OPEN LABORATORY INFORMATION SYSTEM BASED ON CEN DATA TYPES AND LOINC CODES

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Abstract: Laboratory reports are a crucial issue in the clinical record about a patient. They are used to make diagnosis, procedure and therapeutic decisions. Therefore an easier request and access to this information by the healthcare staff could improve the quality of service remarkably.
This work shows an approach to develop a laboratory information system that facilitates the access to the information stored by a human or software agent. The system can be integrated in a healthcare information system taking advantage of a design methodology based on existing standards and a modular architecture.

Introduction

Laboratory tests are crucial to make diagnosis, procedure and therapeutic decisions and are frequently used in the clinical daily work. The lifecycle of laboratory tests include management aspects related to the initial request, booking, planning, execution and reporting. These activities involve several resources and actors from different units and with diverse responsibilities.

The penetration of information and communication technologies (ICT) is very different in each healthcare organization and usually inside the same institution both specialized and isolated information systems can be found. With regard to laboratory tests, doctors usually make requests of laboratory tests filling up paper pre-established forms by hand. The laboratory systems use to be independent of electronic healthcare records (EHR), and a paper report with the results of the test is sent to the petitioner. Some parts of this information can result significant for patient attention and it is appended to his/her EHR, should this exist. Furthermore in the middle of the process the activities of nurses have to be considered too. Of course this situation could differ in each healthcare organization.

Laboratory tests results are clinical data and their management inside information systems has to address aspects related to their collection and validation as well as the aggregation and structuring of the elementary data according to the specific requirements in each context. Even if the test, or part of it, was included in various structured health data, it would be desirable that each piece of information was stored only once, to avoid the need for multiple entering and the risk of inconsistencies.

Summarizing, from the time when a laboratory test is required to the moment when it is reported and possibly included in the EHR, a complex and articulated workflow takes place, involving several actors, in case also distributed across different centres and units. The introduction and improvement of ICT for the management of these activities, for the integration, monitoring and optimisation of the overall workflow of the various actors and for the management of the clinical information is important, not only for improving the quality of the healthcare information services being provided to the patient, but also with respect to the related organisational, managerial and clinical issues [1].

It is evident that creating a direct explicit relationship between laboratory tests and the activities implied in their management should represent a major objective of an advanced healthcare information system. This could provide a major contribution towards the improvement in quality and reliability of the treatment, since healthcare actors may have a more comprehensive and complete understanding of the context in which the tests have been collected. At the same time, it facilitates the possibility of monitoring the costs and the quality of the overall organization. Nevertheless it is necessary to considerer that not all tests are defined through a formalised activity directly carried out inside the organization, for example some of them could be received from external centres.

The system that we introduce in this work presents several advances in relation to the management of laboratory activities and information inside a healthcare organization.

- The management of laboratory tests inside a well-defined activities workflow.
- The use of a standard codification for the laboratory information and a standard interface for laboratory data recovery that will ease the integration in the organization and the communication with other systems.
- The implementation of a GUI based on the existing protocols and documents inside the institution that will make easier the acceptance of the system by the users.

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Materials and Methods

The main objective of this work is the development of an open laboratory system that could be easily integrated in a more complex healthcare architecture. Due to this philosophy it is essential to support our design in existing standards about specific codification of laboratory data, clinical information management and integration procedures in the healthcare domain.

In order to assure the interoperability of the developed system the information stored inside the data base is compliant with LOINC (Logical Observation Identifiers Names and Codes) [2] terms. LOINC codes are universal identifiers for laboratory and other clinical observations, maintained by The Regenstrief Institute. This standard codification provides a specific laboratory lexicon, necessary to avoid semantic conflicts in the meaning of each piece of information when it is managed in internal activities of the organization, or when this information is to be communicated to or received from a external system.

In this work we only use the laboratory portion of the LOINC codes that contains the usual categories of chemistry, haematology, serology, microbiology (including parasitology and virology), and toxicology. The scheme of the data base that stores laboratory results is designed to include all the concepts involved in this terminology system.

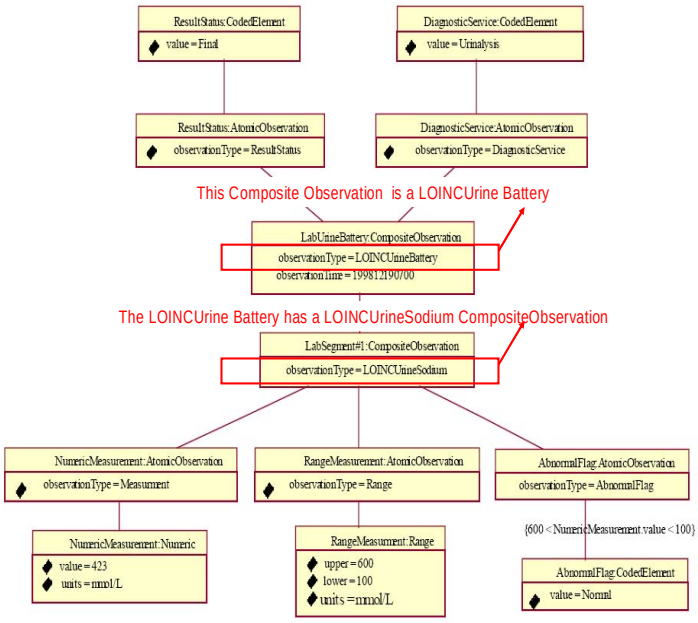

Figure 1: Direct representation of LOINC-based laboratory results in the COAS data model.

