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IoT and Big Data in well-aging: the IoTEA project

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ABSTRACT

New opportunities are continuously arising with the evolution of technologies as Internet of Things (IoT), Big Data, e-Health, among others. In particular, the senior houses and the nursery homes can take great advantage of them in order to promote the well-aging of the community members. Not only their everyday life can be analyzed fetching for their current features; their health trend would eventually help in the early diagnose of illnesses as well, not to mention the promotion of an active life. This study focuses on a new project that has just been started: the IoTEA project. The final aim of this project is to integrate all the above mentioned technologies into a real world application so an improvement in the everyday life of the members of a nursery home can be attained, considering energy efficiency models for being delivered on the wearable and mobile solutions. This project is in its very first stage: gathering data from participants with the aim of characterizing the main tasks and activities, discerning among certain events and, in the best case, identify anomalies. With a successful development of the project, an extension for an open source e-Health platform focused on nursery homes and senior houses will be delivered, introducing real time detection of seizures, falls, etc.; moreover, real time monitoring of the participants -with on line reports and personalized notifications with recommendations and well-aging suggestions will be attained.

Key words: Big Data, IOT, Big Data Aging, e-Health

1. INTRODUCTION

In recent years, the development of technologies such as wearable devices (WD), Internet of Things (IoT), Big Data modelling and analytic, among others. Nowadays, there are certainly a great deal of studies proposing either new approaches and basic research or applying such techniques in real controlled/constrained scenarios. Interesting enough to mention, the main part of the studies focus on a very specific problem, analyzing it and proposing a novel solution. However, when facing a real complex problem that intersects several of the above mentioned topics, a different holistic approach is needed.

This study presents a project that is currently starting, the I oTEA project. This project aims to generate a platform that allows the well-aging of the members of the community in a senior house or a nursery home, integrating as many technologies as possible while at the same time keeps affordable. Very interesting solutions are been considered, like mixing different distributed architectures -including Cloud Computing (CC), Fog Computing (FG) and Mobile Cloud Computing (MCC). On the other hand, basic intelligent services -such as falling detection, activity identification, etc.- are to be integrated, allowing to monitor the participant life status.

Furthermore, the proposal should allow the system to grow in these intelligent services. This requirement means that variable data streams might be needed, modulating the storage needed in each stage of the developing of these new intelligent services as well as the communications acts. Finally, all this project will be deployed on a real scenario, a nursery home located in the central part of Asturias, Spain. This fact will allow to develop and validate the new solutions in real scenarios, while a cost assessment can be performed at the same time. Nowadays, the IoTEA is starting, in the preliminary stage of designing and developing the basic infrastructure and services.

The final goal of the project is to provide an extension to an open source e-Health platform in order to manage the data and information -and, therefore, the extracted knowledge- from nursery homes and senior houses. The project should cope with highly scalable Apps for the Smart-phones, intelligent service federation, fog computing services running on low cost servers and highly interconnection with the healthcare system. The relevance of this project is two-fold: on the one hand, every single building would eventually become into a senior house with a very reduced cost; on the other hand, the ubiquity of the intelligent services provided would allow the elderly participants to engage with a enjoyable life, promoting their well-aging opportunities.

This contribution is organized as follows. Next section deals with the related work in the literature. Section III describes the iniciative, while Section IV focuses on this very initial stage. Finally, some conclusions are drawn.

2. RELATED WORK

The study published in [1] was one of the first studies for deployment of IoT in homes and senior houses. The study analyzed what it's call Aging in Place Initiative: to examine the behaviour of two participants in their everyday living using not only WD but also a distributed sensor network together with local nursery attendance. Several years later, it was found that the Aging in Place Initiative promotes the well-aging, with longer independent and healthier living [2]. This is what IoT and e-Health is here for: introducing technology in our lives, so our wealth is enhanced. Besides, the introduction of these new technologies should avoid -or consider pretty much, at least- the increment of time spent in documentation and clinical review that usually accompanies the e-Health platforms [3].

Wearable devices (WD) are one of the main research lines in the IoT as long as there have been an important reduction in the device prices and an exponential grow in the device offer. Many studies have been proposed in the literature, an interested reader can refer to [4] for a very interesting review of both the design requisites and the different solutions in the market. However, a recent study of perceived attitudes of the users of WD in China came to the conclusion that, despite the utility and the monitoring enhancements that might be available, there still exists a resistance to share health data or even to use a WD in a 24/7 timetable [5].

Well-aging got the focus in recent years, and the research and industry has come to several interesting solutions [6]. Fall detection is one of the most interesting examples of IoT and WD in well-aging, and several approaches have been proposed in the literature, i.e., using wavelets together with an ensemble of simple classifiers [7], [8], images with more realistic falls[9] or acceleration together with Kinetic imaging analysis and KNN classifier [10]. And a relationship between the weight loss and the use of WD has also been published [11]. Recently, a study has evaluated the main technical requirements in order to develop aging friendly smart houses [12]; perhaps this study is too much centered on the intelligent gadgets to include within the building process of this type of intelligent tools and not to much on e-Health.

