A Reference Architecture for Healthcare Supportive Home Systems

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***Abstract*—Ambient Assisted Living (AAL) has become focus of attention for governmental organisations, and healthcare and ICT researchers. AAL includes methods, products, services, and software systems to support the everyday lives of elders. To develop AAL software systems, reference architectures (i.e., a special software architecture that guides the development, standardization, and evolution of systems architectures) have been proposed. Despite of the existing reference architectures, their use is a difficult task, due their high level of abstraction. Moreover, these architectures do not support the development of systems for tele-monitoring and self-management of chronic diseases at home. The main objective of this project is to propose a reference architecture for Healthcare Supportive Home (HSH) systems. With this project we will contribute in promoting and reusing the knowledge of expertise and in supporting the development, standardization, evolution, and quality of HSH software systems.**

***Keywords*-Healthcare Supportive Home; Reference Architecture; Interoperability; Ambient Assisted Living.**

I. Introduction

A major demographic shift is ongoing in most developed countries and recently in developing countries. It is expected that in 33 years from now, the population above the age of 60 will be 2.1 billion people, and above the age of 80 will be of 400 million people [2]. In the context of healthcare systems, important challenges regarding to population aging are: (i) Growing of diseases and disabilities, e.g., annual cost caused by Alzheimer disease grown from US$ 315 billion in 2005 to $422 billion in 2009[1]; (ii) Increasing of the demand for telehomecare to avoid long-term hospitalization [4]; and (iii) Healthcare requires increased efficiency while the number of support workers falls [4].

In this perspective, Ambient Assisted Living (AAL) has been conceived as one strategy for addressing the difficulties that this forthcoming demographic shift is originating. Currently, there is a vast number of European research activities in the field of AAL involving various technology areas (e.g., advanced human/machine interfaces, sensors, microelectronics, web&network technologies, energy generation or harvesting, control technologies, new materials, and robotics) and innovative technology approaches, e.g., smart homes, Ambient Intelligence (AmI), assistance robots, electronic health (eHealth), and sensor networks. Specifically, Healthcare Supportive Home (HSH) systems are a special type of AAL systems that involve a variety of technologies and aim at providing an autonomous life in their residence to patients suffering of chronic disease, handicaped persons, and dependent elderly people. However, current HSH systems are expensive and do not address important characteristics, such as interoperability, integrability, and usability. In this direction, an important challenge is to establish guidelines and standards to orient the development of such systems.

To support the development of AAL software systems, reference architectures have been proposed. In general terms, "a reference architecture refers to an architecture that encompasses the knowledge about how to design concrete architectures of systems of a given application domain; addressing business rules, architectural styles (sometimes also defined as architectural patterns that can also address quality attributes in the reference architecture), best practices of software development (for instance, architectural decisions, domain constraints, legislation, and standards), and the software elements that support development of systems for that domain. All of this must be supported by a unified, unambiguous, and widely understood domain terminology" [3].

However, existing reference architectures for AAL systems present a high level of abstraction and their use to develop HSH systems requires to invest a lot of time and resources. The main objective of this PhD research project is to propose a reference architecture for HSH systems. It is desired with this project to contribute in the promotion and reuse of experts knowledge in AAL and reference architectures and to facilitate the development, standardization, evolution, and quality of HSH software systems.

II. Research methods and partial results

To establish our reference architecture, we are using ProSA-RA [3], a systematized process to design, representate, and evaluate reference architectures. The following steps have been conducted:

Step 1: We selected the main sources of information to investigate and know processes, activities, and tasks that must be automated by HSH software systems. Results of

[1]http://www.alz.org/documents/national/world_alzheimer_report_2010.pdf

this step are the identification of user requirements (e.g., from chronic patients, physicians, geronologists, and nurses) the identification of architectural design decisions (e.g., styles/patterns that are commonly found in HSH software systems), the establishment of common concepts, and the selection of important reference architectures and models that could serve as a framework for our reference architecture. For this, we also conducted Systematic Literature Reviews (SLR), and we used interviews and questionnaires;

