

Task 7 - User Interface options		
Abbreviation	Portuguese	English
[GUDEF]	Guardar Definições	Save Settings

Task 8 - User Interface options		
Abbreviation	Portuguese	English
[GUDEF]	Guardar Definições	Save Settings

Task 9 - User Interface options		
Abbreviation	Portuguese	English
[GUDEF]	Guardar Definições	Save Settings

Task 10 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
LAF	Lista A Fazer	To-do List
LAF2	Lista A Fazer (2)	To-do List (2)
LAF3	Lista A Fazer (3)	To-do List (3)

Task 10 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[AF]	A Fazer	To-do
[+]	Adicionar Tarefa	Add Task
[ENTER]	Enter (tecla do teclado)	Enter (keyboard key)

Task 11 - Screens		
-------------------	--	--

Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
C	Calendário	Calendar
AE	Adicionar Evento	Add Event
REA	Resumo do Evento Adicionado	Overview of Added Event

Task 11 - User Interface options		
[MW]	mobileWAY	mobileWAY
[C]	Calendário	Calendar
[+]	Adicionar Evento	Add Event
[GU]	Guardar Evento	Save Event

Task 12 - Screens		
Abbreviation	Portuguese	English
HA	Home Android	Android Home
EI	Ecrã Inicial	Initial Screen
F	Fórum	Forum
EM	Escrever Mensagem	Write Post
F2	Fórum (2)	Forum (2)

Task 12 - User Interface options		
Abbreviation	Portuguese	English
[MW]	mobileWAY	mobileWAY
[F]	Fórum	Forum
[LAPIS]	Ícone de um lápis que permite Adicionar Mensagem	Pencil icon that allows to Post Message
[AM]	Adicionar Mensagem	Post

11.9.1.2 Results of Participant 1

Table 37 – Results of Participant 1.

Participant:	C1
Takes care of:	-
Kinship:	-

Task no.	1
----------	---

Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		At first, the participant forgot to save.
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	0		
3	ALA	[EAT]	1		The participant tried to add a new activity first.
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0	"It would be nice to have an option to edit the picture on the option bar."	Editing the picture was not explicit. Adding an indicator such as a pencil on the image could help in this case.
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	1		At first, the participant did not save the information and selected "Cancel". This also led to loss of information. It would be a good

					idea to either save the information in this case or tell the user that information was not saved.
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[CU]	0		
3	ALC	[ANA]	0		
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		
6	EI	[AT]	0		
7	ALA	[EAT]	0		
8	ALA2	[CONF]	0		
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPDAACS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		

9	POPMCS	[OK]	0		
10	POPATV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	2		The participant tried to use the "Activity Duration" option followed by touching the icon on the TV screen fragment.
3	D	[UIR]	0		
4	D2	[GUDEF]	0		

5	EI2	-	0		
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Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[LAF]	0		
3	LAF	[+]	0		
4	LAF2	[writes task] [ENTER]	0	"I wrote it but it was not possible to add it." "Something is missing to add it."	The information is added by using the "Enter" option, however this was not clear to the participant.
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[C]	0		

3	C	[+]	2		The participant got a bit lost on the interface.
4	AE	[writes and chooses appropriate information] [GU]	0		The participant forgot to input information in the event's title. The Google Calendar's interface is not very clear nor intuitive.
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		
3	F	[LAPIS]	0		
4	EM	[writes message] [AM]	0	"It is thinking, I cannot do anything..."; "Oh, it is working now."	The interface loaded for a bit.
5	F2	-	0		

11.9.1.3 Results of Participant 2

Table 38 – Results of Participant 2.

Participant:	C2
Takes care of:	-
Kinship:	-

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		

8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	1		The participant touched on the "To-do" option first.
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	1		The participant first selected "Delete", then after a while understood how to change the picture (it was not clear at first).
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[CU]	0		
3	ALC	[ANA]	0		
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		
6	EI	[AT]	0		
7	ALA	[EAT]	0		

8	ALA2	[CONF]	0		The participant forgot to confirm the activity at first.
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPACS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		
9	POPACS	[OK]	0		
10	POPATV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
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Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	1		First, the participant went to the "Activity Duration" option.
3	D	[UIR]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[LAF]	0		
3	LAF	[+]	0		
4	LAF2	[writes task] [ENTER]	0		The participant did not know how to save.
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[C]	0		
3	C	[+]	0		
4	AE	[writes and chooses appropriate information] [GU]	0		
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		
3	F	[LAPIS]	0		
4	EM	[writes message] [AM]	0		
5	F2	-	0		

11.9.1.4 Results of Participant 3

Table 39 – Results of Participant 3.

