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Yes, ICAN(b)E - Active Aging in Place supported by a Caregiver-centered Modular Low-Cost Platform

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Abstract

Aging in place happens when people age in the residence of their choice, usually their homes because it is their preference for living as long as possible. This paper introduces the implementation of a computational platform to support active aging in place with a particular focus on the caregivers and their requirements to accomplish their tasks with engagement and comfort. The platform is supported by IoT, using low-cost technology to increment the platform modularly. It is a modular platform capable of responding to specific needs of seniors aging in place and their caregivers, obtaining data regarding the person under supervision, as well as providing conditions for constant and more effective monitoring, through modules and tools that support decision making and tasks for active living. The paper describes the platform principles and its modular architecture. Preliminary results are presented in the form of an experimental installation scenario.

Keywords: Ambient Assisted Living; Aging in Place; Active Aging; Pervasive Computing; HCI; Context-Awareness; Caregiver; Modular Platform; BLE Beacons.

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1. Introduction

Globally, the population has been suffering significant alterations during the last decades, due to the increase of the average lifespan, along with the decrease of the birth rate. These variables have been leading to the aging of the world's populations, with a tendency to increase [1]. The first time, in history, when there will be more older people than younger people is rapidly approaching. As the number of seniors increases, in what has been called the "silver tsunami", and the number of people who are caring for them decreases, the latter face many difficulties to adequality support the daily needs of the seniors, which may lead to their isolation [2]. The natural aging process, by itself, leads inevitably to the seniors' isolation [3].

Technology has advanced far beyond what many seniors ever imagine it would. The development of a technological solution that provides seniors' remote monitoring and assistance by a caregiver can make a home much safer to grow older, avoiding institutionalization. Despite the limitations of cost, accessibility, user knowledge, and security, technology can help seniors live independently more safely with an improved quality of life, contributing to the maintenance of an active life. However, it is important to have a solution that introduces the caregiver into the equation, facilitating her/his task while alleviating her/his concern. Whether being a family member or a professional and simultaneously with an active life, the caregiver role can become complex to be performed effectively [4].

Apart from the social context, the economical factor may also be problematic regarding the support provided [5]. The lack of investment power is a significant factor in the efficiency of monitoring the safety and well-being of the senior at a distance. Existing solutions for this purpose are usually expensive, which is inaccessible for a large part of the population. Thus, it would be extremely important to reduce costs in order to provide a service that attends the population's needs and characteristics. Over the last years, the smart devices and wearables' evolution has been feeding the increasing tendency of the Internet of Things (IoT) concept [6]. The strong investment in this sector, which is starting to become very competitive, has been leveraging a natural integration of these devices in our everyday lives, presenting validated technology, approved usability, low cost, and consequently, making them accessible for most of the social classes [7].

This paper introduces the implementation of a computational platform to tackle the aforementioned needs, with a particular focus on the caregivers and their requirements to accomplish their tasks with engagement and comfort. Supported by IoT and using the low-cost technology that already exists in the market, it is possible to increment the platform modularly, making it more complete, as well as standardize data coming from the peripheral devices that will feed it to enhance its modules and operations. With the collected data, it is intended to have information regarding the daily routine and activity of the seniors, making it possible to understand and predict, as well, significant changes to their activity patterns. When so, and after determination of the real need, it allows the caregiver to, actively and immediately, interact and trigger support mechanisms and, so, being closer to having an effective performance. In section 3, the paper describes the platform principles and its modular architecture, but first presents related work in section 2. Preliminary results are presented in the form of an experimental installation scenario (also in section 3).

2. Related Work

Initiatives to support healthy aging in place have focused primarily on the views of policymakers, researchers, and health professionals. Several technology areas provide needed solutions for aging in place with health, safety, and comfort. There is a set of systems and platforms developed with the purpose to monitor certain aspects of the daily routine and/or health of the senior [8], and even some projects do promote the distribution of the effort of this task amongst caregivers. However, these projects are mainly focused on the senior person and few are the ones dedicated to the direct support of the caregivers. This section presents a selection of works relevant to our vision, where it is analyzed to what extent the existing platforms cover a set of essential characteristics.

