IoT-Based System to Help Care for Dependent Elderly

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Abstract. The aging of the population in most developed countries has increased the need of proposing and adopting systems to monitor the behaviour of elder people with cognitive impairment. Home monitoring is particularly important for caregivers and relatives, who are in charge of these persons in potentially risky environments (e.g., the kitchen, the bathroom, the stairs, go out alone to the street, etc.), while they perform their household activities. On the other hand, the paradigm of Internet of Things (IoT) allows the interconnection of everyday objects to implement sophisticate, yet simple-to-use, computer systems. In this paper, we analyse the existing IoT-based proposals to monitor elder people at home. Moreover, we propose a generic design of an IoT-based home monitoring system that allows caregivers, relatives and/or emergency services to be notified of potentially risky demeanours. Finally, some scenarios or situations are presented in order to better understand the proposal, and to validate its design to cover some common use cases.

Keywords: Assisted Living · Home monitoring · Elderly Caregiver assistance · Access control to restricted areas

1 Introduction

Life expectancy has been steadily increasing all over the world for the past decades, and it is expected to continue so in the future. As a consequence, both the amount and the percentage of elder people have increased, especially in the most developed countries. This group of people usually suffer from multiple chronic diseases, which convert them into more fragile and dependent persons. Consequently, they demand further caring, also generating a health, social and familiar yet-to-be-solved challenge [1].

Many relatives of dependent old people take care of them, while they also take charge of the household keeping. Moreover, they usually must take responsibility of other activities and tasks. The concerns that these relatives commonly have regarding the well-being of the people who they take care of could be decreased through the implementation of computer systems to monitor them. In this regard, the most recent

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advances in Internet of Things (IoT) [2] could be of great interest to be able to implement a simple-to-use, yet technically complex, monitoring system.

Nowadays, IoT is an emerging research field with a potentially huge transformation effect in our societies. Home appliances, buildings, vehicles, daily objects, etc. are starting to be connected to the Internet, equipped with enough computing resources to be able to capture and analyse information to improve our lifestyle, work, education, etc. The projected impact of IoT over Internet and the worldwide economy is extensive. In fact, CISCO [3] predicted that over 50,000 million devices would be connected to the Internet in 2020.

Some IoT-based systems have been developed to help care for the elderly, with a view to reducing the costs required for the care of this group of vulnerable people. Some of them are systems patient caring within hospitals [4–7], while others perform remote patient monitoring [8–10]. In these systems, sensors collect data from people, as well as the objects they use and their physical environment. The collected data is processed by the system to obtain useful information that proactively and transparently can provide the users with helpful information to improve their lifestyle, thus converting usual environments into intelligent environments [11].

An intelligent environment implies the interconnection of different devices in a determinated physical space, so that computing devices automatically respond to human behaviour and needs. To achieve that goal, systems and applications must be developed to handle both context information [12] and user preferences [13], in order to adequately respond to the needs demanded by the assisted people. In fact, there are works related to intelligent systems and context-aware services [14–16] whose objective is to help elder people to live a more independent and safe life in their own homes [4].

In this paper, a system is proposed for the care of dependent elderly people who live with their caregiver, so it is necessary to identify each person according to their role, using non-intrusive devices. In this system, older people have access restrictions to certain areas of the home that are considered dangerous for them. The caregiver will receive notifications on his/her smartphone. In addition, the elderly will be able to receive notifications about activities that they should or can perform, such as taking their medications, watching his/her favourite TV program, etc.

We have followed the approach of using non-intrusive devices since we consider that dependent elderly people, especially if they have any cognitive problems, might find certain objects used to monitor them as intrusive (e.g., bracelets, smartphones, and body sensors [10, 17]). In practice, such a feeling would make them to take these devices away or to forget to carry the devices with them [18]. Equally intrusive can be considered video cameras, violating the privacy of the person under surveillance [19].

The rest of the paper is structured as follows. Section 2 presents some related work to the proposal presented herein. Section 3 describes the proposal, depicting its layered architecture and giving details about the functioning of each of its layers. Section 4 presents a scenario and a set of use cases to validate the proposal. Finally, Sect. 5 outlines the conclusions and some directions for future work.