In order to improve the functional interoperability of the developed system we are implementing a standard interface for the laboratory information retrieval that is compliant with COAS[3] (Clinical Observations Access Service) specification, defined by the CORBAmed work group from the OMG.

With regards to data models for laboratory information our work is based on the reconciliation of two information models, COAS and non clinical GPICs. First, we have to use COAS information model where classes for atomic or composite clinical observations are defined. The kind of observation is stored in the observationType field and the value in the observationValue. With this information model it is possible to represent a laboratory result based on LOINC codes as figure 1, extracted from COAS specification, shows.

We are planning the integration of the system as a component inside a healthcare organization based on HISA standard. This will be easier if the interface with the system retrieves laboratory information objects compliant with the HISA information model. In the HISA clinical information model, described in the information viewpoint, the equivalent to COAS Observation is the ClinicalInformation class. The advantage is that the model establishes relations between clinical information and other important concepts in the healthcare organization, and the problem is that the clinical information model could be too simple to include all the necessary semantics. In order to improve this information model, another standard we are considering is the clinical General Purpose Information Components for messages (GPIC)[3]. This standard provides classes for the representation of Laboratory and Diagnostic Investigation, specially thinking about a message-based exchange of this kind of information, and being a CEN standard like HISA.

The interfaces for the exchange of laboratory investigation requests and results with other components inside the healthcare organisation architecture is based on COAS methods and is responsible for managing CinicalInformation objects that are in conformance with these standards. This way, although COAS provides the functional interface, CEN gives the information model. We are not using CEN for the functional model because the computational viewpoint of HISA is not enough developed.

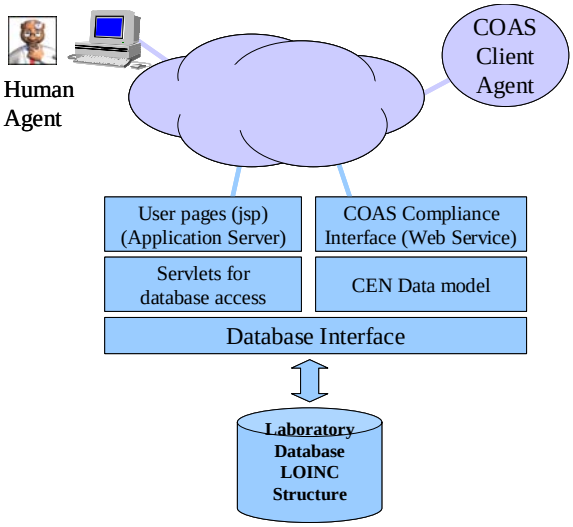

Figure 2: Architecture for the laboratory system.

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Results

The architecture for the laboratory system is shown in figure 2. We can identify the data base, whose schema is completely based in LOINC, and two interfaces for information management: the GUI and the COAS interface.

The first goal was the development of a stand alone application for laboratory test management. The reasons were to develop a tool that helps the entire healthcare professionals involved in the laboratory test management workflow, from request to report, and to obtain a deeper knowledge of this domain.

The priorities in the design of the application have been, first that data base scheme was completely based on LOINC, as this will ensure the semantic compatibility when our system is integrated in a more complex healthcare architecture. And second, that test request forms were identical to those in paper that in this moment the user has to fill up by hand. An example is shown in figure 3. This will facilitate the acceptance of the tool by the implied users.

