A Distributed Service-Based System for Homecare Self-Management

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Abstract. Aging is becoming a critical issue for Europe and many countries around the world. It is imposing significant burden on societies and their national services. Enabling longer home independent living is seen one of the most promising ways to overcome this issue. However, to achieve a number of challenges need to be overcome, especially those related to management of health and disease let alone other social and logistical barriers. One of these challenges is malnutrition, which is considered one of the root causes for the occurrence of other diseases. This paper presents the design of a distributed system that enables homecare in the context of management of self-feeding through balanced nutritional intake. The design employs a service-based system that incorporates a number of services including monitoring of activities, nutritional reasoning for assessing feeding habits, diet recommending for food planning, and marketplace invocation for automating food shopping to meet dietary requirements.

Keywords: Serviced-based design, SOA, eHealth, Homecare, distributed systems.

1 Introduction

The aging population, in many countries, is placing a huge demand on health and social services. These demands do not only include costs, but also logistical and capacity limitations. If left unaddressed, it will eventually affect the whole society not only in the quality of services they receive, but also in their ability to meet these demands. Enabling the elder population to live longer at home is seen one of the most promising solutions. Not only to reduce costs, but also to address other psychological and social factors [6]. One of the critical issues affecting elderlies' ability to live independently at home is malnutrition [2]. Studies have shown that in Europe more than 15% of the older population is affected by poor nutrition and malnutrition caused by the problems of ageing due to decrease in sensitivity, poor dental health, lack of transportation, physical difficulty, forgetfulness and other issues [1].

R. Meersman et al. (Eds.): OTM 2014 Workshops, LNCS 8842, pp. 361–366, 2014.

As part of the DIET4Elders project[1], this paper presents the design of a service-based solution for homecare self-management focusing on malnutrition. It enables older adults self-manage their nutritional intake by preventing unhealthy self-feeding habits, which recent studies report that more than 60% of cases in nursing homes [3], and more than 15% of those living at home [2] are affected by malnutrition. The solution uses a distributed service-based design that incorporates several services, including:

(i) monitoring services aimed at detecting food intake and activities.
(ii) data collection and reasoning services to help the nutritionists to establish the degree in which the older adults follow their prescribed diet and to dynamically re-plan it.
(iii) diet recommending services for planned long term diet plans that can be used and adjusted by dieticians.
(iv) food generation services that can be used to generate longer-term diet interventions coupled with suitable meal and food plans.
(v) marketplace services, that enable food providers to register their services and offerings.
(vi) food shopping services that enable the dynamic selection, based on the prescribed diet, of suitable food service providers, potentially enabling automated shopping.
(vii) user feedback and reporting services, to assist older adults and their informal carers during daily self-feeding activities aimed at creating a continuous feedback and interaction loop not only to detect and prevent the instauration of malnutrition, but also other health issues.

The rest of the paper describes the system design and services that DIET4Elders intends to develop in close collaboration with its target older adults. Section 2 describes the overall design of the system and its services; section 3 presents a brief conclusion.

2 Overall Service-Based System Design

The overall system design is shown in Fig. 1. The design uses services to enable collecting and providing the related recommendations directly to the older adults in their home environment as well as to their dietician and informal carers. The design include a number of services to achieve a complete cycle of monitoring, analysis, through diet recommendation to food ordering services, these are described below.

Monitoring Services

These include a number of services. It relies on the home environment monitoring infrastructures, where wireless sensors are used to monitor and collect related diet

[1] Dynamic nutrItion bEhaviour awareness sysTem FOR the Elders (www.diet4elders.eu)

data including food intake, activities, health data and so forth. For similar types of sensors (e.g. activity sensors), data monitoring services are created that collect the relevant data. A local communication infrastructure pushes the data to respective data monitoring services, which pushes data to the data collection service. This is enabled by the use of advanced sensors technologies to track and detect older adult's daily activities and the context in which these activities took place. The project is looking at using and/or where not available developing advanced wireless non-intrusive sensors that monitors the daily diet intake and physical activities aspects of older adults, including smart containers, smart fridges, accelerometers, health monitoring devices, positions sensors, RFIDs, smart tablets or phones etc.

Diet Collection and Analysis Services

A data collection service collects data from all monitoring services, which are further semantically categorised to enable both context and semantic analysis linked to temporal and longitudinal diet behaviour. Valid and effective diet advice is one key objective of the design. This is pinned by the need to build a dynamic mechanism not only closely linked to accurate monitoring technologies but also based on evidence-based diet knowledge. For such, the project is developing a computational representation of diet knowledge drawn from existing well-established diet evidence. It is drawing knowledge with standardised units and measurements to be able to computationally reason over such knowledge correlated to the specific knowledge collected about individual users, taking into account not only their level of health and chronic diseases that they suffer from, but also the context and culture variations. The need is to be able to reason over collected data to drive and identify self-feeding behavioural patterns that lead to malnutrition and create counter mechanisms to address them. This will require the development and employment of reasoning techniques including graph theory and prediction techniques to discover patterns from chain of activities abstracted to the diet and context of use. With direct input from nutritionists, it will also require the development of learning algorithms with continual feedback and human intervention to achieve more precise and accurate identification of unhealthy behaviour patterns.