2 Related Works

In recent years, many scientific contributions have been made in the field of IoT applied to the care and monitoring of older people. More specifically, most of these works are currently focused on monitoring the behaviour and health status of this group of people. A problem usually addressed in several recent contributions is fall detection. In this context, Odunmbaku et al. [20] propose a tele-health system, based on IO (Internet of Objects), which also allows monitoring elderly people suffering from Alzheimer's disease and the quality of their sleep. This system is capable of capturing the vital signs of the users and making them remotely accessible. De Luca et al. [9] propose an algorithm for fall detection based on the use of accelerometers and gyroscopes.

Monitoring the user behaviour, especially of people with cognitive impairment, is also a widely addressed problem in the literature. For instance, Cunha et al. [10] have developed a system to support the continuous and proactive care of the elderly. This system is based on the detection of ambient light from a mobile device, as an alternative to the use of body sensors, in order to create a ubiquitous and multiuser system to recognize, inform and alert about environmental changes and human activities at home. The system uses lights and sounds to alert about the actions of the monitored people. In addition, it recognizes some of their daily activities, identifying the individual and his/her movements in the house, by using RFID technology.

The improvement of the elderly independence, through the use of technology, is also a very prolific research area. In WITSCare [4], the researchers present an IoT-based system and implement a web application whose main objective is to help older people to live more safely at their own homes. WITSCare offers an analysis of contextual information (e.g., about daily activities). The system learns about users and allows creating rules to personalize services through a graphical interface. After the system learns enough about the user, it offers the contexts as services (universal contexts). However, the authors do not specify what happens when the person in question (from whom the system must learn about) lives with other people.

In the field of positioning and tracking of objects or people, both outdoors and indoors, several works have been published. Among them, Del Campo et al. [21] present an overview of middleware solutions designed for IoT in the domains of health and well-being. Likewise, they present as a case study an assistive technology that includes support for home monitoring of people with dementia. It is illustrated how a specific middleware designed for telemetry applications, the MQTT (Message Queuing Telemetry Transport), can be effectively applied in welfare scenarios, with different architectural options and communication technologies. Chu et al. [22] present the design of a robot with automatic tracking to help the elderly at home, being able to determine their location by using RSSI (Received Signal Strength Indication). In addition, using ultrasonic sensors and internal maps, the robot positions the people and creates a route to find them. If there is any obstacle in its path, it will automatically modify its route to avoid it. However, a limitation of this work is that it does not help prevent access to places that pose a potential danger to the person. On the other hand, Shang et al. [23] present the design of Foglight, which uses light sensors to position objects with an average precision of 1.7 mm. Mainetti et al. [24] propose an Ambient

Assisted Living (AAL) system that includes the continuous monitoring of the health status of the elderly through the data gathered from heterogeneous sources (for example, environmental sensors and medical devices). It is also able to offer real-time user positioning, either outdoors or inside the home. The collected data is analysed and, if necessary, notifications and alerts are generated.

IoT has also been widely applied to health monitoring of patients. Thus, Chen [5] proposes a system of acquisition of multi-physiological parameters for e-health. The system incorporates sensors installed in ZigBee terminal nodes, which are responsible of collecting the physiological parameters of the human body with low latency and transmitting them for their visualization in real time. Zanjal et al. [6] propose the use of IoT to remind patients of the intake of certain medications. On the other hand, Dziak et al. [7] address the problem of assisting elderly people living alone by covering certain healthcare needs, such as difficulty in mobility, symptoms of dementia or other health problems. To do this, they propose a both outdoors and indoors positioning system based on IoT that uses the accelerometer and the magnetometer, as well as pattern recognition, edge detection and an algorithm based on decision trees. In addition, the system identifies falls and daily activities, such as lying down, getting up, sitting down and walking, classifying them as normal, suspicious or dangerous. If necessary, it also notifies the medical attention staff about possible problems.

