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Guest Editors: *José Carlos del Arco-Prieto, Jesús Arias-Fisteus, Óscar Corcho-García, Jorge Cardoso*

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Integration and Interoperability Experiences in Healthcare

Antonio García-Landeira

The Technological environment in Healthcare has usually been defined as a group of information islands. Systems involved have a high degree of specialization in those areas which they support but, in general, they are not oriented to integration and interoperability. In this scenario Business Oriented Applications seem to be a possible solution. Unfortunately, and even when it is commonly accepted that such systems have solved a part of an existing problem, there are a number of reasons which make it impossible to accept them as the best solution. One of those reasons is they unavoidably reside within departmental applications such as Digital Imaging, Pharmacy or Laboratory. Lately, a new approach, which takes advantage of the last technological advance, Service Oriented Architecture and Integration standards in the Healthcare sector, has arisen.

Keywords: DICOM, Enterprise Service Bus, Healthcare, HL7, IHE, Integration, SOA, XML.

1 Introduction

Nowadays, Healthcare Information Systems include a large number of areas or departments. All those areas play a very important part in the daily activity of Healthcare Organizations. The work done at clinical services, Infirmary, Laboratories, Image based diagnostics or Pharmacy is supported by applications specifically designed for their daily management. This fact makes such systems essential tools for the correct performance of each department. In most cases, existing information systems are well designed to support each service workflow, and collect in an exhaustive manner the information needed for their management, or for being exported to other organizational units.

Unfortunately, and due to the large number of specific information systems that coexist in any healthcare organization, it is difficult, if not impossible, to find homogeneous software which supports the full existing functionality. This fact makes very easy to find a large collection of installed applications from different providers and supported with different technologies. Also, it is usual to find solutions from different providers in departments where the same activity is done. The reason is that such applications were acquired and installed just in the moment that they were needed. Due to this fact, it is easy for those applications to be in differing evolutionary stages.

A major part of the information that departmental applications manage is generated and used for the service or area where they are installed. However there is a significant part of that information which must be obtained from other systems, or even sent to other interest points of the healthcare environment. An example of information which is necessary to keep up to the date in any clinical application could be patient identification data, the place where a patient has been assisted and their welfare programme. These data, which are generated at the admission service, must be sent to the different systems involved in the welfare activity (laboratory, pharmacy, infirmary etc.) in order to assure an integrated service. One more example is healthcare professionals' data and the organizational structure where they are working. This information is necessary in order to manage electronic accreditations, access permissions, etc. A third example of information generated by specific information systems and used by more general purpose systems, is the information related to important clinical information and patient treatment such as laboratory or medical image reports. Such information is generated by departmental applications, but once the result is validated, it must be accessible, from a Clinical Station, to everyone involved with patient care.

The conclusion could be that it is impossible to deploy important corporative projects, e.g. Electronic Patient Record, Digital Image management or Electronic prescription, without a correct mechanism for information exchange, consolidation and publishing. At present, this integration frame hardly exists because the different systems involved work on an independent basis in which information is manually introduced in every system. The most optimistic approach consists of the use of specific interfaces developed and designed for every particular case in order to share common information among different applications. This situation has driven the creation of information islands in

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Healthcare Organizations without a coherent or adequate workflow. The problem is still bigger when the objective is to coordinate information across different healthcare organizations or different care levels.

2. A New Technological Paradigm

In this scenario the *Services Oriented Architecture* (SOA) paradigm appears. Many people consider it as the fourth technological wave and the one which will prevail during the next decade. After the previous three waves, Monolitic applications, Client/Server and Business Oriented Applications, SOA focuses on the creation of collaborative systems using XML [1] based technologies. This emerging paradigm seems to have been created in order to solve the traditional problems in the healthcare environment, in special particular those related to clinical systems. Using SOAs, and focusing on assistance processes, it is easier to build interoperability layers, based on traditional Software Engineering concepts such as reusability or encapsulation, but oriented to a new technological environment which makes possible the integration of components on a global clinical area.

Adoption of this paradigm in any organization drives the generation of services from the components of the existing systems which can be easily used by other systems or services. It is possible to use many different approaches in order to build a SOA, but the most commonly used is Web Services implementation. In this case, SOA is usually called *Web Services Architecture* (WSA). Using WSA as SOA implementation has a main advantage: It makes possible the use of I*Net protocols in order to communicate between systems, which makes internal and external integration easier. This fact has a special interest when applied in Healthcare, because it implies an easy integration of the different care levels.

But, building SOAs alone is not enough in a healthcare environment. Today, any healthcare system with an integration approach, must take in account healthcare standards, such as HL7 [2], DICOM [3] and IHE [4] which have been created in order to ease the integration of the different healthcare environment components.

