Medication Dispenser - Therapy Management

David Jorge Marques Nogueira
david.nogueira@ist.utl.pt

Instituto Superior Técnico, Lisbon, Portugal

June 2015

Abstract

Associated with the increasing average life expectancy, it has been observed that more and more cases of people with memory loss have been found, either because of natural reasons or due to illness. Another problem related to the aging population is the increasing need to take medication. In this context, the main objective of this thesis is the design and development of an application for mobile devices that interacts with different systems, including an electronic medication dispenser and an online portal, allowing close monitoring of medication taken and monitoring of other health aspects of the assisted person. The medication dispenser stores medication doses that are only available in preconfigured times and record all interactions with it. Through the online portal one can share information without constraints of location and time. Using the mobile application it is possible to collect information from different systems as well as introduce information manually, such as medication to be administered, future examinations, recorded blood pressure values, among others. The developed application allows the control of how medication is taken and collects information on the health status of the assisted person, enabling the creation and sharing of his health history. In order to validate and test the features of the mobile application, we also developed an application that simulates an electronic medication dispenser and a simple web server that allows consultation of all exported information.
Keywords: Therapy Management Application, Health History, Electronic Medication Dispenser, Mobile Application

1. Introduction

One of the major problems in the current society is the continuous aging of the population. It is necessary to increase the quality of life of older people and allow them to live independently in their homes. This need has led to the completion of multiple research and development of systems to support the concept of Aging at Home [10]. This concept is based on the development of solutions that enable the elderly live at home, the more independent as possible, without compromising health and privacy of the person in question, through the activities of monitoring [8].

The aim of this work is the development of a solution that allows the control and strict monitoring of a person's health, through the collection and processing of information of the assisted person's health and sharing this information with existing systems. It is intended that this solution will be used by people without a specific qualification and should have an acquisition cost as low as possible, taking advantage of existing technologies.

We must point out that this solution will be developed in such a way that it is allowed to add, remove or update features, without requiring large architectural changes. Given the way in which the solution will be designed, it will be possible to integrate it with other systems, complementing the information collected about the assisted person.

In order to fulfill the objectives set out above, the solution must have three key capabilities:

- **Medication control:** using a mobile application to define when the assisted person should be taking the medication; this application interacts with an electronic medication dispenser, setting it up and collecting information about the interactions that occurred with it and the assisted person;
- **Creation of a personal health record:** through the use of a mobile application that allows the collection and processing of information about the assisted person's health;
- **Sharing information:** ability to share information with different systems, such as an online portal, without any problems of compatibility of types of information.

Given the technology available today, it makes sense that the application responsible for the management of health care is a mobile application,

more specifically an application for smartphones or tablets. With this application it is possible to collect and process information coming from different systems, or even inserted manually, so that an health history of the assisted person is generated. This history can be shared with other systems without any information compatibility constraints In order for this to happen the information will be in an open format such as, for example, XML.

In order to demonstrate the functionality of the mobile application, two auxiliary systems will be developed: an application that simulates an electronic medication dispenser and an online portal.

An electronic medication dispenser allows the control and distribution of medicines in home environments. Although there are some solutions related to the medication administration, none of them have the mechanisms that we want to offer with this proposal. The main objective for this dispenser is to be present in the home of people who may have memory loss or in initial states of dementia.

In general, the proposed solution consists of three systems that interact with each other, being the AMapp the central element of this work:

- **AMapp - Android Aplication:** an application developed for mobile devices, smartphones or tablets, with Android operating system. Using this application allows configuration and information's collection from the electronic medication dispenser. It is possible to complement the information collected in order to be processed and made available, in the form of health history, at an online portal;

- **AM - Electronic Medication Dispenser:** development of an application that simulates an electronics dispenser where medication is stored. The main AM's objective is to avoid excessive intake of medication and the registration of interactions made by its users for future processing;

- **AMonline - Online Portal:** development of a simplified version of an online portal that provides its users with information supplied by AMapp, in particular the assisted person's health history.