CarePredict [9] is a project that arose in 2013 and focuses on identifying standards in the daily lives of the seniors to predict declines in their health, allowing early intervention by the caregiver. It combines wearable technology (bracelets used by the seniors), inner location (beacons), with machine learning algorithm for predictive analysis, thus managing to take elations about critical situations and changes in routine, alerting the caregiver. It also allows the senior to ask for help, through the bracelet, as well as allowing voice communication with the caregiver, from the device. It also has algorithms for detecting falls, making it a complete solution in terms of monitoring. SANITAG

[10] is a company that provides interior positioning systems optimized for the health sector. It has developed a solution using UWB RFID technology to locate, protect, and monitor seniors with the communication of critical situations to the responsible caregivers. Wearable technology determines the position of the senior in the physical space, as well as potential risk situations such as falls and prolonged inactivation. DOMO [11] is a platform that allows the senior to request help, at any moment. It also uses wearable equipment, which allows the detection of fall situations, triggering an automatic alert. This system can be complemented with other modules, such as biometric data collection, statistical reports on their clinical and motor status. Environmental sensors scattered around the house can perform the recognition of some daily activities. It also allows, with the use of specific hardware, monitoring, and follow-up outside the home. On the other side, 2PCS (Personal Protection and Caring System) [12] is a platform focused on the support of professional caregivers. It allows the caregivers to follow the location of their monitored seniors in a delimited space, through the wear of a bracelet. It also allows that a senior may trigger a request for help through the bracelet. CARUis [13] system is based on the use of voice interaction hardware to establish direct communication with a caregiver. In case of need, the senior person can trigger a request for help through voice command, followed by the notification of the caregiver. It also allows the recording and exchange of voice messages with the caregiver. Finally, LIFEPOD [14, 15] is a system that centralizes its functionalities in hardware for voice interaction. Allows a caregiver to parametrize questions and routines with specific periodicity and moments to confirm their implementation by the seniors. This feedback is obtained by voice interaction with the senior and the caregiver has access to it through an online portal or text message. It also allows the seniors to ask for help, and to interact with other smart devices in the home.

Table 1 presents a comparative study of the platforms presented. This comparison is made in 3 dimensions: technologies used, features provided, and cost of use. The cost was estimated considering the acquisition of necessary hardware plus installation, with the subscription (when applied) for one year.

Table 1. Comparative study of AAL platforms.

	Daily routine				Social	Hazard detection			Main aspects	Technology						Other	
Platform	Help with daily routine	Monitoring the daily routine	Recognition of activities	Recognition of indoor location	Help in promoting communication	Allows requests for help	Detects critical situations	Automatic alert to caregiver when critical situations are detected	Main aspects	Pervasive	Technologies	Sensors	Physical devices (interaction)	Monitoring system	Installation (hardware)	Country of origin	Estimated cost
CarePredict	×	✓	✓	✓	✓	Button	Inactivation and safe zone exit	✓	• Prediction of decline • Fall detection	✓	BLE	• Environmental • Body	• Bracelet	• Software • Mobile application	• RTLS system installation • Door locking system	USA	≃ 1100€
SANITAG	×	×	×	✓	×	Button	Fall and inactivation	✓	• Location monitoring • Fall detection	✓	UWB RFID	• Environmental	• Bracelet	• Software • Mobile application	• RTLS system installation	Turkey	n/a
DOMO	×	×	✓	×	×	Button	Fall and inactivation	✓	• Clinical monitoring and motor activity • Outdoor monitoring • Fall detection	✓	GSM / GPS	• Environmental • Body	• Bracelet	• Mobile application	• Motion sensors, doors, pressure and buttons	Switzerland	≃ 1300€
2PCS	×	×	×	✓	×	Button	×	✓	• Issue of aid applications	×	RFID	• Environmental	• Bracelet	• Software	• Needs placement of receiver antenna	Austria	n/a
CARU	×	×	×	×	✓	Voice	×	×	• Enhances communication	×	GSM	• None	• Voice interaction device	• Mobile application	×	Germany	≃ 950€
LIFEPOD	✓	✓	×	×	✓	Voice	×	×	• Validation of daily routine	×	WIFI	• None	• Voice interaction device	• Software	×	USA	≃ 500€

3. The ICAN(b)E Solution

It was intended to develop a platform based on low-cost IoT technology, already available in the market, allowing the integration of technology and devices that are already being used by people. With the emergence of this concept, a massive set of technology and devices should be considered, which may be dispersed and independent of each other,

but that is easy to use towards specific purposes, which can also be complex to manage when in excess or parallel. Once the technology exists and is introduced in the market, it would be convenient to conceive a simple way to combine these devices, making it possible to manage them as a whole and, collaboratively, generate useful and complete resources.

