Interoperability prototype between hospitals and general practitioners in Switzerland

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Abstract

Interoperability in data exchange has the potential to improve the care processes and decrease costs of the health care system. Many countries have related eHealth initiatives in preparation or already implemented. In this area, Switzerland has yet to catch up. Its health system is fragmented, because of the federated nature of cantons. It is thus more difficult to coordinate efforts between the existing healthcare actors. In the Medicoordination project a pragmatic approach was selected: integrating several partners in healthcare on a regional scale in French speaking Switzerland. In parallel with the Swiss eHealth strategy, currently being elaborated by the Swiss confederation, particularly medium-sized hospitals and general practitioners were targeted in Medicoordination to implement concrete scenarios of information exchange between hospitals and general practitioners with a high added value. In this paper we focus our attention on a prototype implementation of one chosen scenario: the discharge summary. Although simple in concept, exchanging release letters shows small, hidden difficulties due to the multi-partner nature of the project. The added value of such a prototype is potentially high and it is now important to show that interoperability can work in practice.

Keywords:

Information Systems, Hospital; Informatics, Medical; Records, Medical; Interoperability.

Introduction

The advent of fully electronic patient records has strongly altered data management and processes in hospitals [1]. The availability of all data in digital format allows for an easy communication and clinicians can access the records at the same time as data can be duplicated easily. The exchange of health data in digital format also has other advantages because data loss can be prevented (for example compared to the case of images transported on film) and it can lead to the availability of essential and more complete data on patients avoiding mistreatments [2,3]. Double examinations can be avoided if the examination results can be communicated quickly.

To tackle the high potential of the domain of medical interoperability but also respond to potential risks of data abuse, strategies for the interoperability exist in many countries [4,5] and also on a European level [6]. The Swiss Confederation has also started an eHealth strategy creating a clear outline for the next ten years of managing health data at various scales, and including participants from a large number of interest groups. This effort has lead to several concrete propositions for potential standards regarding data exchange and particularly an identification of partners in the system. For a highly federated country such as Switzerland a strongly distributed structure is foreseen, storing the data at the place where they were produced, and then allowing selected access.

Although many standards already exist in the domain, not all of them offer an optimal scenario and the choice needs to be made well as the consequences are important. HL7 CDA (Health Level 7, Clinical Document Architecture) offers formats for exchanging several types of documents and CEN 13606 (European Committee for Standardization) also offers a general framework for data exchange. Coding standards exist for many domains including ICD (International Code of Diseases) for diseases, SNOMED CT (Systemized Nomenclature in Medicine Clinical Terms, [7]) as a very large-scale terminology, LOINC (Logical Observation Identifiers Names and Codes) for laboratory and clinical results, and many others.

Political processes usually advance slowly as it is a sensitive domain and wrong steps can lead to negative feedback, particularly for politicians interested in the voter's opinions. On the other hand a clear need is currently visible to have all health data of a patient in a single place. Large companies such as Microsoft[1] and Google[2] have also realized this and allow for a creation of personal health profiles. In the US many hospitals also offer such personal health records or allow for an export of the data to one of the commercial solutions [8]. This creates a risk that the commercial players might misuse the data they manage. On the other hand, patients have an interest to have a complete personal health profile.

The Medicoordination[3] project described in this paper tries to complement the Swiss eHealth strategy by collaborating mainly with regional medium-sized hospitals and smaller partners in the health system, where data exchange has not been an as important subject as in large University hospitals that often already exchange health data with external actors [9]. By communicating with several actors in the health system, a few scenarios for health data exchange could be identified, where a simple implementation brings a clear added value for all partners. This allows for testing the infrastructures in parallel to the creation of the eHealth strategy also for smaller actors in

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[1] http://www.healthvault.com/
[2] http://www.google.com/health/
[3] http://www.medicoordination.ch/

the health system to gain experience with these tools and potential problem. This project has currently limited its scope to the French-speaking part of Switzerland.

This paper presents the prototype implementation of an interoperable healthcare infrastructure. The MediCoordination Healthcare Infrastructure (MHI) is based on the recommendations of the Swiss Confederation [5] and is intended to make accessing and sharing important medical data between small-to-medium medical actors more efficient and easier. The objective of the project is to promote electronic healthcare data exchange Switzerland, through:

- the adoption of technologies recommended by the Swiss Confederation, especially Integrating the Health Enterprise[4] (IHE);
- an informative survey, representing the interoperability requirements of the Swiss medical industry;
- a prototype emphasizing the benefits of interoperability in the context of electronic data exchange.