Below are outlined some existing solutions, followed by the solution developed, which will be evaluated and finally outlined conclusions.

2. Related Work

In this chapter solutions and products relevant to the context of this thesis are reviewed. Despite being a relatively recent scope of study, there is already a considerable number of systems that promote health care.

2.1. ILSA Solution

The ILSA's solution ("Independent LifeStyle Assistant") allows an increase in the quality of life of older people living in their homes by reducing the dependence of healthcare providers [9]. This solution is composed by a set of monitoring systems that, through the data obtained, understands and adapts, automatically, their functions of the life's style of the assisted person [9].

For this monitoring, the installation of sensors throughout the house of the assisted person is required. These sensors send stimuli, received in a central controller - Home Controller - which in turn uses a Wi-Fi wireless connection to send all the information collected to a server that will make its processing - ILSA Server.

The information present in ILSA's servers, can only be accessed by ILSA's health care providers. In case of being detected any malfunction, these health professionals warn the assisted person, through a telephone call.

For this solution complementary systems are required, including a system that provides Internet access through a Wi-Fi module. With the use of this module it is possible to send information between the Home Controller, which stores information locally, and the ILSA Server, where the information collected is stored persistently. Given that the only way that this solution to send and process information depends on a Wi-Fi connection, then if it does not exist, it wouldn't be able to collect, process and store the information about the assisted person.

2.2. Philips Medication Dispenser

The PMD service ("Philips Medication Dispenser") is presented as a solution that allows the scheduling and administration of complex medication. The purpose of this service is to prevent the occurrence of lapses like not taking medication [7]. This solution was designed with a focus on people with chronic diseases, that need to take multiple medication, which have loss of cognitive ability and mobility problems. This service consists of an automatic medication dispenser PMDS ("Philips Medication Dispenser System") which is complemented by Philips Lifeline's customer service.

The PDMS was designed to accommodate up to 60 doses of medication, allowing doses to be stored for a maximum period of 40 days. Every day the assisted person can take up to six doses of medication. The dispenser allows the definition of periods for taking medication, the creation of audible alerts describing how it should be made. The PDMS was designed taking into account that there is a constant connection to the telephone network. It is possible

to use the PDMS without a telephone connection, abdicating and limiting of many of its features.

2.3. PharmAssistant Solution

PharmAssistant is a solution designed to prevent failure of non taking the medication or food supplements [3]. This solution has as a target audience people with lives quite active, and can be used by any person regardless of their age. This solution is composed of an application for smartphones - PharmAssistant - and one or more SmartBottle [5].

A SmartBottle consists of a portable case for transport of medicines of a single type. The major innovation is that the cover of this portable case has a mini battery, a Bluetooth module, one led, a device audio player and a cover open sensor [6].

The SmartBottle should be constantly connected with the smartphone which has the application PharmAssistent, through a Bluetooth connection. When it's time to take a certain medication, the application sends a signal to the respective SmartBottle. This bottle will produce a beep and turn on a light until it is open or when the period of taking medication expires [4]. When the SmartBottle is open, this sends a monitoring signal back to the application, allowing family members or health care professionals to realize that the assisted person has not taken his medicine on time.

2.4. E-Pill MedSmart Plus System

The medication dispenser MD2 (MedSmart Plus) is one of several solutions presented by company E-Pill for the control of taking medication. This device is designed for people with problems in controlling complex medications or the ability to manage their own medication. The MD2 can be defined as portable medication dispenser that alerts and offers correct doses of medication to the assisted person [2].

Comparing to the previously systems developed by E-Pill, the MD2 has two new features that makes it one of the best branded solutions: it is a portable system, being able to use this dispenser without requiring a constant connection to the electricity grid; it allows the sharing of information between the MD2 and other systems, in particular mobile communications devices. With this information sharing, it's possible to alert an heath care provider for the occurrence of anomalies.

