ANT+ Medical Health Kit for Older Adults

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Abstract. This paper describes the research made on current mobile health monitoring systems targeting the elderly and the development of an elderly-oriented solution, serving as a proof-of-concept of the research done. It provides a scientific contribution by specifying a system with characteristics never combined before, when applied to the health monitoring of older adults. Also, a prototype for that system was developed and evaluated with its end users – the elderly.

The proof of concept solution allows the patient to measure his weight and blood pressure with ANT+ sensors connected to his Android smartphone. The measured data is stored on the mobile device for later reading and sent through the network, to a medical entity. This entity can, whenever desired, analyse that information and give an appropriate feedback to the patient through a web application.

Keywords: health monitoring, mobile health system, wireless sensors, ANT+, Android.

1 Introduction

Rising life expectancy and declining birth rates are ageing the population of most developed countries all over the world and in a few years there will be a large portion of senior citizens in our society [12]. Therefore, it is very important to figure out ways to improve their well-being and quality of life.

Unfortunately, the elderly are more likely to suffer from certain types of diseases when compared to younger people and if a problem is not detected in time, serious problems can arise, resulting in a longer and more difficult treatment. Which means they need to be monitored more often in order to detect changes in their condition as early as possible [13]. Long trips to the hospital, expensive medical appointments or the lack of specialized doctors in remote areas, are all motives that constantly lead an older person not to have proper health cares [3].

In addition, if the patient eventually gets worse, he will probably have to pay for several medications and different treatments. Treatments that usually also have costs for the hospital; several studies have shown that the health care expenditures increase significantly for the elderly [7]. Eventually if the patient needs to be hospitalized, these numbers will obviously rise and the simple fact of being in the hospital can bring more problems to his health condition [9].

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Summing up, the lack of proper monitoring might end up bringing costs to both patient and health system.

Recent improvements in sensor technology have allowed the creation of small, light weight and wireless devices that are practical and easy to use by almost everyone. The result is that much of the process of clinical examination, once done in uncomfortable and harsh environments, can now be done at the patient's place of comfort. Combining this technology with the computing power of a smartphone and its connectivity to the Internet, there is a large number of possibilities to try to reduce some of the problems regarding the elderly. Renowned entities are already embracing these trends, as the Medical Technology Policy Committee of the IEEE USA refers: "Appropriate adoption of existing and emerging technology can improve the efficiency and quality of health care delivery, restrain cost increases and, perhaps most importantly, improve the quality of life for our ageing population" [2].

1.1 Motivation

The motivation of this work was to apply the growing use of communication technologies, namely the smart-phones and the Internet, in order to:

- **Prevent health problems** — Frequent monitoring of the elderly can avoid severe health problems [13,3]. This monitoring often consists of checking a few parameters, like the heart rate, the blood pressure, among others. Most of these values can be read with wireless sensors and then sent to a common smart-phone. A possible scenario is one in which a patient has a blood pressure monitor at home, does a couple readings and those values are sent to the patient's smart-phone. The mobile device is then able to store those values and send them to the patient's doctor that can, at a later moment, give a more accurate feedback to the patient;
- **Enhance the doctor-patient communication** — Nowadays with the Internet, it is very easy to send big amounts of information in a fast and cheap way. As a result, information that was once only available through direct contact with the patient, can now be easily sent with a smart-phone;
- **Reduce costs** — Both smart-phones and the Internet are becoming more and more accessible to the population in terms of costs and availability. This fact makes the solution being here presented, a feasible and useful product to the patients and also to the health system. A study states that with mobile healthcare, costs related to data collection can be reduced by 24% and costs in elderly care can be reduced by 25% [17,7,9].

1.2 Goals

The goal of this study was to research on mobile health systems for the elderly, using the ANT+ wireless technology and create a system as proof of concept with the interactions presented on Figure 1.