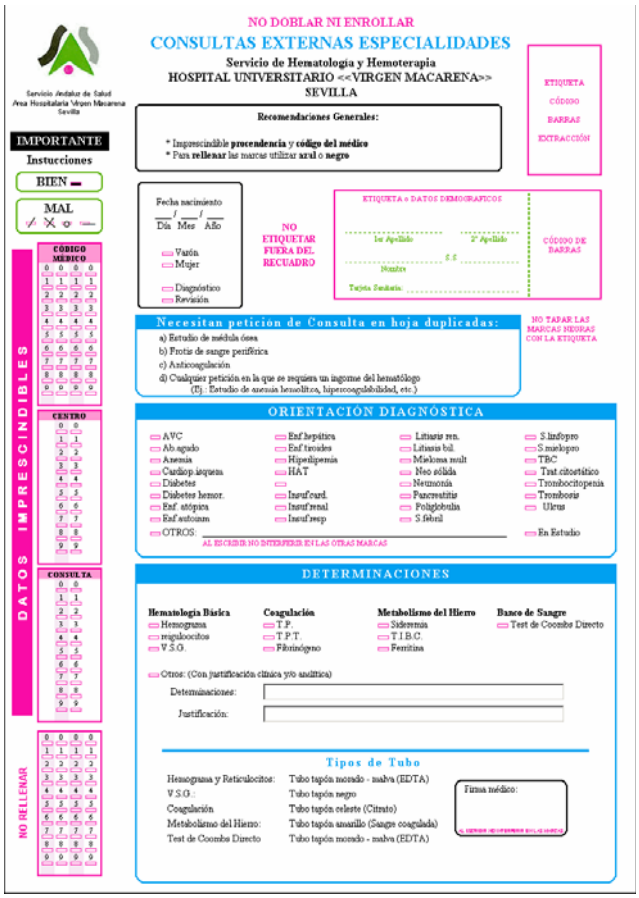

Figure 3: Request form for haematology and haemotherapy unit.

The application is oriented to three different actors: Doctor, nurse, laboratory staff and system administrator. Doctors can request investigations to the laboratory and visualize the results in a friendly manner. A laboratory result item could be visualized in "real time", from the moment when it is stored in the system, although not all the result items from a report have been stored. This represents a great advantage with respect to the actual protocol, in which only completed reports are received, since it allows acceding before to already known information making more agile the process.

Nurses can visualize in real time the requested test and this will make easier the organization of their tasks. The main mission of laboratory staff is the introduction of results. Finally the interface for administration is easy to manage and no specialized information engineer is needed to the maintenance of the application.

The application is based on web technologies and follows the Struts framework [5]. Struts is a volunteer project from the Apache Foundation whose goal is to provide an open source framework for building Java web applications. The core of the Struts framework is a flexible control layer based on standard technologies like Java Servlets, JavaBeans, ResourceBundles, and XML, as well as various Jakarta Commons packages. Struts encourages application architectures based on the Model 2 approach, a variation of the classic Model-View-Controller (MVC) design paradigm. This paradigm confers to the application flexibility, scalability and eases its maintenance.

Once we had finished this stand alone application we began to design and develop the interfaces for software agents. The main objective is to make a design that make easier the integration in a healthcare architecture based in HISA standard. In the first approximation we are only considering the information recovery from external agents, although we are working in a more complex architecture based in the reuse of other HISA components.

The query interface is based on the COAS standard. As mentioned before it gives a set of procedures to access clinical observations. These are ClinicalInformation objects compliant with the clinical GPICs model and the specific laboratory terminology is given by LOINC thanks to the design of the data base that we have made.

Discussion

Healthcare information systems and applications already available on the market have a high degree of heterogeneity and diversity because they have been designed to support specific needs. They are usually mutually isolated and incompatible. Under these circumstances, and in order to provide better functionalities, the existing information systems inside a healthcare organisation must be integrated to share common information and to cooperate according to integrated workflows.

This goals can be achieved through a unified, open architecture based on a middleware independent from specific applications and capable of integrating common data and business logic. This architecture should support all the requirements of the healthcare organisation.

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It is necessary to consider that standards and technological solutions already exist and will continue being defined for supporting specific requirements, so the architecture must be able to accommodate them allowing the specific models to be integrated and facilitating the communication between different components. We are facing a distributed computing scenario where several components, with well defined functions have to interact to achieve a specific goal.

The architecture and the integration policy have to be designed by the organisation managers considering both, existing systems as well as the planning and construction of new ones. This is an ambitious target but standards like HISA are making the first steps and can be good reference points for this complex task, although further work is needed.

Our work began from the point of view of an isolated application but in this moment we are considering the integration in a HISA architecture. In this new framework other components could reuse specific functions of our system if we published them in compliance with the architecture requirements. The COAS interface and the data model introduced in the last section have this mission and could be considered as part of the clinical information activities workflow [1].

However it is necessary to consider also that some of the functions that our application performs internally should be externalised because components specialized in these tasks are present in the architecture. This work has to be developed inside the organization and conform to his rules because a deep knowledge of the existing components is needed. The state of HISA specification in this moment is not advanced enough to make a very detailed model supporting the design only in the standard. Considering the last version published in CEN's website [1] some activities that could be externalised are:

- Subject of care management: in particular identification.
- Activities workflow management
- Resources control: staff and material.
- Security issues: authentication, access control, policy management…
- Audit and version control tasks
- Other clinical information components, in particular those interfacing with the laboratory equipment and those involved in the EHR management.

Conclusions

We have introduced an application developed for the management of a laboratory system. In this application we can difference between a human interface that provides a friendly management of laboratory tests, very similar to the current paper based manner. In addition, an interface for software agents has been designed. The use of COAS standard, CEN data types and LOINC terminology in this interface will improve the integration of the system in an open and distributed architecture solving functional and semantic incompatibilities.

This integration needs further study considering all the components inside the architecture and the task that could be externalized or published from the developed system.

Acknowledgements

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