The MD2 has a small screen and a limited set of buttons that allows to make configurations. One of possible commands to run is to take medication before the defined time. In order to avoid excessive intake of medication, this command can only be executed once until the MD2 is reconfigured.

A major innovation of this system is the possibility to monitor the assisted person remotely, although in a limited way [1]. If she is not taking a particular medication or if necessary refill the MD2, the health care provider responsible for the assisted person receives a call, an email or a SMS as a means of notification.

3. Solution Requirements and Architecture

This chapter begins to define systematically the most important requirements of the solution that we want to implement. Then it presents a global architecture solution that includes three variants.

3.1. Solution Requirements

Given that the solution to develop supports three variants, it will be necessary that the systems that compose the solution to be able to pass between them.

3.1.1 AMapp - Mobile Application

Next we present a set of key requirements for the application AMapp

- Manage multiple people and multiple AMs;
- Run on a mobile device, like a smartphone or tablet, with Android operating system;
- Use the Wi-Fi Direct module and access to the Internet;
- Offer mobile communication that supports the reception of SMS messages;
- Allows consulting and sharing the information gathered.

3.1.2 AM - Electronic Medication Dispenser

As there is no physical AM available, we will develop an application that will simulate the expected AM's behavior. Next we present a set of key requirements for the desired operation of the AM.

- Control medication taking;
- Receive configurations;
- Integration with a Wi-Fi Direct module;
- Optional integration of a GSM's module that supports the sending of SMS messages;
- Support integration with AMapp and AMonline.

3.1.3 AMonline - Online Portal

A set of key requirements for the AMonline is presented next.

- Save information about several people;
- Allow consult multiple people's information;
- Perform information processing.

3.2. Global Architecture

The solution takes into account possible limitations of the target people for this work, considering the ease of access to the Internet, monetary conditions and geographical location, as well as the level of independence of the assisted person.

3.2.1 Solution without Internet Access

The first variant of the solution assumes that the AM does not have a permanent access to the Internet, delegating responsibility to AMapp regarding the collection and sharing of information.

This variant has as target people who are able to live independently in their homes, giving them the responsibility to take control of their own health, as well as enable them to use their own resources to alert to the occurrence of abnormal situations or emergencies. Thus is allowed the AM to have a smaller number of features and associated components, reducing it's exploration costs. Figure 1 illustrates the architecture of this variant, which is described below.

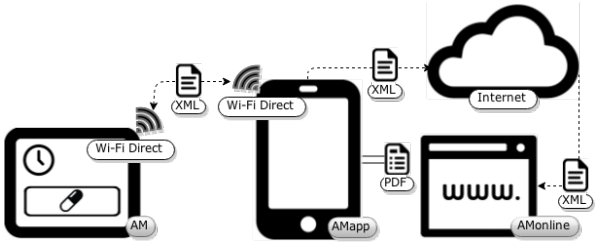

Figure 1: System's architecture for situations without permanent access to the Internet.

Interactions Between Components

In this variant the AM is devoid to any type of internet access. This restriction means that the only way to access the AM will be performed using the application AMapp.

For that, a wireless communication channel between these two systems is created, which will be necessary in AMapp, associating the assisted person with a profile. It is through this profile that the AMapp will be linked with the AM for further configuration and collection of information. AMapp's user will need to enter the password to access a certain profile.

Immediately after the establishment of this communication's channel, the AMapp sends to the AM a request to collect information, in particular the registration of administered medication and accesses made by the assisted person to the dispenser. After these initial steps are finalized, AMapp's user can set up the dispenser. To create configurations will be necessary to resort to features present in AMapp.

As mentioned before, the AMapp will receive information about the interactions between the AM and the assisted person. This information should be stored locally, in smartphone's memory. It is possible to insert information manually in mobile application to complement the monitoring the assisted person.

