Platform to Support the Development of Information Services for Informal and Formal Care

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Abstract: This paper presents a platform to support the development of services and applications for informal and formal care, which is based on the principles of the Services Oriented Architecture. In particular, the paper presents the mechanisms that allow the developers a significant freedom to implement and use new types of information objects.

1 INTRODUCTION

Due to the ageing population and the inherent shift in the burden of illness from acute to chronic conditions, there is a generation of people living with long term illness and disability and, consequently, a substantial increase of the health costs. Therefore, significant organizational changes of the care away from medical institutions are required, which means the urgency for the consolidation of new practices that can contribute to increase efficiency and, consequently, to decrease costs.

As a consequence of major structural changes of the contemporary society, particularly in terms of structure and size of the families, there are a considerable number of elderly people living alone. Thus, the interventions should not be exclusively focused on medical needs, but also in maintaining the autonomy and independence of the individuals (Santana *et al.*, 2007) by supporting a set of activities that are normal for every citizen, such as home activities, mobility, recreation or safety, and also social participation.

Significantly, the ageing population coincides with the technological revolution of the last decades, which is redefining how people work, communicate and relate to each other and that should contribute both to effectiveness and efficiency of the healthcare and social care systems. In this respect, the ehealth (Eysenbach, 2001) paradigm is essential.

One of the objectives of the TICE.Healthy project, which integrates diverse Portuguese academic and industrial partners, is to answer to some of the identified needs by providing a platform, the We.Can platform, supporting applications in the health and quality of life domains.

In this paper, we present some features of the We.Can platform, based on the principles of the Services Oriented Architecture (SOA). This platform intends to complement the existing clinical communication networks. Its main requirement is the support of informal and formal care providers, outside the hospitals wards, that, nowadays, do not have access to services providing structured information related with their clients.

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The paper is composed by this section (Introduction) and three more sections: Related Work, Architecture, Services and Conclusion.

2 RELATED WORK

Health Care Networks (HCN) (Katehakis *et al.*, 2006) are used for the integration and sharing of distributed clinical information. Most HCN in Europe are typically regional, although some national solutions also exist. The implementation of these networks requires the solution of a broad range of technical and non-technical issues, such as user's identification, security, privacy, governance and financial support for common operations.

The sharing of clinical information requires, in addition to the communication infrastructure, the existence of interoperable Electronic Health Records (EHR). This interoperability can contribute to a more effective and efficient care, facilitating the transfer of information and knowledge between different entities.

For that several standards (*e.g.* Reference Information Model - RIM - or Clinical Document Architecture - CDA) are being developed by the Health Level Seven (HL7) organization, part of the American National Standard Institution and founded in 1987, while the European Committee for Standardization - Technical Committee 251 (CEN/TC 251) is being defining the EHRcom whose overall goal is to provide a rigorous and stable information architecture for communicating part or all of the EHR information of a patient.

However, despite all the advances in systems interconnection and interoperability protocols, semantic heterogeneity of information remains a difficult problem to solve. This interoperability is still more difficult knowing that health conditions are influenced by the individual's medical history and other factors, including behavioural, social and environmental factors (Glass &. McAtee, 2006). Thus, we need to consider new requirements in terms of distributed management, integration and use of a whole range of information, such as those related to Personal Health Records (PHR), Electronic Social Records (ESR) and Ambient and Assisted Living (AAL) generated information (Queirós *et al.*, 2013).

PHR include data and information related with the individuals' lifetime and the individuals' care maintain by themselves, namely patient-reported outcomes (Bos, 2012).

ESR are composed by forms (*e.g.* nationally used forms or local assessment forms), coded data (mainly for management and statistical reporting purposes) or unstructured information such as letters, emails or notes of meetings (SCDH, 2004).

Finally, recent developments related with AAL and the consolidation of standards such as the ISO/IEEE 11073 for the interconnection and interoperability of medical devices, have brought new possibilities in terms of new services (Teixeira *et al.*, 2009; Teixeira *et al.*, 2011) and automatic collection of information about individuals and environment. Sensory data are captured by sensors embedded in the environment and can be used for systems automation or to monitor chronic diseases among other applications.

