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An integrated remote monitoring platform towards Telehealth and Telecare services interoperability

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ABSTRACT

Software platforms focused on the healthcare monitoring sector have recently attained a great penetration in the ICT market and they certainly constitute a key contributor to the improvement of the elderly people's quality of life and the reduction of healthcare costs. It is of great importance that the platform allows for the simultaneous health, mental and psychological status evaluation of an elderly person. However, the integration of vital signs monitoring (Telehealth) with behavioral analysis based on home care sensors (Telecare) has not yet been established at a large scale. We describe the design and implementation of such platform that enables the deployment of services to follow-up the patient's health status based on a set of monitored parameters per disease and to profile user's habits and diagnose deviations from their usual activities. A key aspect of the platform is its Service Oriented Architecture middleware that collects data from heterogeneous Telecare and Telehealth gateways and provides the upper service layers with a unified and standards compliant message. In this way, an integrated view of Telehealth and Telecare data and alerts is made possible into a backend Web Portal where clinicians and operators have access to.

1. Introduction

Ageing population constitutes a challenge that needs to be faced in all developed countries. In Europe the old-age dependency ratio, referring to the number of people aged 65 years and above relative to those between 15 and 64, is projected to double reaching 51% in 2050. Inevitably, population ageing and the escalation of related chronic diseases and disabilities requiring Long Term Care (LTC) does lead to higher health care expenditures [1]. Meanwhile, elderly people need to live independently in their own homes and feel self-confident. It is widely accepted that software platforms focused on the

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healthcare monitoring sector have attained a great penetration in the ICT market during recent years and they are certainly a key contributor to the improvement of the elderly people's quality of life.

Particular attention should be paid to chronic disease management due to high morbidity rates and healthcare costs [2]. Indicative categories are congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD). A remote monitoring system should be able to analyze patient's measurements and trends and to generate alerts as well as identify the early indicators of health deterioration. In this way, the goal of decreased hospitalizations leading to healthcare costs reduction and life-time prolongation may be achieved.

There are several research activities related to remote health monitoring of patients focusing on elderly people. MobiHealth is a platform allowing patients to be fully mobile and not confined in a hospital whilst undergoing health monitoring [3]. The patients wear a lightweight monitoring system,the MobiHealth BAN (Body Area Network),which is customized to their individual health needs. Also, a number of EU research projects have developed eHealth solutions based on the LinkSmart Internet of Things and Services (IOTS) middleware [4]. The AAL (Ambient Assisted Living) project [5] mainly addressed the needs of elderly people, with healthcare applications built on top of the LinkSmart middleware, while CAALYX (Complete Ambient Assisted Living Experiment) developed a wearable light device able to measure specific vital signs [6]. A closely related to CAALYX project named eCAALYX has further stressed the importance of mobile phone applications in the modern healthcare domain [7]. Finally, the OLDES (Older people's e-services at home) project piloted easy-to-access entertainment and telecare electronic services for elderly people to improve their quality of life and simplify their access to care [8].

However, these previous approaches have not succeeded in integrating vital signs monitoring (Telehealth) with behavioral analysis based on home care sensors (Telecare). This paper presents the inCASA architecture which aims to combine Telehealth and Telecare monitoring in a unified way, allowing the simultaneous health, mental and psychological status evaluation of an elderly person [9]. For this purpose the platform enables the deployment of services to follow-up the patient's health status based on a set of monitored parameters per disease, to track the suitability of the in-house environmental conditions and finally to profile user's habits and diagnose deviations from their usual activities.

Towards the aforementioned direction, inCASA needs a strong technical architecture to manage data coming from heterogeneous sensor devices and finally provide a useful interface to the clinicians or operators. inCASA implements such a platform based on a Service-Oriented Architecture which relies on the LinkSmart Middleware [4]. LinkSmart receives measurements from proprietary Telehealth and Telecare gateways deployed in the home premises and then transforms them into Health Level 7 (HL7) compliant data, following the prevailing standards at the healthcare enterprise and turning the platform into an easily extensible solution [10]. Moreover, the inCASA architecture has taken into consideration outstanding efforts in the sector of healthcare information systems, namely the "Integrating the Healthcare Enterprise (IHE)" [11] initiative and Continua Health Alliance Guidelines [12].

The rest of the paper is organized into the following main sections. Section 2 introduces the different monitoring domains, namely Telecare and Telehealth, while Section 3 presents the design of a unified message generation process having as input the afore-mentioned heterogeneous sources. Section 4 presents the overall architecture of the multi-component inCASA platform and Section 5 emphasizes the elements that lead to its interoperability. Finally, Section 6 discusses the results obtained from the pilot evaluation of our solution, both from a patients and professionals point of view.

2. Remote monitoring domains

The inCASA platform supports the deployment of a diverse set of services to help and protect frail elderly people, prolonging the time they can live well in their own home. One of the primary inCASA platform functional requirements is the seamless integration of health/environment monitoring to enable the analysis of collected data and the incremental building of user behavior profiles and electronic health records. This functionality is complemented by intelligent multilevel alerts/communication services that allow the timed delivery and prioritization of the pertinent notifications which are forwarded to caregivers, relatives or emergency services.

To meet the above requirements the inCASA platform strives to apply standardized semantics for the characterization of the streams generated by the sensors and medical devices used, which are then consumed by the integrated Telehealth and Telecare services. Fig. 1 provides a generic representation for the wide range of basic and value-added services that the inCASA platform could support and denotes the participating actors in the proposed service model.

The platform also attempts to complement two fundamentally different approaches to data generation and propagation throughout the platform, specifically a continuous monitoring model necessitated by the deployed Telecare services and an event driven model related to clinical measurements undertaken by the patients. Finally, the adherence to proper semantics and common data consumption models enables the deployment of a single reasoning module for the extraction of trends, anomalies and correlations over the monitored data.

2.1. Telecare

Telecare services deployed with the inCASA platform aim at supplying doctors and health professionals with more comprehensive monitoring data for understanding remote user's social/physical conditions and diagnostics. More specifically,