It is possible to share the information present in AMapp with other systems, in particular with the portal AMonline. For being able to share information with this portal, will be necessary for the AMapp's user to have an internet access.

When the AMapp's user executes the command to share all the information associated with a given profile, three events will be triggered:

1) All information associated with the profile of the concerned person will be processed, thus created or updated, in memory of smartphone, the health history of the same;

2) An XML file with the entire health history and sent to the server where the AMonline will be housed will be created. If it is not possible to send the file to the server, this should be stored in the memory of smartphone for future sending;

3) A PDF file will be created, which should be stored locally in smartphone's memory, where the information will be displayed in an intuitive and organized way, allowing this file to be displayed or shared immediately.

To be able to access the information on the online portal, it will be necessary for the person wishing to view this information to be previously authorized for such.

Communication Channels

In this variant there is only need a single communication module type, in particular Wi-Fi Direct. With the integration of this module in the AM, it is intended that this will be able to communicate directly with AMapp and that can be carried over to the remaining variants without the need for integration of other components.

For the AMapp to be able to share information with the portal AMonline, internet access will be needed. This access can be achieved through the use of the communication module Wi-Fi Direct or another cellular data connection, because these forms of access to the Internet are available in most Android smartphones or tablets.

3.2.2 Solution without Internet access but with cellular mobile communication

This variant of the solution is similar to the earlier. However, it is considered that the AM has, in addition, a mobile communication module, we designate of GSM module. The existence of this module allows it to send SMS in situations considered relevant as, for example, not taking medication considered critical.

This variant is intended, primarily, to be used in remote and isolated places, where there is no possibility or ease of access to the Internet. In addition, can also be used when, for economic reasons, not if he wanted to incur the cost of hiring a service of permanent access to the Internet. However, the use of a communication module GSM entails, in addition to the cost of the module itself, the cost associated with the sending of SMS.

In this variant, when the AM detects an anomalous situation it sends a notification through SMS message to the AMapp. Given the characteristics of this service, the AMapp's user always receive this notification, allowing it to be possible a rapid intervention when the occurrence of this type of events.

Figure 2 illustrates the architecture of this variant, which is described below.

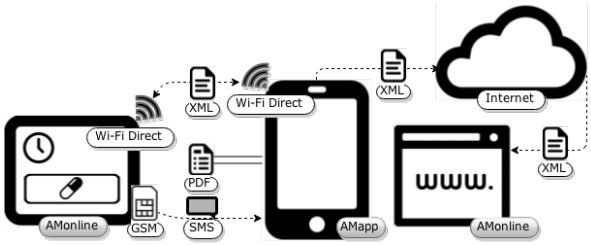

Figure 2: System's architecture for situations without permanent access to the Internet but with cellular mobile communication.

Interactions Between Components

The interactions between the components of this variant are equal to the interactions between the variant described earlier, highlighting only the use of the GSM module to send notifications.

As in the first variant, when the AM detects the occurrence of an anomaly, this records and stores it internally in the interaction's file. This file will be sent to AMapp when this performs a valid authentication with the dispenser.

In this second variant the AM, in addition to record only the occurrence of anomalies, sends an alert through SMS message to the AMapp. This control mechanism allows the AMapp's user to receive this information immediately. This message identifies the occurrence and may contain, for example, the name of the medication not taken

Communication Channels

This second solution uses the same communication channels as pointed in the first variant. The communication using the modules Wi-Fi Direct is still present in this variant.

As previously mentioned, in order to transit between the first to this one, it will be necessary that the AM supports a cellular mobile communication, specifically a GSM module or higher.

For that the AMapp receive SMS messages will be necessary that the device used has communication mobile. This is true for most smartphones is also easy to get tablets Android with this capacity.

3.3. Solution with Internet access

Unlike the other variants presented earlier, this variant assumes that the AM has permanent access to the Internet. As in previous variant, this variant also allows alert to the occurrence of anomalous situations, without the need for the AM include a GSM module.