Another important principle is the integration of modules that allow the design of gamification activities to make the seniors active while they are being monitored. Therefore, those activities for an active life should be used according to the profile of the senior, working as challenges that can be collaborative or competitive.

3.1. Concept and Architecture

Through the continuous monitoring of the daily routine of a senior person in their own home, in a pervasive way, the platform must be able to take elations regarding the activity and potential risks or atypical situations, being able to intervene in a first instance to carry out an autonomous triage, which allows real-time alerts to be triggered whenever required, enabling action by the caregiver in useful time.

With low-cost devices from IoT platforms intended for application in smart homes, it is possible to determinate a wide range of measurements in the home. The routine analysis will work at different levels of granularity. In a first instance, perception of the physical context of the user, through the interior location using signaling devices (beacons) that allow identifying the room in which the senior person is. In each part of the home, there is a set of activities that can be carried out, designed and activated a priori, through the platform's interfaces. Once determined the room in which the senior person is, data are collected from the sensors located in that same physical space to determine the activity in progress (see Fig. 1). The detection of changes to the known pattern can trigger mechanisms to detect problems. At this point, the platform has an essential role, acting as an intermediary between the senior and the caregiver, performing the first triage. It triggers voice interaction mechanisms with the senior, to validate the existence of a problem. In the case of positive feedback, or the absence of it, the platform will inform the caregiver or other competent entities. A mobile application allows caregivers to receive notifications and alerts in real-time, contextualized according to the degree of urgency of the problem and her/his need for intervention. Through it, the caregiver will have the possibility to monitor and follow the daily routine of the person in care, as well as trigger requests for feedback, when convenient. At the level of data analytics, additionally to extraction, classification and anomalies detection in real-time, a predictive approach to detect changes in daily routine over time is provided. These indicators can highlight diverse situations, such as loss of physical motor skills, cognitive or depressive episodes.

Fig. 1 illustrates the fundamental steps of the flow supported by the platform.

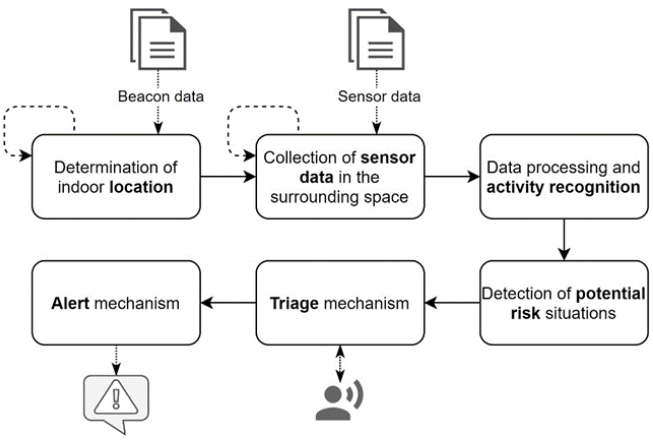


Fig. 1. Fundamental steps of the proposed solution

On the other side, Fig. 2 shows a detailed low-level architecture of the proposed solution, showing its main components.