Another important research field is the one associated with smart homes. Dawadi et al. [25] perform a literature review to determine the most important applications to help the elderly within their home. These authors select 25 works, in which they identify as study topics, from most to least concern, the monitoring of: health, the kitchen, the living room, the bedroom, the security, the bathrooms (toilets), and the social connection, among others. They also identify the following objects as candidates for continuous monitoring: bed, lamp, mobile, medicine bottle, door, window, chair, stove, dishwasher, sink, kettle, fridge, TV, food cabinet, table and sofa. In their analysis, they conclude that the monitoring of these activities and objects is very useful for caregivers. On the other hand, they emphasize that the use of sensors is very frequent, and that the applications developed in the different works act only in very specific scenarios. Zhou et al. [26] present a model of context-aware information for smart homes, addressing the problem of home care services for the elderly (Elderly Homecare Services - EHS). To do this, they use the technique of constructing activity models and apply them for ADL (Activities of Daily Living) recognition. Although the proposal recognizes the activities performed by a person, they do not specify whether or not it addresses the recognition of the specific person who performs them. Davis et al. [27] carry out two studies on the use of lights to transmit information. In the first one, they explore the adequate characteristics of light (colour, frequency of changes and brightness) to promote context awareness, so they examine the preferences, perceptions and interpretations of environmental lighting configurations. In the second study, they determine if there were significant implications of the activity awareness through illumination, without affecting the mood or the social connection of the people. Although it was not tested with older adults, the presented results prompted us to propose the emission of light as part of the notifications.

Several of the works mentioned [10, 23, 26], linked to monitoring, positioning and smart homes, respectively, have similar objectives to the ones proposed in our work.

Likewise, the system presented in [24] emits alerts about events caused by older adults during their daily activities at home. However, in contrast to the proposal presented in this article, access to sites with high levels of danger is not restricted or monitored. More specifically, our proposal consists of an IoT-based system that allows the caregiver to monitor the elderly's activities, establishing areas and activities that are restricted or supervised. In addition, it allows us to provide reminders about routine daily activities that must be performed by the users supervised.

3 Proposed System

3.1 Motivation and Objectives

Many older people live in their homes accompanied and cared by their relatives/caregivers. However, in the literary review carried out, no studies have been found about helping these relatives/caregivers who live with them in their caring tasks. So far, the published works on this subject are clearly focused on proposing IoT-based systems that allow monitoring people and notifying their caregivers, family members and/or emergency health services about certain harmful events and alerts. For example, their vital signs are monitored, their location inside and outside the house, the falls they suffer are detected, etc. In addition to covering some of these aspects, in this work we propose a system that distinguishes whether the elderly is alone at home or with their caregiver(s), focusing especially on serving as an assistant and support tool for the latter. Consequently, the idea is to facilitate his/her caring tasks.

More specifically, the proposed system has 3 main objectives: (i) Blocking accesses (doors) to the rooms of the house that would pose a certain danger for the elderly, particularly for those who have cognitive problems. This contributes to an improved tranquillity on the side of the family member/caregiver, especially when the latter is away from home. (ii) Issuing notifications for those who are inside the house, making use of everyday objects (lights, speakers, etc.), and for those who are out of it, through the smartphone. The notifications may also be issued to alert/warn the elderly about certain activities that they are performing or have to perform. (iii) Informing family members who do not live or who are not at home with the elderly about the events that occur within it.

3.2 System Architecture

The architecture of the proposed system consists of 5 layers, which are depicted in Fig. 1. More information regarding layered-based architectures for cloud computing can be found in [28].

Sensors/Actuators Layer. It consists of a network of sensors/actuators, interconnected through Bluetooth and Wi-Fi, coupled to Arduino Uno boards and distributed throughout the home. The sensors will detect the signals corresponding to environmental events, which will be transmitted to the local computing layer. Actuators will receive from said layer the corresponding control commands to act on the physical environment.

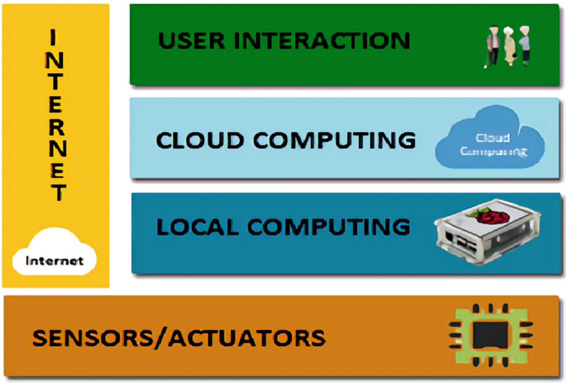

Fig. 1. Layered architecture of the proposed system.