This variant was designed so that you can take advantage of current technology and allows you to improve monitoring features offered in the previous solutions, particularly as regards the sharing of information.

In this variant the AM, to detect an anomaly, notifies directly the AMonline that will appeal to a service of sending an SMS to inform the AMapp of the occurrence.

Regarding the collection of information, in this variant the AMonline is not totally dependent on the AMapp for information gathering. As the AM has permanent access to the Internet, all the interactions it records are sent automatically to the AMonline.

Figure 3 illustrates the architecture of this variant, which is described below.

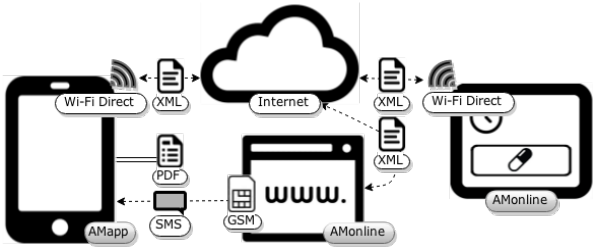

Figure 3: System's architecture for a solution with constant access to the Internet.

Interactions Between Components

Unlike the variants presented earlier, this variant assumes that the AM has permanent access to the Internet. As in previous variant, this variant also allows alert to the occurrence of anomalous situations, without the need for the AM include a GSM module.

This variant was designed so that you can take advantage of current technology and allows you to improve monitoring features offered in the previous solutions, particularly as regards the sharing of information.

In this variant the AM, to detect an anomaly, notifies directly the AMonline that will appeal to a service of sending an SMS to inform the AMapp of occurrence.

Regarding the collection of information, in this variant the AMonline is not totally dependent on the AMapp for information gathering. As the AM has permanent access to the Internet, all the interactions he recorded are sent automatically to the AMonline.

Communication Channels

This third solution uses the same communication channels as the second variant, continuing the use of Wi-Fi Direct modules as main form of communication.

In order to transition to this variant, will only be required to the AMonline support a service for sending SMS messages. For that to happen, it is sufficient to integrate a GSM module, or higher, or use a service for sending messages provided by external entities.

3.4. Information Formats

The proposed solution uses three types of formats for information's transport and sharing: XML, PDF and SMS.

Given the characteristics of the XML format, it is possible to share information without any compatibility problems between different systems. Another advantage of the use of this format is the ability to add information without compromising the normal functioning of the entire solution.

The PDF file allows the AMapp's user to view all the information associated with a profile formatted and organized. With this file the user can view immediately all the information, as well as share it by e-mail or just print it.

In addition to using the XML formats and PDF it will also be using SMS text messages. The content of these messages should be short and precise, allowing to quickly realize the anomaly. The SMS service allows a message to be always received. On the other hand, this service for sending text messages will work even in situations of weak signal or is temporarily unavailable.

4. Implementation

Taking into account the current technologies, it is possible to implement all three variants of the solution and comply with the requirements listed in the previous chapters.

4.1. AMapp - Android Application

This application is intended to smartphones or tablets, more specifically, for mobile devices with Android operating system, having as minimum version Jelly Bean (API version 16) and Lollipop (API version 21) as maximum version.

Most of the information present in AMapp is represented in textual form. All components of this layer follow the graphical style of one of themes packages made available by development tool Android (Android SDK), in particular the theme Light with DarkActionBar. This choice ensures that the information contained in the application, is available in the same way regardless of Android device used to run the application.

For the design of application AMapp has followed a layered architecture. Due to the requirements of the application and due to the characteristics of this architecture, it is possible to replace a given layer by another with a similar role without the need for major changes at the level of the entire application. The layers used in the development of the AMapp are: Presentation, Business, Services and Data.

4.1.1 Features

The features described here allow us to show the potential of the application. It's possible to add new features to the application as well as new data fields, since it would only need the replication of implemented methods of the features already available.