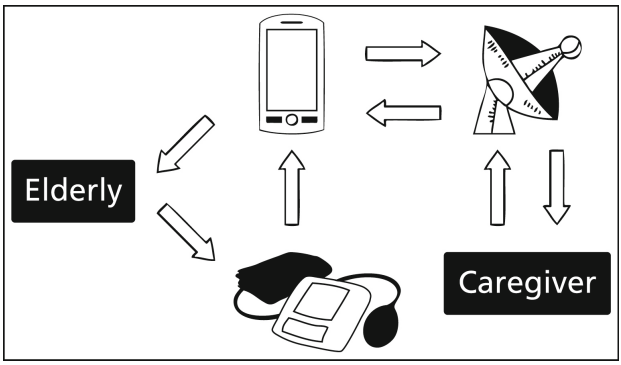

Fig. 1. System architecture

A certain patient would have his sensor that would capture one of several values, including heart rate, blood pressure, weight, body fat, among others. The sensor would then receive the data from the patient and send it to the smart-phone, allowing him to immediately read the collected data. At the same time, that data would be sent through the network to a medical entity, who could analyse it thoroughly and contact the patient again, if necessary. The same information could be registered in a remote server, in charge of the medical entity, so that the doctor would be able to review the historical data from any patient, at any time.

1.3 ANT+

ANT+ is a wireless sensor network technology, designed to enable communications between self powered devices in an extensible network environment, easing the collection, automatic transfer and tracking of sensor data for monitoring of all personal wellness information. This ability to transfer data between sensors is a feature built on top of the base ANT protocol, a proprietary technology. Rod Morris, director of ANT Wireless states at the ANT+ website [18], that ANT is the lightest protocol available that still has the ability to scale into complex network topologies and communication methods, achieving lower costs and power. It is capable of being powered by a coin cell battery, operating on it for up to several years. ANT+ is said to be compact, with a small stack size; scalable, supporting complex network topologies; flexible, supporting ad hoc network reconfiguration; focused, by not being a standard development organization; and proven, because of the millions of nodes delivered around the world.

Ant+ has several device profiles defining the network parameters and the structure of data, so that different products are able to communicate seamlessly. Current ANT+ profiles are currently available for the following devices: Heart Rate Monitor, footpod, Bicycle Speed and Cadence, Bicycle Power, Weight Scale, Multi-Sport Speed and Distance (Radar, GPS).

It is a quite recent technology and not much research has been done using it. Besides, most of the products available on the market focus on sports and fitness, instead of health and well being. One of the innovative points of this study was to take advantage of this technology and apply it to health services.

2 Work Description

The following subsections describe the work done during this study, starting with a review on the state of the art research, followed by a description on the system requirements specification and architecture, both usability tests that were conducted and the implementation of the working prototype.

The prototype consisted on a mobile application developed under the Android operating system, to be used by the patient and to connect with the ANT+ sensor devices; and a web application developed in Ruby On Rails, targeted for the physicians and in charge of receiving and transmitting data to each patient's mobile application.

2.1 State of the Art

Research was made on all areas whose domain intersects this study, going from similar mobile health systems, to designing applications for the elderly, to the technologies being used.

Although related projects have already been developed, some do not use the technologies in this study, others are seeking the detection of health problems in real-time and others are simply not targeted to the elderly [10,5,3,1]. Seto et al. [16] conducted a comprehensive study on mobile health monitoring, providing insights on the main features contributing to a successful heart failure telemonitoring system, claiming it should provide immediate self-care and clinical feedback, it should be easy to use and the perceived benefits of using the system should be clear to everyone involved

Holzinger et al. [6] review the major problems of the elderly using mobile phones, as a way to understand what developers can change to create applications capable of reaching their needs; categorizing their problems into cognitive, motivational, physical and perceptive. Regarding the patient's attitudes and perceptions, it should also be noticed that not all the elderly will be willing to adopt such a monitoring system. A study from Marzegalli et al. [8], showed that some patients embraced the use of mobile applications for remote monitoring, although they were not willing to replace the personal contact with their health workers and older patients with disabilities will find it difficult to adapt to such systems.

The researcher Sarasohn-Kahn [15], is concerned that too much application development is carried out by specialists without the involvement of patients. She believes that the challenges to the smart phone growth include finding the right business model and privacy issues. A report by Fox and Purcell [4] presents the same opinion by stating that despite already existing hundreds of health oriented applications, few of them are designed thinking about the patient in the first place.

At the moment of writing this paper, no project was found that combined the ANT+ technology with the Android platform, together with a web application, for health monitoring of the elderly. Also, this research reinforced the importance of usability when aiming for the elderly. At last, it was noticed that no evaluation metrics were found on the prototypes developed within these studies, leaving little room for a proper comparison with the prototype built for the current study.