In each of the entrances (doors) to the rooms that may pose a risk for the elderly, a sensors/actuators network node (SANN) will be installed. Each SANN will consist of a proximity sensor, RFID sensors [29, 30] and an Arduino board [31]. In addition, a notification node (NN) could be installed, which will integrate LED lights [27] and speakers, together with an Arduino Uno board, in those objects in which the elderly pays special attention (for example: a mirror, TV, etc.).

All the people (whether they are caregivers, relatives or elderly people) who live in the home will imperceptibly carry an RFID tag on their clothing that will store their identification data. The proximity sensor will detect when a person approaches a certain distance, being able to configure this distance (and set, for example, to 80 cm). When someone is at that distance or less from the door in question, the Arduino board will take the data captured by the RFID reader (corresponding to the RFID tag that the person carries) and will send the data to the central processing node, which is located at the local computing layer.

The speakers, as part of the NN, will allow reproducing different sounds or music [32], which will serve as warning or prohibition notifications, depending on the potential risk of the situation. Prohibition notifications will also prevent the elderly to perform certain tasks without the presence of their caregiver. In addition, the LED lights will serve as a visual complement to the auditory signal. Warnings will turn green LED lights on, while prohibition notifications will turn them red.

Local Computing Layer. It will be responsible for managing, validating and processing all the signals captured by the previous layer, as well as generating all the control signals. Its main functions consist of: identifying the person who approaches the entrances of the controlled rooms of the house, issuing notifications about the events that occurred and the orders sent by the caregivers from their mobile devices, as well as delivering the data for its storage in the cloud computing layer. It will consist of a Raspberry Pi [33] (central processing node) on which the database services will be executed, and the software for the control and administration of data.

When this layer receives data from the sensors/actuators layer, it will access the local data (stored in a database) and will make a query to identify a matching person.

In case the identified person is the elderly being supervised and an access to a restricted room is attempted, then it will issue control signals to prevent the door from opening and it will alert of the potentially harmful situation. For other unrestricted rooms, the layer will simply notify that the elderly has entered them.

This layer will manage the data of the people living in the house, introduced by means of a mobile application, and the configuration of the SANNs installed in the doors of the rooms whose access is to be controlled, so that it can deny and alert the access attempt, as well as temporarily disable one of the SANNs or the global system. In addition, it will keep the data updated in the cloud, which can be consulted by the caregivers/family members through a web application.

The layer will also communicate with the SANNs to obtain the data captured by the sensors and send the control commands to the actuators, after searching for matches with the data stored in the database to identify the person in question.

Cloud Computing Layer. This layer involves a (third-party) cloud server for hosting the database (which will contain the data sent by the local computing layer) and the web application, in addition to the web application server. Through the web application, family members/caregivers can be informed about the events that have occurred in the monitored home, as well as send notifications or commands (e.g., reminders, turning a certain light on/off, etc.) to the local computing layer.

The model MVC (Model-View-Controller) has been chosen (see Fig. 2) to develop the web application, which will facilitate its future maintenance. Since this application is hosted in the cloud, it can be accessed from any place and any device through an Internet connection. This application and the mobile application will share the same database.

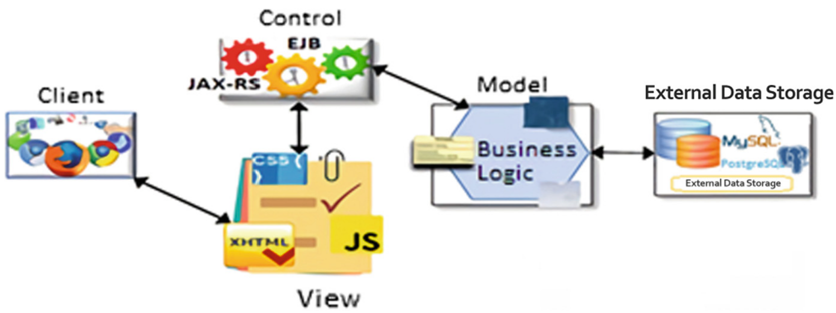

Fig. 2. Development model selected for the web application.