Considering this complex reality, there is the need to develop innovative solutions to persist all the required information, such as the We.Can platform.

3 ARCHITECTURE

Although one of the main requirements of the We.Can platform is the information persistence, its architecture should not only provide the necessary services for information persistence, but also other services supporting applications such as: i) audit services responsible for verifying all interactions conducted among services and end users; ii) authentication services to provide access to the information only to authorized services or end users; iii) encryption services to enable secure communications of sensitive information (Hafner, 2009); iv) concepts and terminology services to assist the processes of data codification, data translation into formats easily understood by humans or data indexing and inference, and to determine the structure and meaning of some data; and v) users identification services, enabling a unique identifier information distributed across multiple entities and systems.

To consolidate the We.Can architecture it was necessary to consider a comprehensive set of problems, namely the heterogeneity of potential end-users and, consequently, the challenges in terms of usability, the difficulty of ensuring a safe and efficient access to different types of information and ultimately, the capture and management of new information types related with knowledge not properly structured, and for which the platform must ensure that its meaning is transversal (*i.e.* their meanings must be the same, regardless the involved actors and the future evolutions).

Ideally, the architecture should allow the integration of software components from different sources. The SOA approach is a good solution to ensure technological neutrality, namely because it can encapsulate components developed in other technologies. Furthermore, this paradigm allows business processes to be responsive with a high degree of flexibility and adaptability, namely (Crawford *et al.*, 2005): i) the development of new services from the aggregation of components that can be built on different systems, running different operating systems, and build in different programming languages; ii) consistency of the infrastructure development and deployment; iii) reduction of the design, development, testing, and deployment time due to the reuse of existing services and components; iv) reduction of the development costs and the risk of introducing new errors, and thus potential points of failure, through the process of enhancing or creating new business services; v) continuous business process improvement, since the developers are allowed to change process flows while monitoring the resulting effects; and vi) user-configurable solutions.

The formal consistency of the information is the responsibility of the persistence mechanisms. Those mechanisms also ensure that the information requirements of individual applications are met through the evocation of standardized primitives.

The customization of the applications to specific requirements of the application domain requires substantial code modifications. To obviate this difficulty there is the modelling at two levels approach (*i.e.* knowledge and information models), which has been considerably developed by the openEHR promoters (Schloeffel, 2003).

The Archetypes and the respective constraint rules domain constitute the knowledge model that is used to adapt the underlying information technical specifications.

The knowledge model considers that there is contextual information that should always be recorded and there is information that will vary according to clients, events and service providers. Therefore, it exist different types of Archetypes that are part of the basic care process. A generalization of base Archetypes was performed in order to systematize the overall information that can be considered essential.

An Archetype is a pre-defined structure which organizes information facilitates the creation of appropriate forms for data input and queries. The basic structure of any Archetype consists of a header, a body and data. The header contains information such as the type, name, author and header details, which, in turn, comprise several attributes.

The body of the Archetype (Figure 1) is a dynamically modelled component and contains three main fields: participations (*i.e.* contextual information), description (*i.e.* the elements that compose the body) and definition. Definition is used to specify one or more groups of information. Each group has a name, an id, the minimum and maximum number of occurrences, and if it is mandatory. The data field is structured to support the information groups specified by the aforementioned body definition field. It comprises a group which can be subdivided into collections and elements. In turn, collections may contain elements or other collections.

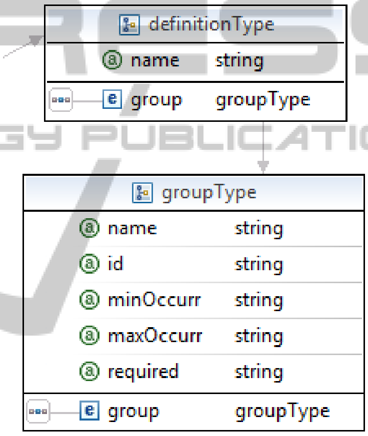

Figure 1: Structure of the Archetype body.

To guarantee the flexibility of the Archetypes and to ensure the persistence of the information together with the respective semantics there is the need of robust information models. Therefore, the data repository (*i.e.* the information model) was implemented accordingly to HL7 RIM (ISO/HL7 21731, 2006).