Assessment, Feedback and Recommendation Services

Analysis services feed their results into these services. The system will employ a number of services that interconnect with the above technologies to circumvent unhealthy feeding behaviours and interconnect with the older adults directly so they are aware of where they could improve on their feeding habits. These will also provide intelligible and useful feedback to both carers and dieticians to monitor changing behaviours in feeding patterns. The key is to produce current and quantifiable information of value to the older adults as well as their dieticians. Given the amount of data collected over time, this becomes a complex data-mining issue, potentially requiring large computational resources required to produce meaningful information in a relatively short time for potentially large number of users. Thus the need is for a system design that employs a distributed infrastructure to enable such analysis. The intended outcome of these services is to produce a computational representation of these results that can be further used by the system and subsequent services, where

decisions are drawn from. Given the sensitivity and impact of these recommendations on the older adult health, continual expert reviews of the validity of drawn results and discovered patterns are integrated within the services workflow.

Food and Meal Plan Generation Services

These services receive unhealthy behaviours and nutritional deficiencies information into a computational form from the assessment services. This information is then used by diet plan generation services, to draw actionable food intake meals and food plans that can overcome identified diet and nutritional deficiencies. These draw a longer-term individual plan, based on the older adult preferences, their health profile and their chronic illnesses. Dieticians are able to adjust these plans based on further discussion and feedback from the user. User feedback is critical to incorporate in the process for these meal plans uptake so they eventually result into effective outcomes [5]. These will require taking a number of various factors into consideration, including health, contextual and cultural variations.

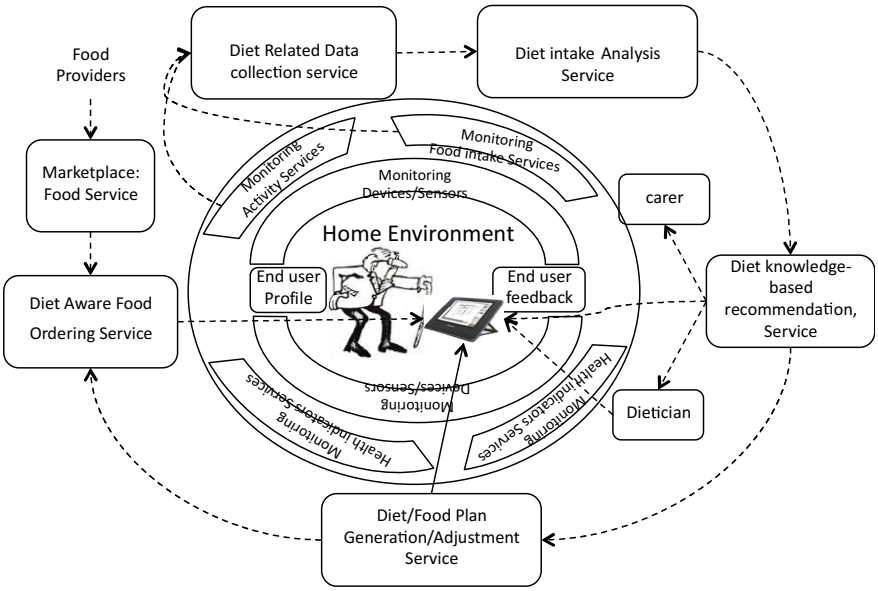

Fig. 1. Service-based Homecare Self-management

Market Place Services

There are a large number of potential food providers with different capabilities and offerings that already provide meal services to older adults, in both nursing homes or at home. However, these mostly employ a manual process and not all provide all types of meals. The system will develop a service-based mechanism with well-defined diet specific market place that allows food providers to register their services and food offerings. It will develop reliability-augmented service descriptions and mechanisms with clear quality indicators that not only enable users to have informed

decisions about the food ordering but also enable the system to make informed judgement of suitable combination of food ordering with suitable levels of nutrition that meet the specific needs of the user. These will include developing mechanisms to capture and validate key quality indicators of food services, not only at the service level but also at nutritional and contextual levels.

Diet Aware Food Ordering

For complex diet requirements and/or user preferences, several food providers are potentially required to meet these requirements or preferences. The selection of the combination of food services, to satisfy potentially complex criteria of the older adult recommended diet or preferences, can thus be a non-trivial task. There are a large number of food delivery services available on the market offering various types of food, which makes finding optimal combination a NP-hard problem, which cannot be solved in reasonable time using conventional techniques. The system will model the problem as a combinatorial optimization problem and solve it using hybrid bio-inspired techniques that should combine the strength elements of different bio-inspired meta-heuristics.

3 Conclusions and Future Work

The paper presents a service-based distributed system design and architecture for homecare self-management. It describes briefly the design and the employed services that will be used by the project to enable self-management of a balanced nutritional intake based on monitoring daily activities, and self-feeding habits. The project builds its solution using a service-based design and employs a number of services to provide nutritional advice, interact with dieticians and carers, and enable food ordering through a reliability-augmented and well-specified marketplace. Although the solution is based on malnutrition management, but it presents a generic solution which can be used to enable effective management of demanding requirements of large data collection and analysis for homecare environments. Such system design need to meet potentially very large-scale requirements, especially as it is required to serve large number of older adults, geographically distributed at their homes, with varied and complex health needs.

The initial version of the design is already being developed part of the project with anticipated incremental planned evaluation and deployment of its components in selected older adults homes. Given the amount of potential data generated by monitoring services, other design considerations will look at the use of big data techniques for data management and analysis.

Acknowledgment. The authors would like to thank all colleagues from the DIET4Elders project who contributed to this work.

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