- Authentication mechanism;
- Define and send settings;

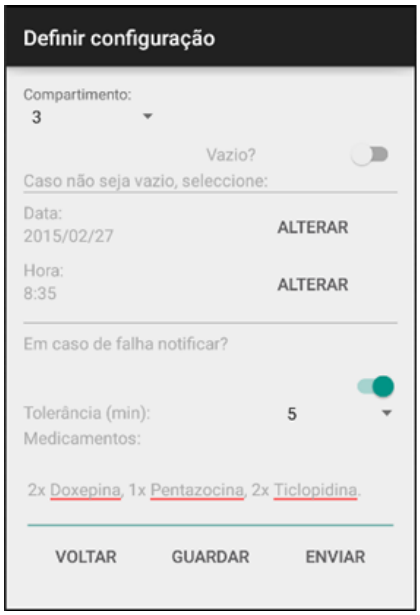

Figure 4: Menu Define configuration

- See registration of medication:
- Registration of blood pressure;
- Registration of observations;
- Creation and sharing of an health history.

4.2. AM - Electronic Medication Dispenser

As described previously, this dispenser will have various sensors, including ones that verify that a given slot is empty, if some kind of unauthorized access was tried, and if the compartment was opened. All of the above information must be recorded so that it can pass to AMapp. We should reinforce the fact that, at each instant, only one compartment will be accessible to the assisted person and this has the exact medication to take at a given time, previously defined.

In this work, we will simulate the behavior of this electronic medication dispenser, allowing us to demonstrated the AMapp's features. This will create a base that will simulate the stimulation of sensors described in such way that will be possible to see how AMapp will react.

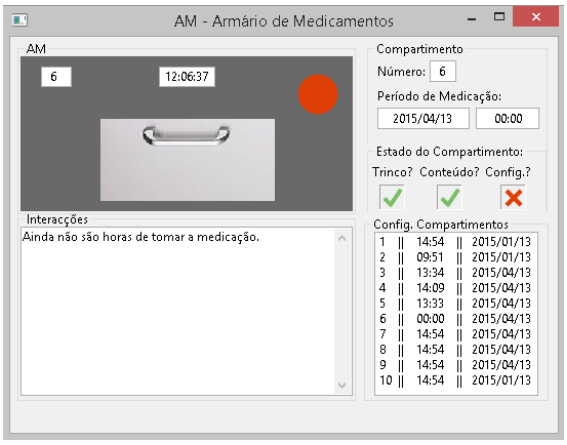

Figure 5: AM interface.

4.2.1 Presentation

As described above, the window of the AM presents two types of information: conceptual picture of the AM (on the left) and information on its internal functioning (on the right).

To obtain a graphical conceptualization of AM, was used the Java SWT 4.4 library, allowing the creation of simple interfaces, but very intuitive. The information that is displayed by the application created to simulate the AM, is divided into two groups: appearance and operation, the left and right of the application, respectively.

The whole rationale for AM's implementation is based on the state machine concept. The state machine which was designed allow the desired AM's behavior, has five different states: **Hold**, awaiting the period for taking medication, being able to receive a new configuration or user's interactions; **Authorized**, allowing access to the compartment; **Not Authorized**. recording an attempt to unauthorized access to the compartment; **Anomaly**, was detected one continuous unauthorized access the compartment or the medication was not taken; **Configuration**, were a new configuration is received or the AM is being refilled.

4.2.2 Features

The features described here allow us to show the potential of an electronic medication dispenser that can interact with the application AMapp.

- Receive new settings;
- Provide medications;
- Signaling mechanisms;
- Control mechanisms;
- Registration and information sharing.

4.3. AMonline - Online Portal

This online portal allows us to view the health history of a particular person, through a prior authorization, without security, time or geographical constraints.

