Personalized Technological Architectures to Assist Dementia Patients based on Energy Efficiency

Fernando Luís-Ferreira, Jorge Calado, Andreia Artífice, João Sarraipa
Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa/UNINOVA, DEE, CTS, Caparica, Portugal
flf@uninova.pt, jsc@uninova.pt, afva@uninova.pt, jfss@uninova.pt

***Abstract*—Technology has progressed over the last years providing solutions to much of our daily live needs. From start-ups to big companies every business is focused on developing devices and services to almost every need people have or imagine will need someday. However, when a health impairment appends to a person or a relative, it is necessary to find a customized solution that could help cope with the problem. The present research targets at developing tangible energy efficient solutions for those faced with the need for assistance to someone they care and has been diagnosed with Dementia. The conceptualization hereby presented aims at providing a personalized solution, so that family and friends can continue to carry a normal life, assisted by a device that will last battery as long as possible. For that reason, the present study aims at a simple but feasible usage of devices to be carried by a person with a yet normal life showing dementia signs that can disrupt normal routines threatens familiar's routines and way of life.**

I. Introduction

Dementia is typically defined as a clinical syndrome of cognitive decline that is sufficiently severe to interfere with social or occupational functioning [1]. It was estimated that 35.6 million people lived with dementia worldwide in 2010, with numbers expected to almost double every 20 years, to 65.7 million in 2030 and 115.4 million in 2050. In 2010, 58% of all people with dementia lived in countries with low or middle incomes, with this proportion anticipated to rise to 63% in 2030 and 71% in 2050 [2]. Dementia of Alzheimer type is the most common form of dementia among elderly persons and accounts for approximately two thirds of cases of dementia and between 60 percent and 70 percent of cases of progressive cognitive impairment in older adults [3]. Americans have Alzheimer's disease meaning that in 2015, more than 15 million family members and other unpaid caregivers provided an estimated 18.1 billion hours of care to people with Alzheimer's and other dementias, a contribution valued at more than $221 billion [4]. The present work fits in a strategy to contribute to provide support and enhance the life of people with Dementia in the scope of the CARELINK project. The tendency to wander and become lost is one of the aspects in the diverse forms of Dementia, including the most frequent case the Alzheimer's disease, that implies the need of technology to track and signal position in such cases.

The motivation here is, to develop a personalized architecture that leads to energy efficient solutions that will extend battery life thus increasing the changes for a lost patient to be found alive and the healthier as possible. In that direction, the proposed solution was developed aiming to establish profiles that, once instantiated in the technological solutions, would result in conditioning the type of services enabled, thus extending battery life, augmenting the chances for that person to be helped in the occurrence of such an episode associated with dementia.

II. Research Questions

- Is it possible to develop personalized technological solutions for Dementia patients?
- Using personalized technological solutions would it result in better energy efficiency?

III. Methodology

The case for the technological devices to support Dementia patients has some specific limitation in what regards to what devices the person with Dementia is willing to carry or wear. In that line, there are some early thoughts, while engaging in such research, that must be debunked with the help of multidisciplinary teams where people that takes care of those patients play an essential role. In result of such cooperation, the researchers get to know that Dementia patients are not easily convinced to change their habits, their cloth or to carry extra gear. That is why we must limit the size and manage the encapsulation of the equipment so that it gets acceptance. That limits functionality and the element that usually requires bigger sized packs, the batteries. The ongoing study of the energy consumption of the tracking devices, used for dementia patients, and each of its components, serves the purpose of identifying and modelling the power requirements, associated with the different operation modes of the device.

Given the multiple modes each component can operate in, the distinct usage scenarios, and the interchangeability of components for establishing the communication link, the process of optimizing battery usage involves the profiling of the most efficient configuration of components and operation modes, regarding each usage scenario.

Each energy profile is tuned according to the results of the analysis of the power consumptions and adjusted to the usage requirements (communication availability, frequency of exchanged messages and degree of priority). The communication components considered in the case studies are those who use the Wi-Fi[5], Bluetooth[6], LoRa[7], GSM[8][9] and LTE[10], [11]. Those have multiple operating modes (e.g. off, idle/stand-by, transmitting, receiving), which are common to the modes of the GNSS[12], thus the consumption and performance studies take multiple measurements of the current drain in each mode, varying the frequency rate of the communications and the signal polling, in different physical environments. It is considered the outside environment: in good and bad weather, near big buildings and in open fields; and the inside environment; near windows and deep in the building. Both are considered as separate case studies in order to test different signal strength and coverage. Given the type of location, the conditions of operation, the battery level and the messaging priorities of the device, in conjunction with the analysis of the consumptions, enables the definition of sets of configurations that can be deployed on-the-fly to the device as these conditions change. This approach ensures a constant minimum level of energy consumption, but also a wider fault-proof signal coverage relying on multiple communication technologies as fall-back.

In the extensive study, hereby summarised in its adopted strategy, an ongoing iteration process is conducted as newer technologies and devices are deployed and tested.

The analysis and management of this knowledge is being processed with a dedicated platform, within the CARELINK project (www.carelink-aal.org). The platform serves as a communication gateway for the devices exchanging messages about configurations, user notifications and status, allowing the execution of different types of device configuration as exemplified next in Figure 1, which represents an exemplification of how the multiple device components settings can be tuned, depending on the conditions of the location and status of the person with dementia (PwD).

Location wise three factors determine the level of data reporting to the platform, namely if the PwD is at home, which is a safer location; outside in a regular location, close to home or near places usually visited by the PwD, which is still safe; or outside in a irregular location, that is not common to be visited and thus can pose some risks.