HL7, the acronym of *Health Level 7*, defines a message collection for information exchange in healthcare, from administrative data to clinical reports. Up to HL7 v.2.5, data exchange was done using text files whose information fields are separated using "*pipes*" and information elements are preceded by "*Tags*". In v.2.5 the first documents appeared using XML formats as an alternative to the primary format configuration. From v.3.0 information exchange will be done using only XML documents.

DICOM, the acronym of *Digital Imaging and Communications in Medicine*, is a protocol created in order to integrate Digital Image Information Systems and Equipment, which are called "Modalities" in the standard.

The meaning of IHE is "*Integrating the Healthcare Enterprise*". Even though it is not a true standard, it has been commonly adopted as a useful reference frame in the healthcare sector. IHE defines a group of integration profiles for each department involved in Healthcare organizations, such as Cardiology, Radiology, etc. Such integration profiles describe healthcare workflows using HL7 and DICOM.

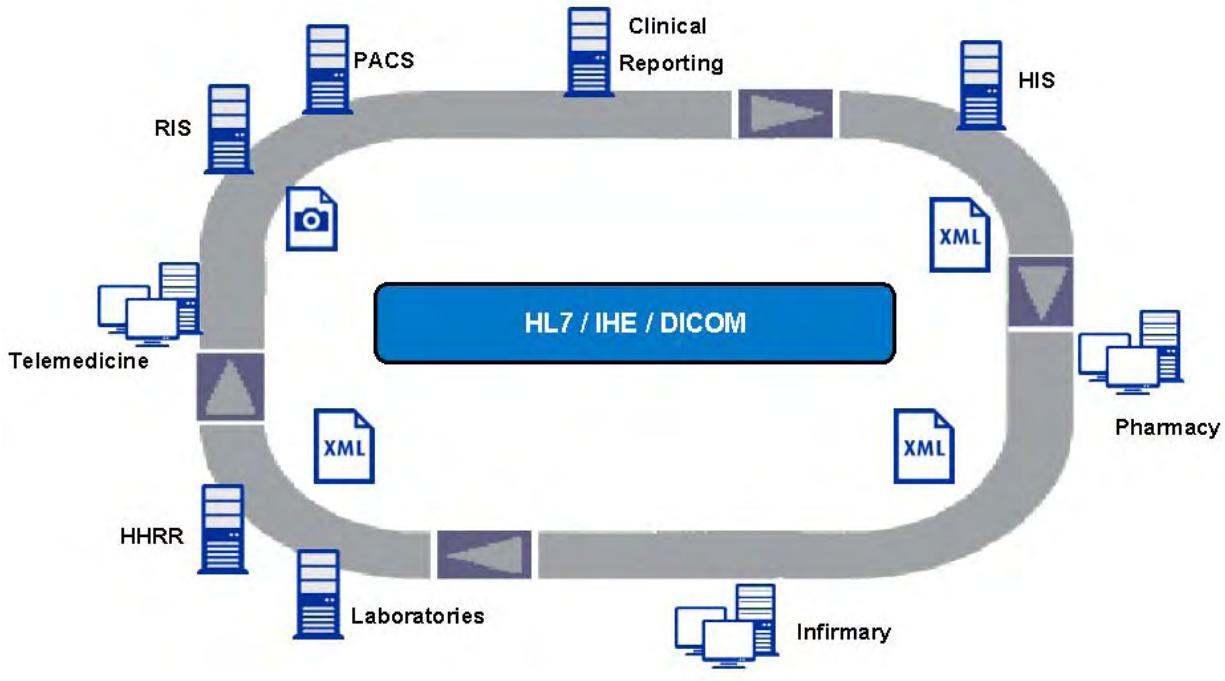

Figure 1: Healthcare Integration Approach

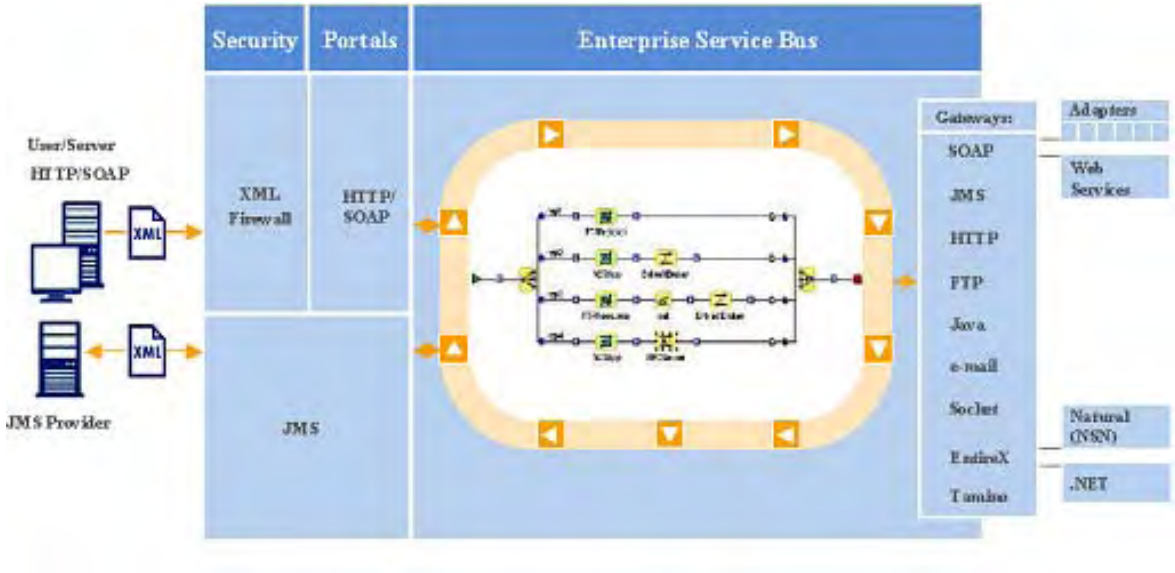

Figure 2: Enterprise Service Bus

3 Integration Approach

SOA and Healthcare information standards have been taken as reference bases for an Integration Model definition which is being successfully applied in many organizations (see Figure 1). The Model uses an Integration Platform to merge legacy applications with emerging technologies.

Such a Platform has the following characteristics:

- Healthcare Integration Standards based solution (XML, HL7, DICOM e IHE). It creates a common information interchange language for the whole organization which can be used to adapt and combine legacy applications and new acquisitions.
- Agility enhancement in existing systems renewal, avoiding any dependency related to solution providers.
- Cost optimization. Once the integration scenario has been defined and developed, any existing system can be included. As an example, patient demographic data updates are done once and information is forwarded to any application connected to the Platform. In addition, there is a return on investment in such an approach by making it easier to change or adding applications with a similar workflow to any other previously integrated one.
- Simplifies Software specification, its delivery to vendors, and evaluation of solutions, making sure that any offered solution is in agreement with healthcare consolidated standards, which can be checked using the appropriate conformance statements.
- The Platform creates a catalogue or dictionary of supported scenarios. Such a catalogue makes understanding and management of the Platform easier.
- It guarantees that any transmitted or received message is in accordance with the given specifications by means of its tracking mechanism which analyzes the correct implementation of messages and warns if any inconsistency is detected.
- Non intrusive solution with little impact on legacy systems development and existing workflows.
- It concentrates integration effort on a single point, the Integration Platform, isolating the legacy systems from the information exchange problems.
- Platform allows short workflow development time due to its incremental approach.