Participant:	C3
Takes care of:	-
Kinship:	-

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0	"What if I want to delete the picture?"	
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	1		At first, the "To-do" functionality was accessed.
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[CU]	0		
3	ALC	[ANA]	0		
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		

6	EI	[AT]	0		
7	ALA	[EAT]	0		
8	ALA2	[CONF]	0		
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPDACS	[OK]	0		
14	POPAITV	[OK]	0		
15	EI2	-	0		

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		
9	POPMCS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
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Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	1		The participant accessed the "Activity Duration" option first.
3	D	[UIR]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[LAF]	0		
3	LAF	[+]	0		
4	LAF2	[writes task] [ENTER]	0		The participant took a bit before pressing "Enter".
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[C]	0		
3	C	[+]	0		
4	AE	[writes and chooses appropriate information] [GU]	0		
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		
3	F	[LAPIS]	0		
4	EM	[writes message] [AM]	1		The participant did not know how to post the message, however by attempting again the operation was successful.
5	F2	-	0		

11.9.1.5 Results of Participant 4

Table 40 – Results of Participant 4.

Participant:	C4
Takes care of:	-
Kinship:	-

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	1		The participant forgot to take the picture before saving.
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	1		The participant went to the "To-do" option first.
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3
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Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[CU]	0		
3	ALC	[ANA]	0		
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		
6	EI	[AT]	0		
7	ALA	[EAT]	0		
8	ALA2	[CONF]	0		
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPDACS	[OK]	0		
14	POPATIV	[OK]	0		
15	EI2	-	0		General note: the participant showed some problems in distinguishing between adding and confirming a resource.

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		
9	POPMCS	[OK]	0		
10	POPATIV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes

1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0	"Nothing is playing."	There was a delay before the tablet played the entertainment on the TV and reported success.
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[UIR]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0	"I am not sure if "entertainment" does what I want as it is not only videos, pictures and slides."	The term "entertainment" is broad and can cause confusion.
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[LAF]	0		
3	LAF	[+]	0		
4	LAF2	[writes task] [ENTER]	0	"There is no "Save" button."	
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[C]	0		
3	C	[+]	0		
4	AE	[writes and chooses appropriate information] [GU]	0		
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		

3	F	[LAPIS]	0		
4	EM	[writes message] [AM]	0	"This is too slow, it is not working."	The interface loaded for a bit while displaying the options.
5	F2	-	0		

11.9.1.6 Results of Participant 5

Table 41 – Results of Participant 5.

Participant:	C5
Takes care of:	-
Kinship:	-

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	0		
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	0		
3	ALA	[EAT]	0		
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		

10	ALA3	-	0		
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Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0	"How do I put this on the TV?"	
2	EI	[CU]	0		
3	ALC	[ANA]	0		
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		
6	EI	[AT]	0		
7	ALA	[EAT]	0		
8	ALA2	[CONF]	0		
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		At first, the participant forgot to confirm the activity duration.
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPDACS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0	"Having to define caregiver, activity and activity duration, nothing shows that things are selected."	

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		The participant thought that there was this field in which a name would be written but after this

					another field would appear where a message description could be written.
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		
9	POPMCS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0	"Play on the tablet or on the TV?"	
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		

2	EI	[DEF]	1		The participant first tried to use the icon on the TV screen fragment.
3	D	[UIR]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		The participant took some time to find the option; the option being inside the "Message Bar" options group did not make much sense.
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		

2	EI	[LAF]	0		
3	LAF	[+]	0		
4	LAF2	[writes task] [ENTER]	0		
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[C]	0		
3	C	[+]	0		
4	AE	[writes and chooses appropriate information] [GU]	0		
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		
3	F	[LAPIS]	0		
4	EM	[writes message] [AM]	0		The participant did not know where to start writing; no keyboard or cursor appeared, circles drop-down box kept loading and could not be accessed (bug).
5	F2	-	0		

11.9.1.7 Results of Participant 6

Table 42 – Results of Participant 6.

Participant:	C6
Takes care of:	-
Kinship:	-

Task no.	1				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADCU]	0		
3	AC	[INA]	0		
4	INC	(writes name) [GU]	0		
5	AC	[AFA]	1		The participant tried to save the resource without selecting a picture.
6	EF	[TIFO]	0		
7	TF	[TIFO]	0		
8	TF2	[GU]	0		
9	AC	[GU]	0		
10	POPCAS	[OK]	0		
11	ALC	-	0		

Task no.	2				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[AT]	0		
3	ALA	[EAT]	1		The participant selected "Add Activity".
4	ALA2	[COAT]	0		
5	CA	[FOAT]	0		
6	EF	[BIBFO]	0		
7	BF	[NIA]	0		
8	CA	[GC]	0		
9	POPACS	[OK]	0		
10	ALA3	-	0		

Task no.	3				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[CU]	0		
3	ALC	[ANA]	0	"How to define as caregiver?"; "Add and define are weird concepts."	
4	ALC2	[CONF]	0		
5	POPCCS	[OK]	0		
6	EI	[AT]	0		
7	ALA	[EAT]	0		
8	ALA2	[CONF]	0		
9	POPACS	[OK]	0		
10	EI	[DUAT]	0		
11	ALDA	[2HO]	0		
12	ALDA2	[CONF]	0		
13	POPDACS	[OK]	0		
14	POPATV	[OK]	0		
15	EI2	-	0		General note: across the test, the participant said various times that resources had to be defined without actually doing it (the participant was thinking).