The goal of the prototype is to communicate a release letter from a hospital to a general practitioner (GP) identified by its EAN[5] (European Article Number) number in an automated way, and integrating the letter directly into the GP health record without manual intervention. The prototype is fully implemented and deployed. Its design, implementation and tests are presented in this paper.

Methods

The Medicoordination project includes two distinct phases. During the first phase interviews were performed with several actors in the Swiss health sector (limited to the French-speaking part of Switzerland), from small to medium and large hospitals, medical associations, insurance companies, producers of laboratory and imaging data, producers of software for GPs and hospitals. The selection was made after creating an exhaustive list of actors, and then choosing to have all sectors included. The second phase has started in early 2009 and concerns the choice and concrete implementation of one use case.

The first phase is described in [10] and a few results are added for completeness. Personal interviews with 18 chosen partners were performed with the goal to have a qualitative evaluation of the needs of each partner concerning medical interoperability at the largest sense. The questions were taken as a basis for a longer qualitative discussion during the interviews. Interviews took around 120 minutes per partner and were moderated by several persons from the project (two persons per interview). The project partners developed questions together:

- Which electronic patient record is used and what exactly is digital?
- Which standards and terminologies are used, or even entire data models (such as HL7 RIM)?
- What is your attitude towards interoperability and data exchange? What is the potential and risks?
- Which scenarios would help you concretely in exchanging data (2-3 examples) with external actors?

[4] http://www.ihe.net/
[5] http://www.gs1.ch/

Use cases chosen for a first reference implementation

Scenarios were defined in [10]. From discussions, 3 use cases were specified: (1) quick electronic release note, (2) electronic release letter, and (3) operation protocol. After discussion, it was clear that a prototype for exchanging release letters would provide the highest added value for GPs.

We defined the first specifications of the scenario with an architecture using a document server, as illustrated in Figure 2. The release letter (RL) is a short text summarizing the patient stay in a hospital. The medical doctor in the hospital (MD) directly writes it in free text (semi-structured) in the information system when the patient leaves the hospital. Currently, RLs are sometimes handed to the patient on paper, but most often sent by fax or mail, often several days after the patient leaves the hospital. The goal of RLs is informing the treating GP about the diagnosis, possible interventions, medications, as well as controls to perform.

The flow of events in the proposed use case can be summarized as follows:

1. The MD in the hospital creates a new release note;
2. The recipient of the document is chosen;
3. The document is generated partly with the data from the patient record;
4. The document is filled with diagnosis information;
5. The document is encrypted (encryption system has not yet been chosen);
6. The document is sent to the document server;
7. The server notifies the GP that a new document is available (GP requests the document on the next patient visit);
8. The GP connects to the server and creates a secure channel;
9. The GP downloads the document into its application using a secure channel;
10. The document is decrypted;
11. The GP checks the document and confirms its validity and correctness, then logs out.

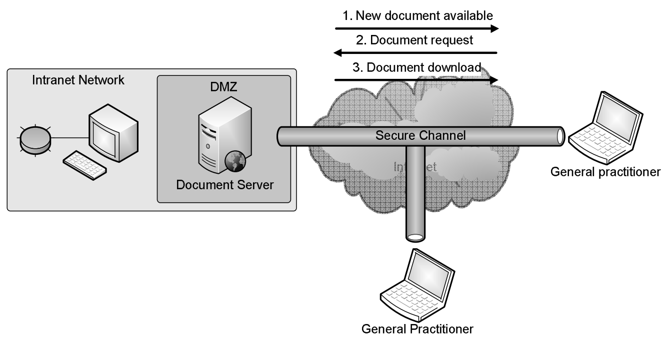

Figure 1 - The scenario of a document server inside each hospital and an exchange with external partners through a secure channel.

The MD is responsible for composing and sending the RL that will be archived in a MediCoordination repository hosted by the hospital (data is stored where it is produced).

In this context, the MediCoordination prototype does not replace, but rather complements the traditional RL communication practices (mail, fax). Paper RLs are still sent to the GP alongside their electronic version for comparison.

Requirements for the reference implementation

Three main requirements for the prototype were sketched out from the results of the survey and from partners' expectations:

- it has to provide a measurable speed gain (orders of magnitude) compared to old practice (post mail, fax);
- it must not disturb the normal practice of the GP (transparent for the user);
- it has to provide interoperability with solutions already installed in medical offices (no IT changes or updates).

We collaborated with several GPs in the elaboration of a set of requirements for metadata and document formats. This process made clear that release letters are currently preferably produced in the Portable Document Format (PDF) format before printing them. For each produced document, we chose to generate metadata as XML documents including identifiers for the sending and receiving clinicians as well as for the patient.