To avoid false wandering detections and maximize the understanding of the involvement and environment of the PwD, the device can detect if a caregiver, family member or registered acquaintance is present nearby, by the use of smartphone discovery (e.g. using Bluetooth), and adjust the safety settings, reducing the rate of reports.

Similarly, if the onboard sensors detect abnormalities in the reported signals consistent with possible health hazardous situations, or if the A.I. in the platform detects wandering events or signals that indicate possible dangerous behaviour of the PwD, then according to each situation (warning or alert), the necessity to acquire more precise detailed data requires the device to increase the rate of the data reports to the platform and from the sensors.

Combining these factors with the hardware features of the devices enables the smart management of power resources by switching on or off the wireless and the cellular communication modules, turning off the GNSS receiver or adjusting the location polling frequency, and configuring the sensors polling frequency, as exemplified in each blue square of Fig. 1 presented below.

Status of the Person with Dementia	Home		Outside (regular location)		Outside (irregular location)	
	Alone	Accompanied	Alone	Accompanied	Alone	Accompanied
Normal	Wireless on GNSS off Cellular off Sensors 15 min	Wireless on GNSS off Cellular off Sensors 15 min	Wireless off GNSS 15 min Cellular on Sensors 30 min	Wireless on GNSS 30 min Cellular off Sensors 30 min	Wireless off GNSS 10 min Cellular on Sensors 10 min	Wireless on GNSS 15 min Cellular off Sensors 30 min
Warning	Wireless on GNSS off Cellular off Sensors 5 min	Wireless on GNSS off Cellular off Sensors 5 min	Wireless off GNSS 10 min Cellular on Sensors 10 min	Wireless on GNSS 15 min Cellular off Sensors 10 min	Wireless off GNSS 5 min Cellular on Sensors 5 min	Wireless on GNSS 10 min Cellular off Sensors 5 min
Alert	Wireless on GNSS off Cellular on Sensors 1 min	Wireless on GNSS off Cellular off Sensors 1 min	Wireless off GNSS 5 min Cellular on Sensors 5 min	Wireless on GNSS 10 min Cellular off Sensors 5 min	Wireless off GNSS 1 min Cellular on Sensors 1 min	Wireless on GNSS 5 min Cellular off Sensors 1 min

Figure 1. Example of an energy profiling solution

IV. Discussion

Many technological devices and services exist in the market and can be deployed in order to assist patients with dementia in different stages. Dementia patients use to manifest some resistance to use devices that are not usual to carry and there is forgetfulness, associated with such pathology. A device will not be useful if is rejected or if the battery runs out while the person is in need to be detected or assisted. This is why extended battery designed solutions can be a life saver. It is also possible to be applied to common devices, such as smartphones, that will not be rejected by patients. The proposed approach consists in profiling patients so that using the most appropriated strategy for a patient's profile it will enable activation and deactivation of services, as needed for each profile, thus extending significantly the battery life. This will improve the chances for a patient to be detected and check for safety and, if needed provide him the necessary assistance.

Acknowledgment

The authors acknowledge the European Commission for its support and partial funding and the partners of the research project CARELINK, AAL-CALL-2016- 049 funded by AAL JP, and co-funded by the European Commission and National Funding Authorities of Ireland, Belgium, Portugal and Switzerland.

References

[1] H. Chertkow, H. H. Feldman, C. Jacova, and F. Massoud, "Definitions of dementia and predementia states in Alzheimer's disease and vascular cognitive impairment: consensus from the Canadian conference on diagnosis of dementia," *Alzheimers. Res. Ther.*, vol. 5, no. Suppl 1, p. S2, Jul. 2013.

[2] M. Prince, R. Bryce, E. Albanese, A. Wimo, W. Ribeiro, and C. P. Ferri, "The global prevalence of dementia: a systematic review and metaanalysis.," *Alzheimers. Dement.*, vol. 9, no. 1, pp. 63-75.e2, Jan. 2013.

[3] J. J. Jalbert, L. A. Daiello, and K. L. Lapane, "Dementia of the Alzheimer Type," *Epidemiol. Rev.*, vol. 30, no. 1, pp. 15–34, May 2008.

[4] Alzheimer's Association, "2017 Alzheimer'S Disease Facts and Figures," *Alzheimer's Dement.*, vol. 12, no. 4, pp. 459–509, 2017.

[5] "Wi-Fi Alliance." [Online]. Available: https://www.wi-fi.org/discover-wi-fi. [Accessed: 29-Apr-2019].

[6] "Bluetooth Technology." [Online]. Available: https://www.bluetooth.com/bluetooth-technology/. [Accessed: 29-Apr-2019].

[7] "LoRa Alliance." [Online]. Available: https://lora-alliance.org/. [Accessed: 29-Apr-2019].

[8] "ETSI - 2G." [Online]. Available: https://www.etsi.org/technologies/mobile/2g. [Accessed: 29-Apr-2019].

[9] "Cellular Standards for the Third Generation." [Online]. Available: https://www.itu.int/osg/spu/ni/3g/technology/#Cellular Standards for the Third Generation. [Accessed: 29-Apr-2019].

[10] "Release 13." [Online]. Available: https://www.3gpp.org/release-13. [Accessed: 29-Apr-2019].

[11] "Standards for the IoT." [Online]. Available: https://www.3gpp.org/news-events/3gpp-news/1805-iot_r14. [Accessed: 29-Apr-2019].

[12] Ross Bowie, "Global Positioning System/Wide Area Augmentation System," *Aviat. Saf. Lett.*, no. October, 2010.