Flexible Home Care Automation

Adapting to the personal and evolving needs and situations of the patient

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Abstract — Health monitoring and healthcare provisioning at home (i.e., outside the hospital) have received increasingly attention as a possible and partial solution for addressing the problems of an aging population. There are still many technological issues that need to be solved before home healthcare systems can be really cost-effective and efficient. However, in this paper we will highlight another category of issues which we call architectural challenges. Each patient is unique, and each patient has a unique lifestyle, living environment and course of life. Therefore it should be possible to personalize the services provided by home healthcare systems according to the needs and preferences of each individual patient, and it should be possible to make incremental adaptations at later points in time if this is necessary due to, for example, a changing health condition. The architectural challenges and solution directions related to this has been discussed in this paper.

Keywords: flexibility, tailoring, personalization, home healthcare, health monitoring, social context, service-orientation.

I. INTRODUCTION

Healthcare provisioning in the home has been proposed as a cost-effective solution for the demographic changes in especially western countries that put increasing pressure on the traditional healthcare systems [1]. In addition, higher living standards enabled people's concern for personal health and quality of life and generated interest for home-based solutions that support well-being, health monitoring and independent living [2].

Arguments for home healthcare include economical benefits (by providing more efficient healthcare solutions and unburdening institutionalized healthcare) and social benefits (by facilitating and prolonging independent living). However, a medical motivation for promoting home healthcare is the ability to monitor patients continuously in their familiar environment, often in a non-intrusive way and without causing stress, as opposed to medical examinations in the hospital, which have to take place on appointment at a specific time and place.

We are now witnessing many innovations in the area of home healthcare, thanks to recent technology advances in areas such as sensor technology, body area networks, wireless communication and information processing. This already enabled an array of applications, ranging from health monitoring, event-based alarm, automated analysis to communication of health-related information [2].

Although some home healthcare applications have been proven in practice, and several promising prototypes have been developed in research projects, it is only fair to say that many challenges are still ahead of us. These challenges can be technological, such as: **memory space limitations** [3] (For the long-term recording of health-related information -24/7 monitoring- a huge memory space will be required.), **identity establishment** [3] (In family situations, it should always be possible to distinguish between the individual members of the family.), **power consumption** [4] (Battery-powered devices must have a useful lifetime and replacing or recharging batteries should be done routinely by service persons, if not automatically.), **self diagnosis/healing** [4] (Considering the fact that people should be able to use the system without supervision or help from healthcare professional or technical experts, the system's robustness and reliability should be high.), **privacy** [5] (Privacy is a major concern in healthcare systems. The system must have appropriate mechanisms in place to control who can access which personal and health-related information.), **non-intrusiveness** [2, 3] (People prefer to have as much as possible a normal life at their home.), **ease of use** [2] (Typical users of home healthcare systems have no or limited technical skills.).

In this paper, we focus on another category of challenges, which we call *architectural* challenges, while being aware of the technological challenges and the technological state of the art. The architectural challenges stem from the fact that current home healthcare systems are generally stand-alone (vertically integrated) systems for specific diseases assuming a 'standard' patient. However, in reality each patient is unique in the way (s)he experiences or is affected by a disease, or a combination of diseases, not only because of his/her mental and physical condition, but also because of his/her social and physical environment. Section II further elaborates the background of architectural challenges. Section III discusses the solution directions that we are planning to explore. Finally, in section IV, we present our preliminary conclusions and outlook of future research.

II. ARCHITECTURAL CHALLENGES

We assume that technological advances will eventually enable us to solve the technological problems mentioned in the previous section. An additional concern, apart from the ability to offer certain application functionality, is how to cope with the uniqueness of a patient's needs and preferences, and the dynamicity of a patient's condition and circumstances.

In order to address this concern we need to start thinking about the architectural requirements and constraints that would facilitate the development of appropriate solutions. It is economically not feasible to develop personalized home healthcare systems for each individual patient. Instead, home healthcare systems should provide a set of patient-neutral healthcare-related functions which can be configured and composed according to the needs and preferences of each individual patient. We call this process *tailoring*. The tailoring process should be easy and intuitive, possibly depending on who carries out the tailoring (patient, caregiver or technician). Moreover, it should be possible to incrementally change the result of the initial tailoring at later points in time (e.g., because the preferences and needs have evolved) by subsequent applications of tailoring. For home healthcare systems, especially for elderly people, we consider the following motivations for tailorability:

- **Personalization**: each patient is unique, and therefore different individuals have different preferences and needs with respect to monitoring and support functions.

- **Evolution**: health problems of individuals change over time (in the case of elderly people, health problems normally increase), and therefore needs and preferences change accordingly.

Tailoring, as introduced above, is a process that is normally carried out by a human being. However, one can think of another form of tailoring, where adaptation is carried out by the system itself, based on measurements using sensors embedded in the home or carried by the patient. Typical measurements determine the location or the activity of the patient, which may be relevant information for the application to adapt its functionality. In any case, tailoring should be possible without changing the hardware or software infrastructure of the system. Further, it should be possible to integrate functions of different systems, i.e. existing system solutions should be made interoperable and/or provide their functionality without presenting the patient with different 'system images'.

III. SOLUTION DIRECTIONS

We intend to make further contributions to the tailoring of functionality and the integration of existing technology solutions, applied in the domain of home care. For this purpose, we explore the following solution directions:

- **Holistic patient view**: In order to adapt our system to needs and preferences, first of all we need to explore what these are. So an important aspect, which is much harder to address, is "expectation"; what does the user expect?

- **Context-awareness**: Context-aware solutions allow to take the patient's current situation (location etc.) into account and adapt functionality accordingly in real-time. Since this can done based on automated sensing, thus avoiding explicit input from the patient, non-intrusiveness and ease-of-use will be improved [6].

- **Service-orientation**: We will adopt a service-oriented architecture to facilitate the integration of existing systems and to support tailorability. Further, we will identify basic (sensing and health-related) functions and package them as configurable and composable core services. Tailoring is carried out in terms of manipulating service descriptions (corresponding to the core services) in order to find a composition of properly configured services that satisfies the patient's needs and preferences. The tailoring result is then transformed to a set of executable 'orchestration' instructions for the home healthcare system.

- **Stakeholder views**: Various stakeholders are involved in the development, deployment, usage and maintenance of a system. System solutions will only be successful if all stakeholders' requirements can be considered and properly balanced.

We collaborate with our healthcare partners in the U-Care project (http://ucare.ewi.utwente.nl) in order to develop realistic scenarios, obtain real-life requirements, and validate intermediate results using the testbed environment offered by these partners.

IV. CONCLUSIONS AND OUTLOOK

Home healthcare systems are rapidly developing, in order to (a) reduce the cost and time for medical treatment that would otherwise take place in hospitals, (b) support independent living in the familiar home environment, and (c) improve on the accuracy of medical examinations by long-term health monitoring from the home.

In this paper we have discussed tailorability as an important architectural concern for home healthcare systems. To be effective and become accepted, home healthcare systems should offer functionality that matches the personal and continuously changing needs and preferences of the patient. We have argued that tailorability is required because the health status of a patient is unique and also changes in a unique way We also discussed the use of context-awareness to enable adaptation in real-time to the current situation (or context) of the patient.

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