- Transparency in communications with any information system, irrespective of the development language or the platform it is running on: (Windows, Unix, 4GL, application server, J2EE, .net etc.).
- It concentrates full recovery procedures in case of a system failure.
- It supports an early warning system for every integration element to make problem management easier using a proactive approach.
- The platform supports messages persistence in the event of failure of any component or system involved. As an example, when the Integration Platform receives a delivery error from a destination system, it stores the message and retries the operation later. In this way there is no possibility of information loss.
- Exchanged messages are stored in native XML, which allows the use of XML signature.
- It manages messages delivery to more than one receiving system on a broadcast approach. Delivered messages can be equal to the received message or transformed, even with different content or structure for every destination.
- This solution allows the definition of synchronous, asynchronous and transactional scenarios, as well as automating processing and information routing, using message content or structure based rules.

This Platform is oriented to Systems interoperability, it is not related to its technology, it runs on a variety of platforms and Operating Systems and it is a SOA backbone.

This makes systems and middleware reuse easier, allows a low cost incremental approach and gives great flexibility to intersystem communication.

Though the main purpose of the Platform is oriented to XML management, it can also handle nonXML HL7 versions, and virtually any information transference format. HL7 was elected as the dialect to use due to its healthcare orientation and the fact that it is a commonly accepted Healthcare "de facto" standard, not through any restriction related to document format.

At the same time, this solution is one further step in the search for a Single Point of Integration, allowing healthcare and administrative processes definition and integration using IHE. In addition, it is possible to describe those business processes which are executed by legacy applications and the flows they generate. This makes possible an Enterprisewide Single Point of Integration.

In relation to security, the Integration Platform supports digital signature and XML encryption which can be used for communications with internal or external systems.

4 Underlying Technology

A SOA usually implies a higher level of complexity compared to present architectures because the entire system which results, or at least a part of it, is based on a set of cooperative services which can use, and be used by, other different services in a networked approach. Thus, it is unavoidable to use some tools, such as *Integration Metadata Repository* (IMR) and *Enterprise Service Bus* (ESB), in order to guarantee easy SOA management and maintenance. IMRs are used to store the information needed to build and manage the SOA, and ESBs are used to define and manage "relationships" among the different services involved in SOA. Using ESBs, complexity of services implementation and resulting architecture is reduced in a radical manner, because services need just one connection with the ESB in order to talk with any other service, relying on the ESB for integration logic management.