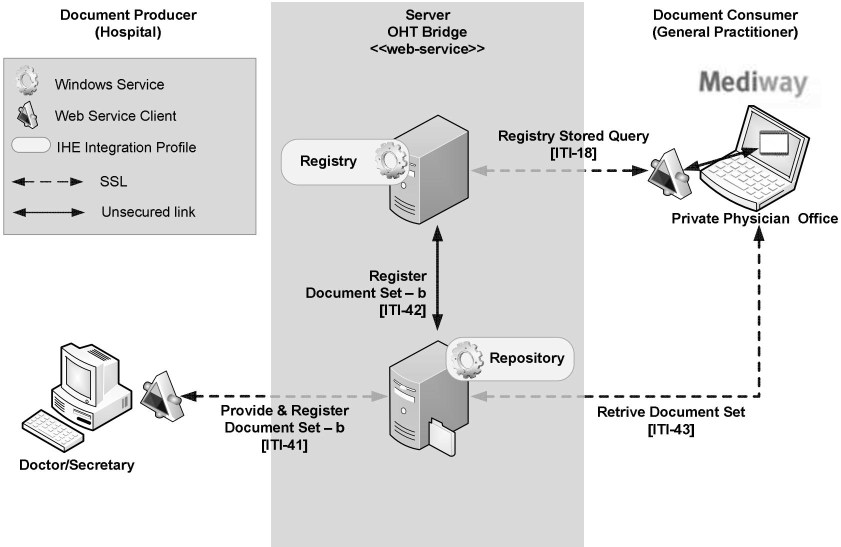

Figure 2 - Global view of the prototype with IHE IT Profile Transactions.

Results

This section details the architecture of the prototype and the results we obtained with the current implementation.

Architecture

The prototype's architecture consists of a registry/repository and two clients, one for submitting documents (MD) and one for receiving them (GP). An XDS-based (Cross-Enterprise Document Sharing) server was used for both the repository and the registry. The IHE XDS Integration Profile describes an infrastructure based on standards (ebXML), for managing the information exchange of sensitive medical data between medical enterprises. A more recent version of the XDS profile (XDS.b), replacing the old one (renamed as XDS.a) was released. It supports SOAP 1.2.

The MHI prototype does not implement notifications. GPs have to manually query the registry. Once a document is downloaded it is archived and disappears from the server.

The MHI architecture in Figure 2 shows the interactions between actors. Corresponding IHE transactions are shown as link lables. The MD writes the discharge summaries for the patient and forwards it to the server along with predefined metadata. The client application of the GP then communicates with the server registry to query and retrieve the available documents. Client-server communications are channeled through a Web service endpoint in the bridge.

Server-side implementation

The server infrastructure (blue rectangle) is subdivided into two layers: an XDS.b implementation and a bridge. Bottom Layer : XDS.b

The backend server in charge of the XDS transactions consists of a Microsoft XDS.b Reference Implementation service. The registry and repository are both implemented as Windows Communication Foundation (WCF)/.NET services using standard Web communication protocols. Simple Object Access Protocol (SOAP) 1.2 is used for messaging, Message Transmission Optimization Mechanism (MTOM) for message attachments and WS-Addressing[6] for message delivery.

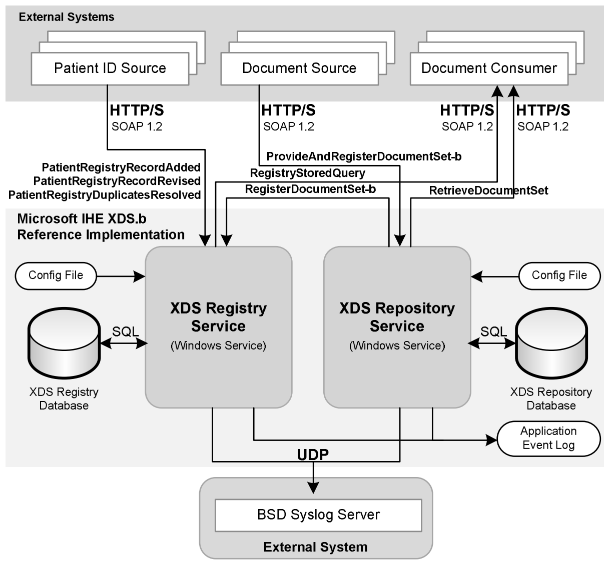

Figure 3 - Microsoft XDS.b reference implementation, including protocols and components.

The architecture illustrated in Figure 3 shows Microsoft's XDS.b implementation. The prototype described here uses bidirectional (certificates in each side) SSL (Secure Socket Layer) encrypted communication channels between layers. The certificates are self-signed (for testing purposes).

