Adaptive Software Architecture for Confident Homecare in the Digital Home

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Abstract. Smart spaces foster the development of more natural and suitable forms of human-computer interaction taking advantage of customization possibilities offered by the home. The interaction chances of the Digital Home, as a special type of smart space, have a special interest in fields where the acceptance of new technologies is low and restrictive. Homecare is a discipline where this acceptance is more problematic. The integration of digital home design patterns in homecare solutions should enhance the final acceptance of users. In this position paper, we present the main challenges identified from the literature for the successful implementation of homecare solutions in smart spaces and the design of a software architecture that models entities and functionalities involved in solving these challenges.

Keywords. Personalized Healthcare, Person-Smart Space Interaction, Confidence.

1 Introduction and Problem Statement

The interaction model that ambient intelligence (AmI) offers has a particular interest in the definition of smart spaces used for the deployment of critical services such as the promotion of personal autonomy, telemedicine and e-health solutions [1]. In particular, AmI is being studied as a new concept of development in the field of homecare, because it facilitates the monitoring of patients in their usual environment [2]. It also provides other socio-economic benefits that must be taken into account such as the reduction of costs in the management of chronic patients [3] and the possibility of establishing a more direct relationship between primary and specialized care [4].

The Digital Home is a particularly interesting case of eHealth. Many studies point at the home as a suitable place to perform certain therapies, therapy management and patient follow-up [4][5]. ICT should facilitate or even enable such personalized healthcare effectively. However, users may not feel comfortable nor confident with these technologies, particularly in areas related to their health. Therefore, a proper

integration of ICT and the home would allow taking advantage of communication and automation capabilities of ICT with the customization and acceptance possibilities of the home environment. In this way, despite that trends in healthcare and the needs of today's society demands the use of AmI to develop new types of health services [6], there are unresolved issues that prevent the final implementation of solutions based on these models [7]. Therefore, the main objective of the digital home is the correct integration of technologies at home pursuing the deployment of useful services for users maximizing their acceptance.

2 Architecture Challenges of the Homecare Developments

The development of a homecare service that allows the integration of the different roles involved in clinical practices in an effective manner is an issue that poses serious challenges previously studied [8]. The addition of technologies that allow the integration of these services with the so-called smart spaces poses additional challenges from immersing users in, a *priori*, highly sophisticated environments.

After a review of homecare solutions and technologies deployed in the home, it can be concluded that, up to date, most of the new contributions have included adaptations of the technology used in other application areas. However both telemedicine and digital home have characteristics that significantly alter the requirements imposed on the technology in other areas. One of the critical issues defining a solution is the proposition of a functional architecture. Software architecture shapes the requirements in a formal way so it shows the patterns to fulfil those requirements. Next, the novel requirements recently detected are presented:

(1) *Installing devices*. Other solutions studied as background of this research, *including* ATLAS [9], S3OiA [10] or UniversAAL [11], lack the rigor required for medical applications so technology integrators have to be involved in most of the cases. Specialized technology integrators are the responsible to verify the proper operation of the final deployment. Thus, such role must be included in the architecture.

(2) *Interacting with the user's home*. There is a close relationship between the interaction pattern and the application logic in most of the services. This way a change in the logic of the application implies changes in the interface with users and vice versa. However this model does not fit well with homecare solutions at digital home because home users usually learn these new patterns of interaction and do not handle properly meaningful changes. Therefore the final design should disengage the strong connection between logic and interaction pattern.

(3) *Evolution of the solution*. Any solution based on ICT should be seen as an element evolving with its users. Evolution must allow both the addition of new features on the already deployed services and a change in the actual behaviour of the solution based on the acquisition of technical skills and confidence by their users [12].

(4) *Resilience.* The final use of a technology depends on the analysis and design for the solution and also on how the users finally decide to use it. Often technology have ended up being used, anyhow successfully, but in different ways that they were

originally set out for [12]. Thus, an architecture oriented to homecare must take into account both user experience and possible variation of use of the technology.

(5) *User confidence*. A key aspect is the confidence that users can develop to the system. Without this intrinsic and strong feeling, the acceptance of any proposed solutions will be low in any case, but especially in the case that real alternatives to provide the service *exist and are available*. This is considered as one of the main reasons behind the limited impact of telemedicine solutions today [8]. The architecture must be able to respond to the fears of users aiming to improve their confidence in the system.

3 Architecture Definition

The challenges discussed in the previous section organized the development of the architecture presented in this position paper. The main goal of such architecture is to provide the necessary level of confidence to all the stakeholders in any homecare system (End-user; Relatives and other informal take carers; Service provider such as health professionals, healthcare entities, etc. and Integrators), to provide the acceptance of all services being deployed. This confidence is based on a high level of adaptability and then it is organized in a modular approach (figure 1). In addition, we used the model action defined by the Activity Theory to determine the capabilities that architecture provides to each user, making it more comprehensible.

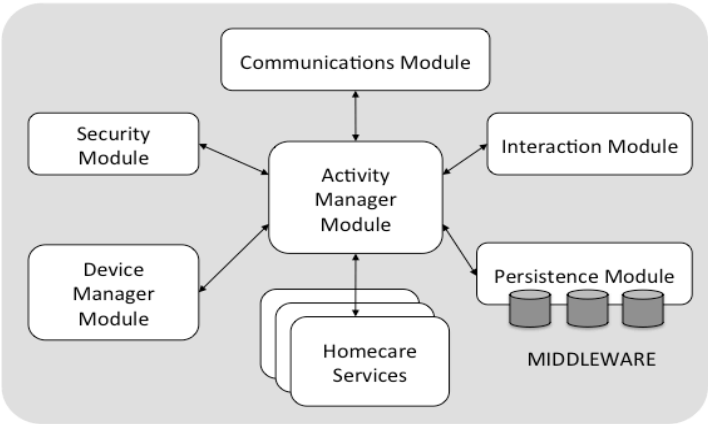

Fig. 1. The graphical representation of the architecture and the relationship between modules.

(1) *Activity manager module*. Activities represent an abstraction for the behaviour of our architecture, which set the capabilities of the smart space. This module manages all actions involved in each activity and organizes the interaction between the rest of the modules.

(2) *Device Management Module*. The devices are any element which process or provide information bringing that concept beyond the sensors and actuators offered by the current market for homecare. This means it should be possible to introduce as a

device some everyday object such as clothing, furniture or building materials. This module is in charge of standardizing a set of devices from different manufacturers or entities.

(3) *Persistence Module*. The information generated and managed by the architecture and systems must be tightly housed and stored. The Persistence module provides a unique address space and model to access to all the information handled by the architecture.

(4) *Interaction Module*. Smart spaces which are necessary for deploying complex services as homecare have a huge amount of items [13], usually imperceptible, which hinder the direct involvement of users. The interaction module aims to define an appropriate model for each type of user interaction, simple, intuitive and understandable, based on the set of activities that the deployed system has defined.

(5) *Communication Module*. This module manages the communication between remote systems. The homecare solutions have a distributed topology including communications between every kind of place involved, *e.g.* home and the health care centre. The communication is based on exchange of activities.

(6) *Security Module.* Security is a critical aspect and as such, it is necessary to define security comprehensibly for all the stakeholders involved in providing the service. Including security as an independent module forces to define protection capabilities of the architecture in terms of specific actions.

4 Future Work

The proposed architecture aims to provide a framework for deploying personalized healthcare solutions into smart spaces, particularly in a digital home setting, improving greater user acceptance. Next steps should cover service characterization, the design of a model for information exchange between entities and proper validation with a case study.

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