In addition, storage and processing in the cloud are designed with the possibility of implementing the system in different houses where older people live. Therefore, a single web application, hosted in a single domain, allows non-co-located users to use the same infrastructure, but only accessing their private information, thus reducing the costs that would entail the installation of multiple instances (one per address) of the web application.

User Interaction Layer. It consists of a mobile application and a web application. Its function will be to keep caregivers/relatives informed, when they are away from home. The applications will enable to send notifications and commands that will be processed by the local computing layer. More specifically, caregivers can use these applications to: configure the sensor network, enable/disable the system, issue/receive notifications and issue commands.

The notifications and commands may be issued by the system, the caregivers and/or the elderly (as long as they have the capacity to handle the mobile/web application). Likewise, the notifications and commands may be directed to be received by the caregivers, the elderly and/or the sensors/actuators layer to take any action.

The network nodes, when installed at the entrances of each room of the house, must be configured as completely restricted or potentially risky. To do this, the mobile/web application will interact with such nodes and store the corresponding data in the database, in both (local and cloud) computing layers. Moreover, the web application will allow the relatives to consult the events that occurred within the home(s) for which they have access permission to consult this information.

Internet Layer. Internet will be the communication network between the three upper layers, that is, it will serve to communicate and synchronize the local and cloud computing layers, and to communicate the user interaction layer with the computing ones.

3.3 Mobile Application Interfaces and Their Evaluation

In Fig. 3, four screenshots of the prototype user interface are depicted. Screenshot (A) shows the login screen, in which the application asks for the user's email and password, while Screenshot (B) presents the current menu options. The profile of the supervised people can be configured in the mobile application, as shown in Screenshot (C). Finally, Screenshot (D) presents a list of the locations in which the monitored older person has been during a timespan.

In order to validate the usability of the user interface, we make use of several contributions [34, 35], since we are willing to test an unfinished prototype application. Analysing users' reaction and their comments while they use the application is the key to improve the user interface and produce a final application prototype. The pilot usability test will be oriented to analyse the user experience. We have determined that the usability tests will last from 30 min to one hour, depending on the skill of the user. The first test will involve 5 people, but we plan to extend that analysis to more users before developing the final prototype. Users will test both the mobile application and the web application. The mobile application (.apk) is going to be sent by email to be directly installed on the users' smartphones. The mobile application will automatically collect usage statistics. The web application is going to be tested by each user in front of a computer connected to an intranet.

The evaluating users will be asked to fill out and sign the informed consent letter and fill in the form with their demographic data, including age, gender, experience in the use of mobile applications, and Internet experience. If the user has any comments regarding the applications, he/she should mention them and explain them to the member of the development team who is present during the test.

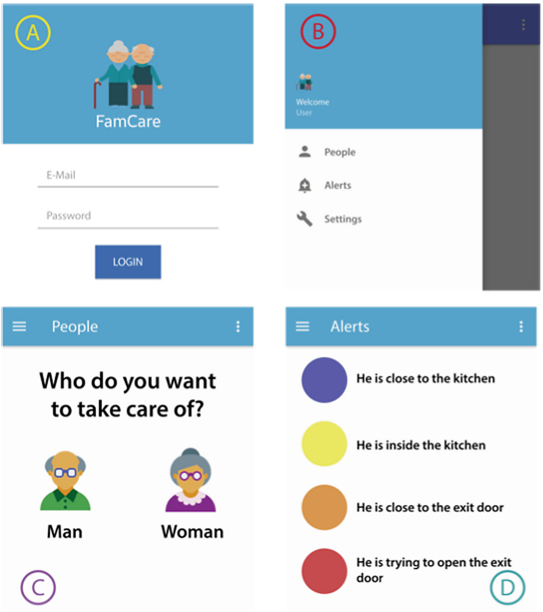

Fig. 3. Several screenshots of the proposed mobile application user interface.