2.2 Requirements Elicitation

For a better requirements specification, interviews were conducted with a few medical specialists, bringing a better knowledge on general health care and on the clinicians opinions regarding this project. As expected, some of these thoughts confirmed what other studies have already stated. The main opinions that resulted from the interviews are presented next:

- Hypertension and diabetes would be the most easily detected diseases, within the monitoring system here envisioned, using a blood pressure monitor and glucose meter, respectively[1].
- A better knowledge of the disease by the patient himself is always beneficial and integrating some kind of hint advisor before and/or after each measurements, would be interesting, thereby confirming the study from Seto et al. [16].
- Regarding the user interface, they thought to be very important to keep things simple and not complicate processes and operations for both patients and physicians.
- Giving constant feedback from the clinician to his patient is an important feature, although it may be hard for him to handle extra workload and a proper delegation of work between doctors and nurses should be made.
- Similar systems currently being used are focused on real-time monitoring, with the patient having to walk with a device at all time. The flexibility and mobility provided by the system being developed here would be a big advantage.
- All interviewed clinicians referred the importance of separating the information presented to patients and physicians. For instance, if an anomaly is detected perhaps it is not wise to show it to the patient right away, or even show it at all. This type of information may worry the patient in a way that is not beneficial for either patient and physician.

Given all the insights and after weighting the pros and cons, important decisions were made on the features to be developed on the working prototype.

2.3 System Architecture

A description of how physical components interact between each other is presented on Figure 2. This diagram was grouped by: devices which solely interact

[1] During this study, the only available devices were a weight scale and a blood pressure monitor.

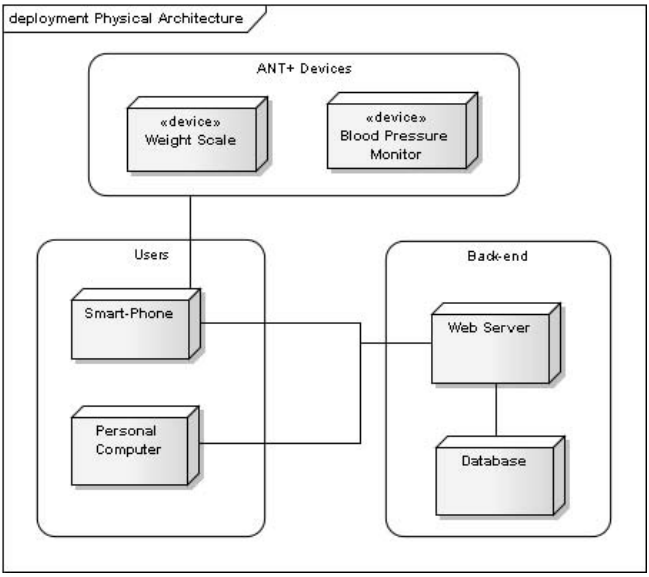

Fig. 2. Physical Model

with ANT+ technology, devices which remain on the back-end and devices used by patients and physicians.

On the users devices there is the smart-phone, which is used by the elderly and interacts with all available ANT+ devices – weight scale and blood pressure monitor. The other device on this group is the personal computer, used by either patients or physicians. Both users devices interact with the web server on the back end group, serving as the connection point between the system users. At last, the web server connects with its database in order to store and retrieve the system's persistence data.

2.4 Low-Fidelity Usability Tests

Once the system was thoroughly planned, low-fidelity usability tests were conducted with 9 elderly between 62 and 81 years old and in average, 71.6 years old, willing to help the project. The tests followed instructions advised by human-computer interaction experts, such as the think aloud protocol [14] or how to properly introduce the test to the participant [11].

This phase resulted in user-interface prototypes and its advantages were significant: a much better understanding of the users by the developer and the output provided – user interface prototypes – which ended up saving much of the development time, thereby accomplishing a better quality in the proof-of-concept solution.

2.5 Implementation

The mobile application development, started by implementing the ANT+ communication with the available devices – a weight scale and a blood pressure monitor. Then the Android application was developed, allowing the elderly to measure his weight and blood pressure with the help of the smart-phone and if desired, send those values to his clinician — the values are stored on a local database for later reading. He is also able to communicate with his clinician by sending and receiving messages through the application interface. Furthermore, if a physician schedules a measurement with one of the sensor devices, within the web application, the smart-phone appropriately notifies the elderly of such measurement.