4.3.1 Presentation

OutSystem technology was used for the design of AMonline, allowing the creation of simple interfaces, modular and very intuitive. Although this technology is proprietary, which involved additional costs, but brings many benefits. These benefits highlights the speed of portal's construction and modification, available tools for manipulation of information, strong security mechanisms, as well as adapt the portal to different types of devices.

Figure 6: Portal AMonline.

4.3.2 Features

The features described here allow us to show the potentiality of the creation of an online portal for information sharing that can integrate with the application AMapp.

- Provide information;
- Real time update.

4.4. XML Files

As the primary format for the representation of information was used XML. Given how the information was structured, it's possible to add extra information, even if the current system does not use it.

It will be possible to integrate new systems to the presented solution without problems of information sharing.

In order to integrate this solution with other systems, the format of how the information is structured in a XML file should be well defined, using a fixed structure.

On the other hand, the structure's definition should take into account the resources of each system, in particular their processing power.

4.4.1 AM Configuration

The AM configuration file has a very straightforward structure. Each dose of medication (*tray_content*) is associated with an identifier, started by the term *tray_number*. This identifier allows the AM to be able to select the right medication. For each *tray_content* is provided information about the time, date, and constitution of the medication to be taken, as well as the period for taking the medication and, if the solution's variant allows, alert the responsible for the assisted person for an occurrence of a non-administrated medication.

4.4.2 AM Interaction's Record

In this registration file it is discriminated the type of interaction detected by AM, as well as information that allows to describes it. The solution developed only detects three interaction's types: medication taken, medication not taken (time expired) and attempted unauthorized access(violation).

4.4.3 Health History Generated by AMapp

This file contained all the information resulting from the monitoring of health associated with a given profile. The way the information is structured differs from the XML files previously shown. This decision was mainly due to the fact that facilitate the management of multiple profiles, as well as the application of search algorithms.

Each profile is associated with an identifier that allows the separation of information from different people, facilitating the registration of information associated with a particular person and an easy association of information between different systems. Each profile has four child nodes to form the group: personal information (*details*), the medication taken (*medicationTaken*) and not taken (*timeExpired*), records of blood pressure (*pressure*) and relevant observations (*notes*).

Given how he structured the information, it is possible to add new features to the AMapp without compromising the existing information. In terms of the structure of the XML file, a new feature will entail a new child node associated to all profiles.

5. Results

5.1. Characterize the respondent person

We found that of 122 respondents, most of them regularly check their health (72.1%), it was found that there is a concern to save all records of health monitoring (58.2%), as well as there is some concern in organizing them (22.1%).

5.2. Health control

As one would expect, the majority of respondents have a smartphone (96.4%) with operating system Android (73.7%). Most people think that an application to record all the information about the health check performed is very useful and needed (96.7%), as well as the sharing of such information with a health care professional (96.7%) or even with other entities (79.5%), like researchers.

5.3. Taking medication

The respondents were asked about the possibility of using an electronic medication dispenser, revealing a little unreceptive to the idea of using it as a method to control their own medication. However it was found that the majority of respondents (92.6%) have relatives who take medication, and of those respondents, the majority controls or would like to control the medication taken of their relatives (68.8%) using an automatic medication dispenser.

5.4. Sharing information

With the answers, we found that almost all of the respondents find extremely interesting if there is an information's repository that contains not only their entire health history (98.4%), as well as the health history of a family member (96.7%).

5.5. Final Balance

We found that the mean age was slightly lower than expected. In spite of this fact, we can conclude that these respondents already have the need to use a solution to monitor the health of a family member or even their own.

In addition to the features wanted by respondents, it was possible to realize that one of the main uses that respondents would give to this solution would be for information sharing, with a focus on making this with health professionals.

It was found that there is an acceptance almost unanimously of the solution developed in this thesis. With the data obtained, we may conclude that the designed solution is not only in accordance with the needs of the user, as well as it is prepared for future needs.