4 SERVICES

The information persistence service, based on the RIM implementation provides a simplified access to the platform databases. In order to offer a high abstraction level, the create, read and update operations to access the relational databases that support the implementation of the RIM container allow the manipulation of objects and, therefore, provide enough abstraction to the services that use them. Since the deletion of previously persisted information is not allowed, the delete operation was not implemented. This is one of the fundamental rules that must not be violated in order to ensure coherence and consistency of the stored information.

Queries are important features to bear for any information system. This importance becomes even more critical when the volume, complexity and variability of the stored data increase.

Considering the Archetypes modelling approach and the variability of the Archetypes structure becomes critical the existence of specific search syntax sufficiently flexible to answer the needs of the final information consumers (*i.e.* applications). Therefore, we propose a domain specific language with adequate syntax to formalize flexible queries.

A search is formalized through a Search operation that contains a Query or a Filter mechanism.

The Query mechanism is prepared to be used when searching free text fields, which is extremely useful for research in fields with long text, or when the result should be sorted by relevance. On the other hand, it is recommended to use the Filter operations in binary searches (*i.e.* searches that return yes or no results), exact value searches (*i.e.* filtering by a certain value) and recurrent searches that need to be optimized by caching mechanisms.

The formalization of a Filter or a Query search can be refined with additional criteria including different types of operators (*e.g.* Boolean, exact, range or fuzzy).

Archetypes are complex structures and, therefore, the platform provides dedicated services to create and edit them. Furthermore, the support services provide search functions for the selection, within the existing Archetypes, the one that must be edited, and the required operations to manage the information introduced by the application domain experts and to manage the different Archetypes versions.

The developed support services use the LiU Archetype Editor of the openEHR framework, which has been complemented by a parser able to adjust to RIM.

The Archetypes processed by the parser can be included in an Archetypes repository. This is an application that allows all the required Archetypes operations, namely, searching and publishing, authentication, versioning and ownership management.

Once the applications that can be supported by the platform We.Can necessarily have a broad range of requirements in terms of user interfaces and that these interfaces must evolve over time with the help of domain experts and the end users themselves, it is important to have a support development services based on the Archetypes formulations for the extension of the presentation features.

The presentation service provides a generic interface to create, access, modify and delete records based on existing Archetypes without the need to change the persistence layer. The selected development environment was the Play Framework, which is a web framework based in Java and the configurations of generic entities are stored in JSON.

The created custom fields are dynamic so that they can be modified at runtime. Depending on the predefined configurations there is a code generation component that is able to create a visual representation of the Archetype contents and implement the business rules that govern them.

Among the features provided by the module it should be pointed the following: i) abstraction of data access and business rules; ii) customization of fields and web components (*e.g.* data type, maximum size or validation constrains); iii) automatic update of the template whenever there is a definition of new components; iv) automatic generation of custom forms for viewing, entering and editing data; and v) versioning management.

There are four types of views that can be configured, namely: i) insertion view; ii) edit view; iii) presentation view (*i.e.* a view to present data from a register); and iv) data list view.

In order to allow having presentation services truly flexible and extensible independently of the application environment it is necessary to provide a mechanism to define and modify business rules of the final application.

The most common validations are pre-programmed accordingly to rules based on the Archetypes definition. Additionally, there is the possibility to validate one or more fields of a presentation entity in a different way that the one initially foreseen. For example, if we had two date type fields whose validation rules include the requirement that the content of the field should be posterior to the first one, and this had not been planned, it should be possible to add a rule to validate this condition. Beyond this basic case there are many others cases that may rely on the rules engine to allow the application modification without recompilation and deployment costs

A rules engine helps to reduce the problems and difficulties inherent to the development and maintenance of the business logic of an application (*e.g.* the recompilation and deployment costs).

5 CONCLUSIONS

Through the use of different application scenarios it was possible to verify that the RIM based information container is able to support a wide range of information structures. Furthermore, the formal structure of the Archetype was proven to be useful for the development of the user interactions mechanisms. In particular, the validation process demonstrated that user interfaces can be automatic generated from the Archetypes structure.

Currently, a full version of the platform is being prepared to be evaluated in real conditions, supporting different services and applications related with health and quality of life domains.

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