The web application was targeted for the clinicians, although patients also have access to it. From a clinician point-of-view, it allows him to choose what patients he wants to monitor. Once a patient is being monitored by him, he is able to: view his measurements and messages history; send him a new message; schedule measurements with a custom frequency; and specify threshold values for each sensor, so that he is warned whenever a measurement value is too high or too low. From the patient's point-of-view, he can access the web application in order to view his measurements and messages history and also send the physician a new message.

2.6 Prototype Usability Tests

Once both mobile and web applications were done, it was time to test the prototype with its end users, the elderly. Similarly to the usability tests previously conducted, 9 elderly were involved in the tests, this time between 59 and 74 years old and in average, 67.8 years old. These tests were conducted within an apartment, so the elderly could feel more confortable, relaxed and the tasks they would do could be simulated with the maximum possibly realism.

The goal was to simulate the entire process of the system's usage: the patient goes to an appointment in the hospital or clinic, then goes home with both smart-phone and ANT+ devices, and when a scheduled alarm appears on the phone he measures himself with the corresponding device and sends the values to his physician. Then on the web application side, a clinician analyses the patient's measurements and sends a feedback message to the patient. Now back to the patient, he receives that message, reads it and gives an answer to his physician. To finish the process, the patient uses the smart-phone to review his latest measurements. In each session the smart-phone was given to the participant and the entire session was recorded from three angles: one camera on the living room, another on the bedroom and the last one on the smart-phone itself, recording everything the elderly was doing.

All testes were made in average, in 29 minutes, with a standard deviation of 5 minutes. The graph presented on Figure 3, shows how much time each measurement took, from the moment a participant received an alarm in the smart-phone, to the moment he sent the values to his physician. Each blood

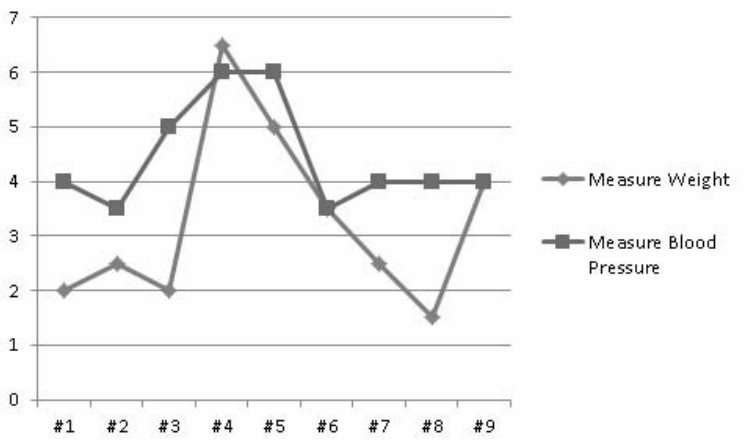

Fig. 3. Duration of Measure on Prototype Tests

pressure measurement took in average 4 minutes and 30 seconds, while the weight measurement took in average, 3 minutes and 20 seconds. Comparing these times with the ones taken on the low fidelity usability tests, a decrease in the duration of each measure was visible. This proves that not only the mobile application matched the success of the usability prototypes, but it also made both operations quicker. The peak on participants number 4 and 5 can be explained by those participants clearly difficulties, when comparing to the remaining participants. One of them, was the oldest participant, while the other had a chronic injury in his fingers.

All of them told that any difficulties found in each task would only occur on first usage and if they were to make the test again, it would be much easier and much quicker.

On the remaining tests – reading the feedback message, writing it back to the physician and viewing the latest measurements – several difficulties were found and the times taken on each of them are not conclusive. The user-interface used on these tests, was not subject to prior usability tests and although it followed a few guidelines taken from the first usability tests (font type, size, background and text colors, etc.), participants still found some obstacles. These difficulties only prove the importance of conducting usability tests with the end-users of a system.

3 Conclusion and Future Work

One of the innovating points of this study was to apply ANT+ devices to health care services and its usage was proved to be as effective as any other wireless technology, with the advantage of achieving very low costs and power, by today standards. During development, the ANT+ chip was used quite often and still,

no significant changes in the battery life of the smart-phone were noticed. Its current competitor, Bluetooth 4.0, is still integrating with current devices and it is still early to tell which of them is a better choice.