The created Platform is based on an ESB which is the centrepiece that concentrates any XML based information exchange (see Figure 2). Such a Bus handles XML transactions over the I*Net, delivers documents to the appropriate receiving applications and changes back-end message formats and presentation styles such as HTML (*Hyper Text Markup Language*), PDF (*Portable Document Format*) and WAP (*Wireless Application Protocol*), when it is necessary. Any connected application send HL7 messages to the ESB which is in charge of routing, transformation, composition, distributed transaction consolidation, etc. All the information needed to execute such operations can be dynamically managed by the System Administrator using a Management Hub.

Organizations or providers of Healthcare Centres do not need to know or understand any architecture or formats used by their customers. In the same way that printed documents are managed, electronic documents need a unique entrance point to assure their right delivery to the appropriate destination. The ESB used works as an XML communications centralizer capable of deciding where documents will be sent by applying content or structure based rules. These rules can be dynamically updated in order to allow the addition of new applications without changing existing application. Input documents are received via I*Net protocols and routed to their destinations. After being processed, output routing is managed making sure that complete XML transactions are handled in a consistent way.

In the same way, the ESB adapts documents structure and content in order to deliver them with the format expected for the receiving application. Such a transformation is done by means of a high performance engine which uses XSLT (*eXtensible Stylesheet Language Transformations*) to handle different source and destination formats. Stylesheets can be used, as well, to transform XML documents to a variety of formats such as EDI (*Electronic Data Interchange*), HTML, *Wireless Markup Language* (WML) for mobile devices and Adobe PDF among others.

Complex transactions often need the action of multiple systems before the result is returned. The ESB used includes a sophisticated sequencer that can be used to create and update document flows, as well as a document aggregator that combines transaction results from both sides of the sequence. These functions simplify processing of documents and enhances the ESB competitive advantages, preparing it for a faster and more flexible reaction to new business needs.

As to be expected, such an ESB supports HTTP (*Hyper Text Transfer Protocol*), which means that the addition of organization providers or partners can be done in real time, just by adding the server URL. It is not necessary to install any proprietary communications software in the associated site. In those sites where a firewall is used, the ESB can take advantage of the Web Server security features in order to allow encrypted transactions via HTTPS (*Hyper Text Transfer Protocol Secure sockets*).

Industry and providers standards such as *Simple Object Access Protocol* (SOAP), *Universal Description, Discovery and Integration protocol* (UDDI), *Document Object Model* (DOM), *Web Services Description Language* (WSDL) and *Simple API for XML* (SAX) are supported as well.

5 Conclusions

The existing technological scene in Healthcare Information Systems is a natural environment to apply SOA, which seems to have been created in order to solve their integration and interoperability problems. The experience acquired in this field demonstrates that the most productive approach is the definition of an Integration Model in order to collect every specific feature of this given business environment.

Such a Model may be based on Healthcare technological standards such as HL7, DICOM and IHE framework. In the same way that it is necessary to know and understand business requirements in order to build optimal business applications, such an Integration Model is the functional and technological base in an Integration Project. If the model

is correct, it can be easily and quickly implemented and deployed using tools such as an ESB. The ESB election is a key aspect for project success, because it must support those specific

Healthcare features such as HL7 document management and transformation. At the same time it must provide the most adequate connectors for an environment made of different types of Information Systems which has been developed using different technologies at different stages of evolution.

Translated by the author

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Glossary of Terms

DICOM: Digital Imaging and Communications in Medicine. Is a protocol created in order to integrate Digital Image Information Systems and Equipment, which are called "Modalities" in the standard.

HHRR: Human Resources.

HL7: Health Level 7. Defines a message collection for information exchange in healthcare, from administrative data to clinical reports.

HIS: Hospital Information System. A component of the Healthcare IT environment which mainly manages administrative, financial and clinical aspects of a hospital.

IHE: Integrating the Healthcare Enterprise. It has been commonly adopted as a useful reference frame in the healthcare sector. IHE defines a group of integration profiles for each department involved in Healthcare organizations, such as Cardiology, Radiology, etc. Such integration profiles describe healthcare workflows using HL7 and DICOM.

PACS: Picture Archiving and Communication System. Computers or networks and specific software dedicated to the storage, retrieval, distribution and presentation of images which are mainly managed with DICOM.

RIS: Radiology Information System. Specific Healthcare information system used by radiology departments to store, manipulate and distribute patient radiological data and imagery. It supports the complete Radiology department workflow and it's commonly integrated with PACS.