However, plenty of the approaches are not completely wearable -at least, they are constrained to be experimental only-. A solution for monitoring the meal time and events for elder participants was proposed in [13]. Several sensors were placed on the body -one on the chest, one on the abdomen, one on the wrist- to detect the normal breathing, liquid and solid swallowing, and speaking. Technically sound, this study is rather too much to be deployed in real scenarios as no one would like to carry all these equipment during all day long. Solutions should be worth their benefit but introducing as less constraints as possible.

Furthermore, the concerns with the data framing and tailoring of wearable e-health communications were studied in [14], where the authors stated that there would be a balance between the two variables in order to optimize the e-health communications. This means that each problem would need its specific study concerning these two variables, fetching for the optimal values. Additionally, these variables also affects to the gathering of information for the developing of new intelligent services and the amount of data that would eventually be interchanged. Moreover, the ideas proposed in [15] concerning that there should be a collaboration in the design of both the WD and the e-Health systems. This is actually what was proposed by certain WD brands, like Pebble [16]; unfortunately, this is not the most common procedure and this company discontinued the production.

Open m-Health, its opportunities and challenges have been addressed in [17]; although there are favorable chances to develop interesting solutions, the lack in collaboration and the sparsity of the approaches might introduce an important delay in this future becoming a present today, as suggested in [18].

Two very interesting and promising open software tools are gathering the focus on e-Health: the case of mHealth and GNU-health. The former, with Apache 2.0 license [19]- is devoted to integrate the data from different sources -as WD can be-, allowing to store, process, share and monitor data from patients. On the other hand, GNU-health is an ERP software specialized in the health system, designed and developed to manage from a single medical consultation to a network of hospitals.

As a conclusion, several problems arises and are still unsolved in the context of well-aging. First of all, the available platforms are mere ERP software platforms, not involving the participants in the whole system. On the second hand, existing solution providing some services for well-aging have been designed as isolated proposals, dismissing the relevance those services can represent for the healthcare system. Furthermore, the ergonomic issues have been barely considered, either in the selection of the sensory systems or in the required training stages. All these problems need addresing, which is what the IoTEA project focuses on.

3. THE IOTEA PROJECT

The IoTEA project -IoT for the active aging, in Spanish *envejecimiento activo*- aims to develop an specific platform for health monitoring and promoting the well-aging, to be deployed on senior houses and nursery homes. Using smart houses and WD technologies together with specialized e-health solutions, the project should integrate the medical monitoring, the intelligent tools for identification of relevant events, the feedback to the user to promote the physical activity and healthy habits, among others. As can be seem, this is a very ambitious project, which is in its very beginning stage.

The main idea is to integrate the two open source initiatives mentioned so far, Open mHealth and GNU-health. This integration is, basically, to avoid reinventing the wheel; moreover, the project itself is though as to be open source, so it makes sense to reuse strong open projects.

Nevertheless, there are some interesting perspectives that should be kept in mind. Using WD and similar smart solutions introduces the big data problem and the network bandwidth problem. The big data problem refers to the amount of data streams that might be needed to identify an event, to detect a seizure or fall, etc. Furthermore, this also refers to the extensibility problem due to more intelligent services that might be designed at any point in the future, needing unexpected data streams. Or the contrary, once a new intelligent service has been designed, there could be a reduction in the data traffic among the agents.

However, it is not possible to guarantee network connections for every single possible location of an elder house. On the other hand, each intelligent service will require computational power, the data storage is also required, and so on. Therefore, this is why we propose a different architecture, one that makes a balance between the location constrains in network connection and computational capabilities. In this context, the development of energy efficient models and data processing is an unavoidable concern.

In this proposal, MMC, CC and FC should be loosely integrated, so to allow the services be carried out in the different possibilities according to the current status of the environment. Essentially, a set of servers should be deployed at each location, establishing a FC environment. FC should be the main contributor to the needed computation and storage, sharing data with external e-health services and even with the Health Care system. Whenever necessary, some computations can be performed in the mobile, releasing some computation from the FC, always taking in consideration the energy efficiency issues. In this sense, the MCC must consider the battery life, so there is a limit on the use of this type of computation. Finally, before reaching the scenario in which the services can not be delivered, the computational services should be requested to the CC -mainly, a confederated CC of Senior houses or the Health Care system-.

Clearly, the MCC introduces new problems in privacity and authentication [20] that should be solved. So does the authentication problems between Wearable and the mobile devices [21], not to mention the security problems that may arise in e-Health systems [22].