Step 2: Based on information from last step, in this moment, we are establishing a quality model, i.e., taxonomic, hierarchical decomposition of quality attributes for the AAL domain. In short, quality attributes are characteristics of software that specify the degree of an attribute that affects the quality that the software must possess[1]. This quality model will help to measure and evaluate the quality of HSH systems. Moreover, this model is the basis to define the requirements of the reference architecture, and it will constitute a method to communicate software quality knowledge during the use of our architecture. To create this quality model, we are using the DUMOND (Domain-oriented qUality MOdels Development) process [6]. DUMOND aims at defining quality models for specific domains based on standards and literature, and further validation by domain experts and software engineers;

Step 3: We will design the reference architecture for HSH systems. RAModel [3] will be used as basis for the establishment of this architecture, as it allows a better understanding about its elements, essential to adequately build, use, and evolve such architecture. Activities of this phase will be conducted at University of Groningen (RuG) during the sandwich period; and

Step 4: We will evaluate our reference architecture regarding quality characteristics, architectural description, and architecture design. For this, we will use checklist inspection approach [5], which guides on detecting defects in documents related to reference architectures. Moreover, it allows to evaluate the architectural description itself, through identification and elimination of defects related to omission, ambiguity, inconsistency, as well as strange and incorrect information. Besides that, we intend to instantiate our reference architecture for a specific HSH system.

Evaluation of results: Results of this PhD research project (i.e., the quality model and the reference architecture) are based on multiple sources of evidence (i.e., literature reviews, health professionals experience, software engineering expertise, and the analysis of current AAL solutions) and involve knowledge of AAL related areas (i.e., smart home, AmI, and eHealth). To evaluate our results, we will conduct case studies, experiments, and/or surveys. We will consider specialists in the related areas (such as medicine and physiotherapy) and also specialists in the Computer Science area.

III. Expected contributions

The present project intends to contribute to the AAL domain, specifically to HSH, a sub-domain that has not been properly investigated from the perspective of software architecture. The expected results are: (i) contribution to the AAL domain with a quality model for HSH, which will serve as method to communicate software quality knowledge when the reference architecture will be used; (ii) contribution to the Software Architecture area with a reference architecture that guides the development of software systems for the HSH sub-domain; (iii) contribution to two research projects supported by FAPESP (Grant: 2014/02244-7) and Capes/Nuffic (Grant: 034/12), which have as main goal to propose means to facilitate the design of critical embedded systems, including the establishment of reference architectures; (iv) consolidation of the research cooperation between ICMC/USP and RuG; and (v) an indirect social contribution will be the improvement of the quality of life of elderly people in their home.

References

[1] International standard ISO/IEC/IEEE 24765. Systems and software engineering Vocabulary (First edition) (2010).

[2] Nakagawa, E. Y.; Antonino, P. O.; Becker, M.; Maldonado, J. C.; Storf, H.; Villela, K. B.; Rombach, D. Relevance and perspectives of AAL in Brazil. *Journal of Systems and Software*, New York, United States: Elsevier Inc., pp. 985–996 (2013).

[3] Nakagawa, E. Y.; Oquendo, F.; Maldonado, J. C. Reference Architectures. Oussalah, M. O., *Software Architecture: Principles, Techniques, and Tools*, 1st edition. Chapter 2, London: Wiley, pp.55–82 (2014).

[4] Pare, G.; Sicotte, C.; Poba-Nzaou, P. Home telemonitoring for chronic disease management: An economic assessment. *International Journal of Technology Assessment in Health Care*, 29(2), pp.155–161 (2013).

[5] Santos, J. F. M.; Guessi, M.; Galster, M.; Feitosa, D.; Nakagawa, E. Y. A Checklist for Evaluation of Reference Architectures of Embedded Systems. *25th International Conference on Software Engineering and Knowledge Engineering (SEKE)*, Boston, MA, USA, pp.451–454 (2013).

[6] Villalba, M.; Fernández-Sanz, L.; Martínez, J. Empirical support for the generation of domain-oriented quality models. *IET Software*, 4(1), pp.1–14 (2010).