Task no.	4				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ADME]	0		
3	AM	[INMA]	0		
4	INM	(writes name) [GU]	0		
5	AM	[GU]	0		
6	POPMAS	[OK]	0		
7	ALM	[DDM]	0		
8	ALM2	[CONF]	0		

9	POPMCS	[OK]	0		
10	POPAITV	[OK]	0		
11	EI2	-	0		

Task no.	5				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[SEEN]	0		
3	SE	[SEVI]	0		
4	SV	[OPDC]	0		
5	SV2	[SEL]	0		
6	POPVSS	[OK]	0		
7	EI2	-	0		

Task no.	6				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[ALEN]	0		
3	SE	[SESL]	0		
4	SS	[ANF]	0		
5	SS2	[SEL]	0		
6	POPPVSS	[OK]	0		
7	EI2	-	0		

Task no.	7				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	1		First the participant defined the activity duration using the option with the same name.
3	D	[UIR]	0		The participant touched on the clock, was not sure if it was saved, and after that

					used the "Save Settings" option.
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	8				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MBM]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	9				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[DEF]	0		
3	D	[MAE]	0		
4	D2	[GUDEF]	0		
5	EI2	-	0		

Task no.	10				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[LAF]	0	"Is it To-do?"	
3	LAF	[+]	0		It was necessary for the facilitator to touch the "+" option.
4	LAF2	[writes task] [ENTER]	0		
5	LAF3	-	0		

Task no.	11				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		

2	EI	[C]	0		
3	C	[+]	0		The "+" was not immediately understood.
4	AE	[writes and chooses appropriate information] [GU]	0		There were problems in understanding how to save.
5	REA	-	0		

Task no.	12				
Screen number	Screen designation	Selected option	Number of errors	Participant's commentaries	Notes
1	HA	[MW]	0		
2	EI	[F]	0		
3	F	[LAPIS]	1		The participant first used the "Add people to circles" option and did not know how to post. Then the participant understood it.
4	EM	[writes message] [AM]	0		
5	F2	-	0		

11.10 Second round of usability tests – Participants' Questionnaire Results

11.10.1 Participant 1

Table 43 – Questionnaire results of Participant 1.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	b
Q5	a
Q6	b
Q7	b
Q8	b
Q9	a
Q10	b
Q11	b
Q12	1) Touch screen interface; 2) Possibility of adding videos, pictures and music; 3) Possibility of adding reminders.
Q13	The colours.
Q14	1) Colours should be more appealing; 2) Instead of "To-do", use "Don't Forget"; 3) The tasks list; 4) Add logical games to the TV; 5) Place a background image on the TV allusive to the current season of the year, for example.

11.10.2 Participant 2

Table 44 – Questionnaire results of Participant 2.

Question	Answer
Q1	b
Q2	a
Q3	b
Q4	b
Q5	a
Q6	a
Q7	c
Q8	a
Q9	a
Q10	a
Q11	a
Q12	The interconnection with the TV and the clear language and enlightening symbols.

Q13	1) Interface blocks; 2) Differences between the application and the forum; 3) Differences between the application and the calendar.
Q14	1) Response time; 2) Calendar and forum like the rest of the application.

11.10.3 Participant 3

Table 45 – Questionnaire results of Participant 3.

Question	Answer
Q1	a
Q2	a
Q3	b
Q4	b
Q5	a
Q6	a
Q7	a
Q8	a
Q9	a
Q10	a
Q11	b
Q12	1) Pleasant interface; 2) Available functionalities; 3) The possibility of entertaining the dementia-affected person.
Q13	1) To-do and forum interfaces - less intuitive and small size; 2) Could not delete the taken picture.
Q14	1) Response time; 2) Confirmation pop-up of "information sent to TV" takes some time; 3) Customise the Google's services interfaces.

11.10.4 Participant 4

Table 46 – Questionnaire results of Participant 4.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	c
Q5	c
Q6	c
Q7	d
Q8	c
Q9	c
Q10	c
Q11	d

Q12	The caregiver having the possibility of sending messages to the dementia-affected person's TV.
Q13	-
Q14	-

11.10.5 Participant 5

Table 47 – Questionnaire results of Participant 5.

Question	Answer
Q1	c
Q2	c
Q3	c
Q4	b
Q5	b
Q6	b
Q7	b
Q8	b
Q9	b
Q10	b
Q11	c
Q12	1) The ability to leave messages to the dementia-affected person; 2) Share the calendar with the whole family.
Q13	1) Information organisation; 2) Layout structure; 3) I did not understand the division between the second content group (vertical) and the horizontal bar (at the bottom).
Q14	1) Explaining of the necessary steps to "publish" information on the TV; 2) Calendar, forum... The Google's applications usage does not work very well.

11.10.6 Participant 6

Table 48 – Questionnaire results of Participant 6.

Question	Answer
Q1	b
Q2	b
Q3	b
Q4	b
Q5	a
Q6	a
Q7	b
Q8	b
Q9	a
Q10	a

Q11	c
Q12	Simplicity of the big and visible buttons.
Q13	Google's applications' buttons were too small.
Q14	-