The advantages that may arise from this project were visible through the developed working prototype. The results on Figure 3 show us that on average, an elderly would take less then ten minutes to measure important health values and send them to his physician. As a monitoring operation, we believe it is a non-intrusive and acceptable duration for the elderly to do on a regular basis.

The tests participants were all clearly motivated on the work being made and several even asked where they could buy such a product. In the country where this study was made, Portugal, no similar mobile health system has ever been implemented. Their only concern was the cost of buying such devices, which is understandable given the current economic crisis. Although with the right partnerships and a sensible business model it may actually become a reality in the near future.

Future work should start by refining the working prototype. The approach on getting the data from the blood pressure device could be enhanced, as well as implementing the HTTP-Secure protocol for transferring data from the mobile device to the web server. Also, conducting prototype tests for the web application on the physicians point-of-view, would be very important in order to evaluate the developed prototype. Conducting more usability tests would also be valuable, especially on the user interfaces that were not tested during this work. At last, efforts could be made together with health specialists, in order to look for other devices to be integrated with the prototype here developed.

References

1. Boulos, M.K., Wheeler, S., Tavares, C., Jones, R.: How smartphones are changing the face of mobile and participatory healthcare: an overview, with example from ecaalyx. BioMedical Engineering OnLine (2011)
2. IEEE-USA Medical Technology Policy Committee. Technologies for addressing the health care needs of our aging population (November 2009)
3. Chan, V., Ray, P., Parameswaran, N.: Mobile e-health monitoring: an agent-based approach. IET Communications 2(2), 223–230 (2008)
4. Fox, S., Purcell, K.: Chronic disease and the internet. Technical report, Pew Research Center's Internet & American Life Project (2010)
5. Gay, V., Leijdekkers, P.: A health monitoring system using smart phones and wearable sensors. International Journal of ARM 8(2) (2007)
6. Holzinger, A., Searle, G., Nischelwitzer, A.K.: On some aspects of improving mobile applications for the elderly. In: Stephanidis, C. (ed.) Universal Acess in HCI, Part I. LNCS, vol. 4554, pp. 923–932. Springer, Heidelberg (2007)
7. Mayhew, L.: Health and elderly care expenditure in an aging world. Research report (International Institute for Applied Systems Analysis) (2000)
8. Marzegalli, M., Lunati, M., Landolina, M., Perego, G.B., Ricci, R.P., Guenzati, G., Schirru, M., Belvito, C., Brambilla, R., Masella, C., Stasi, F.D., Valsecchi, S., Santini, M.: Remote monitoring of crt-icd: The multicenter italian carelink evaluation – ease of use, acceptance, and organizational implications. Pacing Clin. Electrophysiol. (2008)

9. Creditor, M.C.: Hazards of hospitalization of the elderly. Annals of Internal Medicine 118(3), 219–223 (1993)
10. Milosevic, M., Shrove, M.T., Jovanov, E.: Applications of smartphones for ubiquitous health monitoring and wellbeing management. Journal of Information Technology and Application (2011)
11. Nielsen, J.: Usability Engineering. Morgan Kaufmann Publishers Inc., San Francisco (1993)
12. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. World population prospects: The 2010 revision. Technical report, United Nations (2011)
13. Scanaill, C.N., Ahearne, B., Lyons, G.M.: Long-term telemonitoring of mobility trends of elderly people using sms messaging. IEEE Transactions on Information Technology in Biomedicine 10(2), 412–413 (2006)
14. Senger, C.J.: Thinking Aloud Protocols: A Tool for Teaching (1992)
15. Sarasohn-Kahn, J.: How smartphones are changing health care for consumers and providers. Technical report, California HealthCare Foundation (2010)
16. Seto, E., Kevin Leonard, J., Joseph Cafazzo, A., Barnsley, J., Masino, C., Heather Ross, J.: Perceptions and experiences of heart failure patients and clinicians on the use of mobile phone-based telemonitoring. J. Med. Internet Res. 14(1), 25 (2012)
17. The Socio-Economic Impact of Mobile Health. Technical report, The Boston Consulting Group and Telenor Group (2012)
18. Morris, R.: Why ant?, `http://www.thisisant.com/why-ant`