Evaluation Metrics for eHealth Services and Applications within Smart Houses Context

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Abstract. eHealth services is a continuously growing sector, driving the need for advances in both the network characteristics and infrastructure, as well as in the available mobile devices used. The same need requires the development of quality software applications to facilitate and service eHealth activities. On these grounds, this paper proposes a novel evaluation methodology that takes into consideration the peculiarities of sensor/actuator related services. It further focuses on aspects of software quality for eHealth services and applications, and identifies a set of quality characteristics and attributes to take into consideration. These quality characteristics are integrated into our proposed evaluation methodology during the analysis and engineering phases, which is a revised version of the spiral software process used in web engineering. The efficacy of the proposed approach in a real scenario is discussed.

1 Introduction

eHealth services and applications are becoming more and more adopted in today's modern mobile computing society. Some factors that contributed to this end are amongst others the impressive growth of wireless mobile and sensor networks and actuators. The integration of the latter technologies into residences has led to the construction of Smart Houses (SHs). SHs are the evolutionary technological step of home in current society. Currently, many researchers have studied various aspects of Smart Houses [9,10,11]. A SH relies on real-world sensory equipment data, which are collected from smart integrated sensors/actuators that reside in heterogeneous distributed environments. Based on this input, the smart integration of sensors enables us to recognize the user interaction, sensing the situation and observe the context of the interaction and providing data inputs that can be analyzed and utilized for related eHealth services' decision making.

The main objective of this paper is to suggest a new approach for promoting quality in eHealth services and applications in smart houses, by enhancing existing evaluation methodologies for their assessment. To accomplish this, we propose a set of quality characteristics along with their corresponding metrics, that that take into account the peculiarities of developing eHealth services that employ sensor/actuator technologies. In order to validate our approach we evaluate the MPower project's [2] middleware platform using our evaluation methodology.

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2 Extending Evaluation Metrics for Smart Houses

Nowadays, a "Smart House" is considered to be a blending of wired and wireless computational technologies including sensors, actuators and processing units that cooperate with the aim to improve the quality of life of the user. Although current evaluation methodologies [12] seem to comprehensively approach the issue of services assessment, they are still lacking of focus regarding particular constraints and/or advanced technologies and tools incorporated nowadays in SHs, such as the use of sensors and actuators.

In this particular work, we are specifically interested in sensor and actuator technologies that support the creation of a smart house environment. In general there are two broad categories of classification regarding sensor devices: (a) *Smart House Sensors* (usually used for increasing the quality of life of the user), and (b) *Commercial Sensors* (providing mostly customized solutions to specific areas). To accommodate this additional functionality provided by sensors and actuators many new reference architecture models have been proposed [6,7,8], with Service Oriented Architecture (SOA) [5] being the most dominant.

However, little research effort has been devoted to the design and development activities of such sensor/actuator powered eHealth services and applications with the research effort to be mainly emphasized on mobile applications. Indicatively, a software quality model for mobile applications is presented in [1] denoting the general characteristics, sub characteristics, along with attributes and their metrics.

Nevertheless, as we can easily observe, the existing criteria are lacking any support for the sensor and smart house integration. In this regards, sufficient extension quality metrics criteria for eHealth services and applications within sensor smart homes context could include: (a) Sensor monitoring, (b) ease of management, (c) interoperability, (d) diversity of usage, (e) robust operations, and (f) flexibility. The abovementioned enhancements will be used as the base for the proposed evaluation methodology.

3 Proposed Evaluation Methodology & Metrics: The Case of MPower

Our proposed evaluation methodology (see Figure 1) starts by specifying the goals for this evaluation which enables us immediately after to define the quality metrics that we want to involve in the process. Although many quality metrics can be incorporated in the evaluation of software services, not all will prove highly useful at the end. All of the quality metrics introduced in the previous step are rated based on the importance and some of them are omitted due to low importance score. This results in the formation of the final quality metrics list that will be utilized in the process.

Subsequently, we identify the stakeholders that will be used to evaluate system based on the quality metrics produced in the previous step. Based on the stakeholders' expertise as well as other parameters (e.g., location diversity, network access) we develop an examination method. During the development of the examination method various information collection methods will be analyzed and some will be selected to carry out the evaluation. The final step is the presentation of the evaluation results.

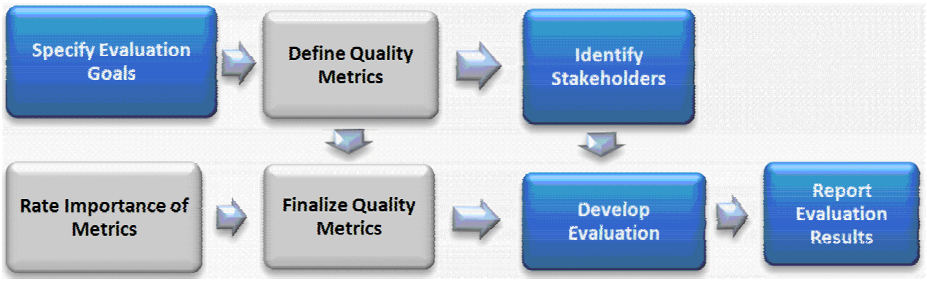

Fig. 1. Evaluation Methodology

Henceforth, the three new components introduced namely, *Define Quality Metrics*, *Rate Importance of Metrics*, and *Finalize Quality Metrics* (clearly note in fig. 1). The remaining four elements are usually found in such evaluation methodologies [3]. An optimized series of quality metrics that is utilized in the evaluation process has been selected and categorized according to specific aspects of the MPower middleware platform. Those are: Usability, Flexibility, Easiness, Performance (time), Performance (work), Interoperability, Robustness, Security, Multilingualism, Documentation, User satisfaction and Error Handling. These metrics ranked as most important due to eHealth context, peculiarity and constrains arising (e.g. Confidentiality, Security, Availability, Ease of Information Sharing, Expandability and Awareness).

It has to be noted that in the MPower project case, we have ranked the quality metrics with respect to the usability aspect of the platform, as if not satisfied may render the platform useless and the inability of been adopted.

4 Experimental Method and Results

Given the experimental setting constraints (users located in different facilities scattered across Europe) the user sample was around 20 users. We've ruled out information retrieval methods that require human interaction like Interview, Focus Groups, Observations and Case Studies and opted for online questionnaires. Specifically, we have tailored an online 100 items questionnaire method [4] and invited our user group to answer a series of questions organized in categories. Each question had to be answered in rating scale form which enabled us to extract and aggregate the evaluation results in a trouble free manner.

The results of our case study were really promising for the future of our work, showing that we have successfully managed to apply the proposed evaluation methodology in order to assess the MPower middleware platform. We list below the most significant gains of our evaluation:

Firstly, our evaluation methodology succeeded in providing continuous feedback to the developers of the MPower middleware platform through various phases of the project's lifecycle. This resulted in creating more usable and robust eHealth services. Secondly, utilizing our methodology made it easier for developers to methodically customize services to the specific needs of selected and new user groups. Thirdly, it

lowered the development costs that leaded to an increase in the number of services developed and enhanced functionality of provided services.

5 Conclusions

Current evaluation methodologies of Smart House eHealth services seem that do not include all these components that can comprehensively assess them since they are lacking elements referring to latest advancements such as sensors and actuators. Therefore, in this paper we have proposed an evaluation methodology that takes into account the unique characteristics of sensor/actuator powered eHealth services. In order to prove that our methodology is successful, we have utilized it to assess the MPower middleware platform. We have observed that applying our methodology led to the production of highly usable and robust eHealth services while reducing the time, cost and complexity required to develop such services.

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