ISO 13606 based system for biomedical parameter storage, querying and alarm detection

Miguel RAMOS NAVEIRA a, Javier BROULLÓN MOLANES a, Dolores RIMADA MORA a, Daniel LLAMAS GÓMEZ a, Lino CARRAJO GARCÍA a and Guillermo VÁZQUEZ GONZÁLEZ a

a Avances en Telemedicina e Informática Sanitaria (ATIS). Instituto de Investigación Biomédica de A Coruña (INIBIC), Complexo Hospitalario Universitario de A Coruña (CHUAC), Sergas. Universidade da Coruña (UDC). As Xubias, 15006, A Coruña, Spain.

Abstract. ACHEGAMED is an unsupervised real-time patient monitoring system, with the goal of decreasing the exam and diagnosis time of the most prevalent diseases in today's healthcare services. We developed, as a component of ACHEGAMED, a system for storing a wide range of biomedical parameters as ISO 13606 extracts. The system is able to detect clinical alarms in those parameters and communicate them, if needed, to the appropriate medical staff. Although a component of ACHEGAMED, it can be integrated in other systems in a semantic interoperable way thanks to the ISO 13606 standard, allowing the continuity of patient care.

Keywords. Telemedicine, Chronic Disease, Triage, Clinical Alarms, ISO/EN 13606 standard, Continuity of Patient Care

Introduction

ACHEGAMED [1] is an unsupervised real-time patient monitoring system, capable of safely capture, store and process a wide range of biomedical parameters. The goal is to decrease the exam and diagnosis time of the most prevalent diseases in today’s healthcare services, which would help reduce the current saturation of medical facilities. The project is being developed by Tecnologías Plexus, Imaxdi Real Innovation, IECISA and Intellectia Bank. The system allows the unsupervised monitoring of a broad spectrum of chronic patients, and can also be used as an automated emergency triage system. To fulfil those requirements, ACHEGAMED captures the biomedical parameters using two different devices: a fixed kiosk (for use at medical facilities) and a portable device called cube (for use at patient’s home), both connected to a clinical information system. In this paper, we present the development of a component of that clinical information system, the one responsible for the storage, querying and alarm detection of the biomedical parameters as ISO 13606 [2] extracts.

1 Corresponding Author. Email: miguel.ramos.naveira@sergas.es
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1. Methods

Our approach was to first interview the medical staff of CHUAC to identify the most prevalent diseases and the needed biomedical parameters to monitor them. We also obtained the parameters used for the Manchester Triage System (MTS) [3], which is the protocol used at CHUAC for determining the priority of patients' treatments based on the severity of their condition. Using that information, we developed ISO 13606 archetypes to model all the required biomedical parameters, following appropriate guidelines for interoperability [4].

Many of the archetypes were already defined in the openEHR Clinical Knowledge Manager [5], so we did the work of converting them from the openEHR standard to the ISO 13606 one. In order to being able to validate the archetypes and also to easily generate and validate extracts, we developed a Java implementation of the ISO 13606 standard, based on JAXB [6] and the openEHR Java implementation [7].

Once we had the archetypes and the ability to generate and validate extracts, we developed, using an incremental life cycle mode, the system responsible for the storage and querying of biomedical parameters as ISO 13606 extracts. During this phase we strongly focused on reusability, both to minimize the impact of feature changes and to be able to build other interoperable systems in the future.

Finally, we developed the alarm detection system, which needs to detect anomalous values in triage as well as be capable of more complex alarms in the future. Using the information gathered in the interviews with the medical staff, we identified the needed clinical decision logic for firing the alarms. After that, we analysed the different rule engines and Business Rule Management System (BRMS) available, and the conclusion was that JBoss Drools [8] was the best choice for us due to its free license and top performance. The development of the system also followed an incremental life cycle model.

ACHEGAMED’s clinical information system follows a Service Oriented Architecture (SOA), so both our components (the storage and querying of biomedical parameters and the alarm detection and notification system) were designed and implemented as two separate services in that architecture, exposing JavaScript Object Notation (JSON) based Representational State Transfer (REST) facades to integrate into ACHEGAMED’s architecture.

2. Results

2.1. Use case identification and archetype creation

As a result of our interviews with the medical staff of CHUAC, we identified the most prevalent groups of chronic diseases of four medical specialities (see Table 1). Aside from the interviews about chronic diseases, we also interviewed the medical staff of CHUAC’s emergency service, obtaining the required parameters and protocols of the MTS.
The result of the information gathering phase was the identification of all of the use cases of ACHEGAMED and their required biomedical parameters, which are the same for the system we present in this article. Specifically, the required biomedical parameters are: body weight, body mass index, body temperature, heart rate, blood oxygen saturation, blood pressure, ECG recording, capnography, blood glucose, spirometry and respiratory rate. Also, the rheumatology specialty extensively uses standardized patient questionnaires.