An overview of the whole approach can be seen in Fig. 1. Each participant is given with a kit including a wearable device and the matched Smartphone. Either alone or connected to the home WIFI network, the MCC is performed. In the first case, it's mandatory as no other service is available without a severe increase in the phone service fees. Whenever the home network is available, the services can be performer elsewhere. The home infrastructure is the responsible of the Fog Computing services, performing as much as possible according to the services complexity and the availability of computing resources. Any service not reachable through MCC or by means Fog Computing should be delivered through the healthcare system. However, the data extracted or the facts educed should represent the feedback from the healthcare

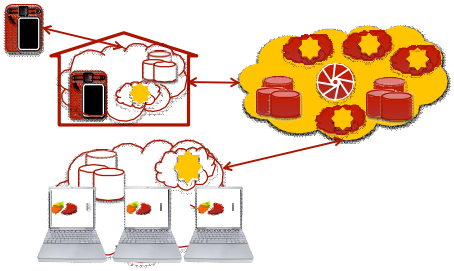

Figure. 1: An overview of the main proposal. Fog computing working on the houses and homes, Mobile Cloud Computing on the mobile devices, and Cloud Computing on the healthcare system. Intelligent services will generate and deliver relevant facts for the medical staff.

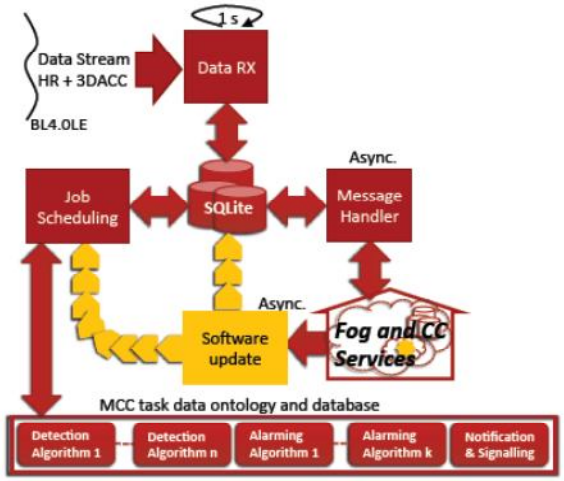

Figure. 2: MCC software model. The underneath ontology of task sequences are not included. The scheduler organizes the sequences of tasks and where to have them accomplished. All the tasks and models, even the communication with the wearable device, aer totally controlled by the information stored in the database.

system. This latter is modeled as an specific ERP software, as presented in the GNUhealth platform. Finally, both the control of the sequences of services performed for each participant and the intelligent generation of reports and suggestions to either the medical staff or the participants, are to be integrated to the specific e-Health ERP platform as well.

The MCC model is depicted in Fig. 2. All the tasks and data communication acts are represented in the database, allowing to hot swapping from either wearable device or desired tasks to perform on a set of variables. Even the models are stored in the database, so continuous updating and active learning can be achieved.

4. FIRST STAGE DEVELOPMENT

The very first step in this project is the deployment of a simple system to gather data from participants in a Senior House in Asturias, Spain. Each participant will be given with a pack of a BL4.0 wrist-located WD -measuring the heart rate and the acceleration- plus a smart-phone, all configured to work properly. Furthermore, a server with storage capabilities will be placed in the senior house to avoid the internet flow,

mimicking the above discussed environment.
Data from up to 10 participants will be gathered during two months, with the collaboration of the physicians from the senior house to record the activities timetable and relevant events for each participant. An initial stage for calibration will the included, making the participants to accomplish with a set of activities in a constrained time period.

The calibration stage will eventually allow us to identify the most relevant transformations for detecting some activities, and to learn their range of heart rate variability. Furthermore, the records from the physicians will allow to segment the data gathered form the participants during the two months trial.

Once the data is gathered, the data processing and model learning will take place, with the aim of extracting relevant models to deploy. The next step in this project will be based on these discoveries: all of them will be implemented as intelligent services and validated in the next generation of trials, which we expect to be on daily basis.

5. CONNCLUSION

This manuscript deals with a new project, called IoTEA. This project aims to develop an open source platform for monitoring and promoting the well-aging of elder people. The main ideas of this project are i) to include the available open software platforms to deal with e-Health and with wearable data, ii) to give each participant a set of WD and smart- phone in order to gather data, and the senior house with a FC capabilities, iii) to learn from real data the most interesting transformations and values to detect events, activities, etc.; all of these computations considering the energy efficiency as a restriction to decide whether a service should be delivered.
This project is now in the initial stage, where the basic infrastructure will be deployed in a senior house in Asturias, Spain. We do expect that by the end of the year relevant models would have been learned in order to prepare the second generation of trials to validate the findings and to continue the project.

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