6. Conclusions

Associated with the aging of the population, it has been observed that more and more cases of people with memory loss exist, as well as the increasing

need to take medication. To tackle these problems we developed an integrated solution that would make it possible to control the taking of medicines, the management of other care and the creation and maintenance of a health history

With this work, we designed and developed of an application for mobile devices (AMapp) that interacts with different systems, in particular an electronics medication dispenser (AM) and an online portal (AMonline), thus allowing a strict control of the medication taking and monitoring of other assisted person's health, through the creation and sharing of their medical history.

In order to meet the needs of the target audience, it was necessary to develop three variants of this solution. The first variant assumes that the AM does not have a permanent access to the Internet, by delegating responsibility to AMapp regarding the collection and sharing of information. The second variant considers that the AM has, in addition, a mobile communication module, allowing it to send SMS messages notifying to relevant situations. The third variant assumes that the AM has a permanent access to the Internet, so it can be possible to alert for anomalous situations without the need for the AM include a GSM module.

For the sharing of information we opted for the use of XML formats, PDF and, optionally, SMS. Given the characteristics of XML format you can share information between different systems without that have compatibility issues. The PDF format was chosen for ease of viewing, printing or sending via email. With the use of SMS messages, it will be possible for the user of AMapp receive notifications, regardless of its location or does not have access to the Internet.

We validate this solution with the target audience, getting a high percentage of acceptance. Through this validation, we realized that the use of this solution would have a major impact on how it monitors the health, as well as is prepared for future needs. In addition, we identified some additional features that are not implemented in the solution. Given the way the systems were defined and implemented, it will be easy to add these features, because its implementation will be similar to the implementation of the features currently offered.

In conclusion, it is considered that the work offers an integrated approach to a problem that exists now and will get worse in the future. The proposed solution gives more autonomy to the elder and allows them to age in their own homes, offering better monitoring capabilities to family members or caregivers.

References

[1] Automatic medication dispenser get medsmart and compare e-pill dispensers automatic pill dispenser. http://www.epill.com/getmedsmart.html. Accessed: 15 January, 2015.

[2] e-pill md2 medsmart locked automatic pill dispenser (without monitoring). http://www.epill.com/medsmart.html. Accessed: 15 January, 2015.

[3] Pharmassistant: a app que lembra a hora do comprimido. http://exameinformatica.sapo.pt/videos/reporterei/2014-06-30-PharmAssistant-a-app-que -lembra-a-hora-do-comprimido. Accessed: 10 January, 2015.

[4] Pharmassistant em parceria com a bayer. http://observador.pt/2014/12/02/pharmassistant-em-parceria-com-bayer-solucao- portuguesa-vai-ser-testada-em-berlim/. Accessed: 10 January, 2015.

[5] Pharmassistant garante "o medicamento certo, à hora adequada". http://www.jornaldenegocios.pt/empresas/exploradores/startup-em-destaque/detalhe/pharmassistant.html. Accessed: 10 January, 2015.

[6] Pharmassistant keeps patients taking their prescriptions on time. http://backerjack.com/pharmassistant-keeps-patients-taking-their-prescriptions-on-time/. Accessed: 10 January, 2015.

[7] Philips lifeline and medication management services. http://www.vnacares.org/healthcare-services/philips-lifeline-services. Accessed: 2 January, 2015.

[8] J. Demongeot, G. Virone, F. Duchêne, G. Benchetrit, T. Hervé, N. Noury, and V. Rialle. Multi-sensors acquisition, data fusion, knowledge mining and alarm triggering in health smart homes for elderly people. *Comptes Rendus - Biologies*, 325, 2002.

[9] P. Rashidi and A. Mihailidis. A survey on ambient-assisted living tools for older adults. *IEEE Journal of Biomedical and Health Informatics*, 17:579–590, 2013.

[10] G. Virone and a. Sixsmith. Toward Information Systems for Ambient Assisted Living. *Proc. of the 6th International Conference*, 2008.