4 Scenario and Cases to Validate the Proposal

In this section, we present a scenario and a series of cases that can occur within that scenario in order to validate the feasibility of the proposed system. Let us consider the scenario of a house with two (or more) floors. On the ground floor, depicted in Fig. 4, we find the living room and other spaces that will be considered for the implementation of our system. As shown in Fig. 4, there are 6 access points that can be assumed to be risky, 3 of which are completely forbidden: main entrance (A), and exit doors to the terrace (B and C), and 3 are precautionary: kitchen (D), stairs (E) and toilets (F). The system has been configured so that objects O1 and O2 reproduce a different sound when the elderly tries to access and/or enter each of these rooms in the house.

In all the cases considered, the system stores the data in the cloud (in addition to the local computing layer), so that they can be accessed through the web application from anywhere and from any device that has a browser installed and an Internet connection. The notifications are also sent to the mobile device [36] when the system reacts in some way.

Two situations have been considered: the first one, when the caregiver is in the house with the elderly person, and the second one, when the caregiver leaves the house and the old person is left alone. Below, we detail the cases that can occur in each of these two situations.

Fig. 4. Blueprint of the ground floor with the rooms of the house to consider for the tests.

4.1 Situation 1: Caregiver at Home

Let us suppose that the caregiver is on the top floor, and the elderly is sitting on the sofa in the living room (which is on the ground floor, as shown in Fig. 4), watching his/her favourite television program. Below, we will analyse a series of cases that can occur in this situation:

Case 1. The elderly stands up and goes to the bathroom, so the proximity sensor placed in F detects that he/she is approaching. The Arduino board at that point (F) calculates the distance with the information received from the proximity sensor. When it is less than the determined distance (for example, 80 cm), it takes the data read by the RFID sensor and sends this data to the central computer (Raspberry Pi). It searches in the database to identify the person and identifies the elderly. It then sends the appropriate control signals to the O1 and O2 objects so that the speakers reproduce the warning sound or music (configured according to the preferences of the inhabitants of the house) and the green LED lights turn on. When the caregiver listens to the music, he/she knows that the elderly has entered the bathroom. While the elderly remains in the bathroom, the music continues to play and the LED lights remain lit in green. When he/she leaves the bathroom, the speakers stop playing the music and the LED lights go off, so the caregiver knows that he/she has left the bathroom. In case the elderly stays for too long in it, the system could indicate that something might go wrong; thus, the caregiver would quickly go down to see what is happening.

Case 2. The elderly goes to the kitchen to take something from the fridge. The proximity sensor placed in D captures the nearness and the Arduino that is at that point calculates the distance similarly as done in the previous case. When the distance is within the considered range, it takes the data read by the RFID reader and identifies the elderly. Then the system sends the relevant commands to the objects O1 and O2 so that the speakers play the corresponding music (different from the bathroom) and the LED lights turn on, also in green, since it is a warning notification, as in Case 1. When the caregiver listens to that music, he/she knows that the elderly has entered the kitchen, and the moment the music stops playing and the LED lights go off he will know that the person has abandoned that place. If the elderly stays for too long in the kitchen, then the system will notify it, and the caregiver may go down to check if everything is going well. Hence, as this case is similar to Case 1, the system will act analogously in both cases, except in the reproduced music. Something similar will happen when the elderly approaches and goes up or down the stairs, except that the music played will be different from the one played in the mentioned cases. So, if the elderly falls down the stairs, the caregiver will quickly know it.

Case 3. The elderly approaches the door of the terrace, considered a restricted area to which he/she cannot access alone, given that he/she could then go out into the street and, as this person becomes easily disoriented, he/she would be lost. The proximity sensor placed in B detects that the elderly person brings near and the Arduino board of that SANN identifies him/her (as explained in the previous cases). Then, the system blocks the access door to the terrace, to ensure that the person cannot access that place, and sends the commands to the objects O1 and O2 to reproduce the corresponding sound or music of prohibition and turn on the red LED lights. When the caregiver listens to that sound or music, he/she knows that the elderly is trying to access the terrace. While the latter remains within the established distance range (about 80 cm, for example), the system will continue to play the music and the LED lights will light red. If the elderly stays there for a long time, then the caregiver could go down and persuade the elderly to return to the room or go out with him to the terrace. Something similar would happen if the elderly tries to open the other door that gives access to the terrace (C) or the one of the main entrance (A).