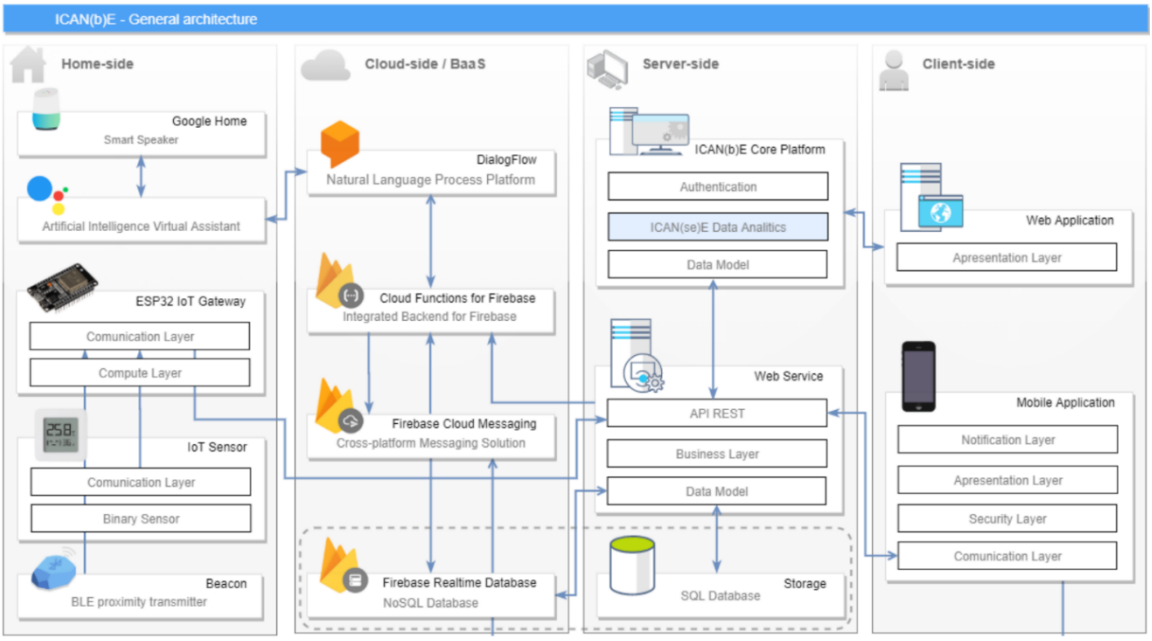
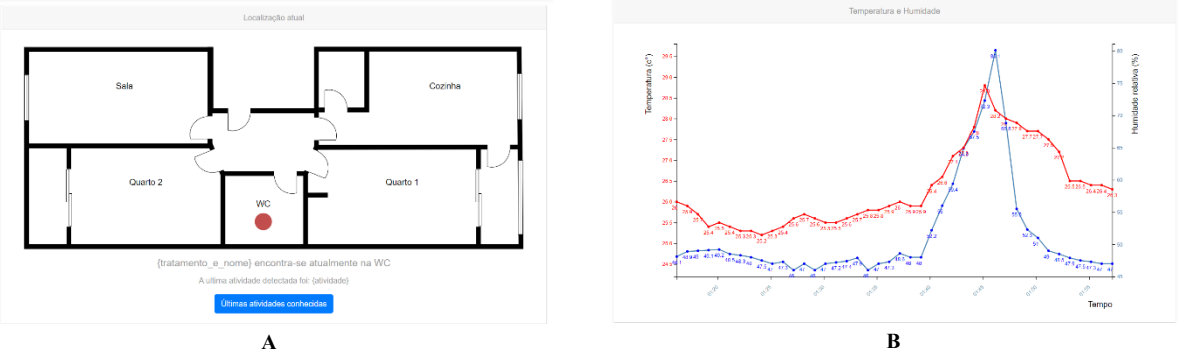


Fig. 2. Low-level architecture of ICAN(b)E.

3.2. Preliminary Results - Experimental Installation

The ICAN(b)E solution is just partially developed since some components are still under development. However, it was already possible to show its potential in discovering the activity of a senior, which was participating in the design, at a particular period in a specific room through the data obtained in the first installation. The test consisted of checking if the system could detect if the person was taking a shower (a potential risk activity for a senior). Humidity and temperature sensors, besides BLE (Bluetooth low energy) beacons, were placed in the bathroom and connected to the system.

The person entered in the WC and took a shower. Firstly, the beacon detected the person in the WC, and the system received the signal, processing it to finally show in the user interface (see Fig. 3A) that the person was in the WC. At the same time, it triggered the data collection from the environmental sensors in this space. With the extraction of features from IoT Sensor data (see Fig. 3B), the ICAN(se)E Data Analytics Component detected that the individual was taking a shower. Then, it detected the period of shower activity throw the pattern recognition of temperature and humidity curves. As the time of this activity exceeded the usual, it recognized an anomaly to the pattern and notified the caregiver.



A **B**

Fig. 3. A -Indoor positioning of the senior obtained using BLE technology. B- Humidity and Temperature Data obtained from the WC.

4. Conclusions and Further Work

This paper introduced the design of a computational platform to support active aging in place with a focus on the caregivers to accomplish their tasks with engagement. The platform is supported by IoT, considering the use of low-cost technology, commercially available, which can be modularly added to the platform. It is a modular platform capable of responding to specific needs of seniors aging in place and their caregivers, obtaining data regarding the person under supervision, as well as providing conditions for constant and more effective monitoring, through modules and tools that support decision making and tasks for active living. Preliminary results are positive since they show that central modules for the detection of activities are well implemented and communicating accordingly to what was designed.

We are already working on the remaining modules and planning user tests with real end-users selected by partner entities of our active aging network, who work with us on the project.

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