<table>
<thead>
<tr>
<th>Medical speciality</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatology</td>
<td>All chronic diseases</td>
</tr>
<tr>
<td>Cardiology</td>
<td>Chronic hypertension, atrial fibrillation and ischaemic heart disease</td>
</tr>
<tr>
<td>Endocrinology</td>
<td>Obesity and type 2 diabetes</td>
</tr>
<tr>
<td>Pneumology</td>
<td>COPD and bronchiectasis, asthma, obstructive sleep, apnoea-hypopnoea</td>
</tr>
<tr>
<td></td>
<td>syndrome, non-invasive mechanical ventilation patient revision, lung</td>
</tr>
<tr>
<td></td>
<td>transplanted patient revision and pulmonary fibrosis</td>
</tr>
</tbody>
</table>

We wrote an ISO 13606 archetype to model each parameter and each rheumatology questionnaire. Also, we created (whenever possible) the necessary SNOMED-CT [9] subsets to accurately represent the medical terms of the archetypes.

2.2. ISO 13606 Java implementation

Our Java implementation of the parts 1 and 2 of the ISO 13606 standard provides us the features needed for managing archetypes and extracts. Specifically, it enables us to:

- Read and write archetypes written in ADL 1.4. In Java the archetypes are modelled by the classes of the Archetype Object Model (AOM). For this purpose we reused most of the openEHR Java implementation due to ADL being independent of the underneath reference model.
- Validate the ISO 13606 compliance of the archetypes. We check that each constraint of the archetype is coherent (in name, type and number of attributes) with the matching class of the ISO 13606 reference model, and that its hierarchy is preserved.
- Read and write extracts. JAXB allows us to create, from the reference schema, the Java classes needed to represent the ISO 13606 reference model, and also to parse and serialize extracts as XML documents.
- Retrieving any arbitrary value of an extract.
- Easily generate an extract by specifying the list of path-value pairs that contains all the needed information to create the extract. Following the convention over configuration principle, it is possible to omit the default values that could be obtained from the archetype, like terminologies or magnitude units.
• Semantically validate extracts. It checks that all the nodes of an extract match the corresponding archetype constraint.

2.3. SOA services implementation

For the ACHEGAMED’s clinical information system, we designed and implemented two SOA services (see Figure 1), which are the topic of this article. One is the extract generation service, responsible for storing the captured biomedical parameters as ISO 13606, following the constraints and structure defined in the corresponding archetypes. The extract generation service also allows to query the stored extracts by patient ID, extract creation date and biomedical parameter type.

On the other hand, the alarm detection service is able to detect (and notify the appropriate medical staff by email) clinical alarms when the value of a parameter exceeds a certain threshold. The decision logic for firing the alarms is defined as JBoss Drools business rules, and those rules can be created, modified or deleted in real-time without restarting the application.

![Figure 1](image)

**Figure 1.** Diagram of ACHEGAMED’s architecture. This article presents both the ISO 13606 and the alarm detection services.

3. Discussion

ACHEGAMED’s ability to capture, store and process biomedical parameters is a step forward towards the goal of reducing today’s saturation of medical facilities. As the components of ACHEGAMED responsible for the extract generation and alarm detection, the services we present in this article share the same potential. It is important to highlight that due to the SOA paradigm, the services are reusable outside the scope of ACHEGAMED.
Additional value has been added by the use of the ISO 13606 standard, making the extract generation service able to communicate with other systems in a semantic interoperable way, allowing the continuity of patient care.

The created ISO 13606 archetypes meet most of the quality requirements [10]: their use cases are clear, they are flexible and expressive enough for our purposes, based on scientific evidences, able to be consistently reused in different scenarios, consistent with the other created archetypes and binded with suitable terminologies (SNOMED-CT in our case). On the other hand, the archetypes have not been accepted yet by a recognized organization and they have not been used on the field, but those two requirements are outside the scope of this article and could eventually be met in the future.

Thanks to our implementation of the ISO 13606 we can manage archetypes and extracts. It provides a much needed abstraction layer over the complexity of the standard, easing the task of creating and validating the conformity of the archetypes for each biomedical parameter. Also, for the ISO 13606 service we only needed to implement a JSON REST facade and a persistence layer, because the business logic of creating and validating extracts had already been given by our ISO 13606 implementation.

Finally, we can conclude that the reusability of the work presented in this article lays the foundation for future interoperable applications. Therefore, the goal of continuity of patient care seems closer than before.

Acknowledgements

ACHEGAMED has been funded by CDTI (Centro para el Desarrollo Tecnológico Industrial) and the ERDF (European Regional Development Fund), thus being backed by the Ministerio de Economía y Competitividad of Spain and by the Consejería de Economía e Industria of the Xunta de Galicia through the GAIN (Axencia Galega de Innovación).

References