Case 4. The caregiver goes down the stairs, and goes to the bathroom, the kitchen, and the door of the terrace. As the system identifies the caregiver (making use of the signals detected by the SANNs placed in E, F, D and B respectively, when he/she is within the range of distance specified for each place), the corresponding doors are not blocked and commands are not issued to reproduce any sound or to switch on the LED lights.

4.2 Situation 2: Absent Caregiver

In this situation, the caregiver leaves the home, leaving the elderly alone at it, sitting on the couch in the living room, watching his favourite TV show. Now, we will analyse a series of cases that may occur in this situation:

Case 5. The elderly approaches the bathroom and the system detects it, like in Case 1. As a result, instead of sending the commands to objects O1 and O2 to play the corresponding music and turn on the green LED lights, the caregiver receives the notification on his/her smartphone by means of the mobile application, informing that the elderly has entered the bathroom. In addition, the mobile application turns on the flash of the caregiver's smartphone intermittently, which will remain that way until the elderly leaves the bathroom. Therefore, when the caregiver's smartphone flash goes out, the caregiver will know that the elderly has left that location. Something similar will happen when the elderly goes to the kitchen or the stairwell.

Case 6. The elderly approaches the door of the terrace. When the system detects him/her (as explained in Case 3), in addition to blocking the door to ensure that he/she cannot open it, it sends a notification to the caregiver's mobile application. If the caregiver considers it necessary, he/she could send notifications to the elderly person's smartphone (if he/she has one) or to another object in the environment (such as loudspeakers, for example) with a reassuring message. In addition, he/she could send a notification so that one of the other caregivers/family members approaches the home and checks for the status of the elderly person and reassures him/her, if necessary.

Case 7. The caregiver sees that returning home will take him/her longer than expected at the time of his/her departure, so he/she sends a notification directly to the person being cared for (if he/she is able to use his/her smartphone) and/or objects of the environment, to inform him/hem of the activities he/she must perform, such as: showering, taking a nap, taking some medicines, etc. As in the previous case, if the caregiver considers that the elderly needs direct attention, he/she could inform all the family members so that someone come to the home and give the elderly person the help he/she needs.

5 Conclusions and Future Work

We have presented a system especially intended to help caregivers or family members in their responsibility to ensure the well-being of the elderly people that they take care of, as well as to monitor, protect and assist the latter. In the literature review carried out, we have found systems that have been implemented/proposed with the aim of helping elderly people who live alone. However, from our point of view, such systems have not focused enough on the caregivers who share their lives with the elderly served. In addition, no systems have been found that control access to certain rooms, considered dangerous for people who have certain cognitive problems.

An outline of the architecture of the proposed system has also been presented, and each of the layers that integrate it (as well as its components) has been explained.

To validate the proposed system, we have presented a scenario and a series of possible cases within it, considering the two general situations that can occur in a dwelling with dependent elderly people in it: (1) these elderly people are left alone at home (because their caregivers have left); and (2) both the elderly people and their caregivers are at home.

Our proposal has to be tested with real users in their own homes. This will provide us a lot of information to improve the system, and especially its user interfaces regarding usability and adaptation aspects.

All of the monitoring data obtained will be stored, with the permission of the people involved, to be analysed and used later in a study on the behaviour of dependent older people with and without their caregiver present at home. The idea is to use the results that can be extracted from this analysis to implement systems that autonomously make increasingly intelligent decisions, in order to improve the well-being of the elderly people they are trying to serve. This task will occupy the authors' attention in the near future.

Additionally, the usability of the mobile and web applications will be tested with real users before developing a final prototype.

Security and privacy issues will be addressed in a future research paper, and the whole system implementation will be published as open source as soon as we finish producing a debugged source code and a detailed deployment documentation.

Finally, facial recognition techniques could be incorporated into the system to identify people and, depending on who they are, to allow them or not to access the different rooms of the dwelling. Decision making techniques could also be applied to automatically analyse the collected data in order to increase the accuracy of the alerts.

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