Top Layer: OHT Bridge

iheprofiles is a subproject of Open Health Tools[7] (OHT), formerly known as Open Health Framework (OHF). It aims at

[6] http://www.w3.org/Submission/ws-addressing/
[7] https://iheprofiles.projects.openhealthtools.org/

facilitating the integration of IHE profiles into healthcare projects and consists of a plug-in oriented architecture. As shown in Figure 4, profile implementations are interfaced by plug-ins. A Web service end-point (OHT Bridge) then exposes functionality behind a unified interface..

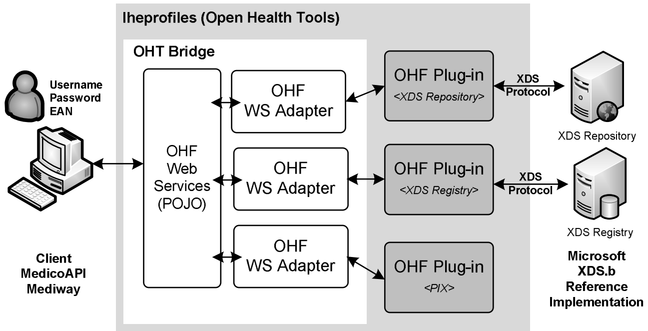

Figure 4 – iheprofiles integration in MHI

The bridge consists of many Web services encapsulated in an AXIS 2.0 container running on top of a Tomcat 6 server. Communications with the XDS.b server use SOAP 1.2 and SSL with self-signed certificates (SSC). Communication with the clients uses SOAP 1.1, SSL with SSC and token-based authentication (UsernameToken[8] from WS-Services).
The prototype uses a complementary access-control mechanism. Indeed, GPs and MDs have to provide an additional EAN-13 number in order to submit or retrieve documents. This additional credential is used to filter out documents that are not intended for the requested recipient. The EAN is kept in a database (currently a text file) along with the credentials.

Client-side implementation

The document source produces documents and the document consumer retrieves them. The prototype provides thus implementations for two types of clients.

Client-side implementation ─ Document Producer

A Java tool, CheckAppFolder, polls the state of the folder at regular intervals. When new documents are available they are forwarded to the bridge for registration and storage by the MedicoManager component, as illustrated in Figure 5.

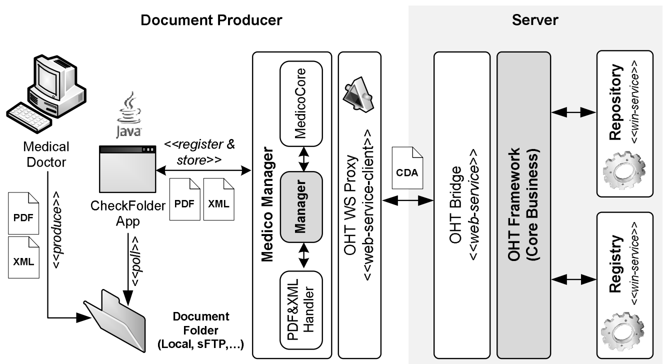

Figure 5 - Document Producer to Server integration

Documents found in the folder are base64-encoded and embedded in a HL7 CDA file by the MedicoManager component. This behavior follows from the fact that it is the only supported format by the bridge. Accompanying metadata files (in XML) are used to complete the associated CDA files before they are sent to the XDS server, and are mapped to XDS Registry.

Client-side implementation ─ Document Consumer

The consumer client is implemented in a modified version of existing well-disseminated software. Mediway[9] is an application for managing Electronic Health Records (EHR) of GPs.
The modification was brought in the form of a .NET module, the OHT Connector, connecting seamlessly with the existing software. It is responsible for the communication with the repository and the registry (through the bridge).

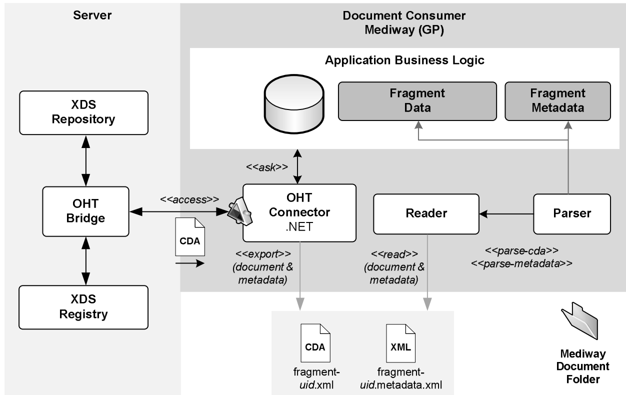

Figure 6 – Document Consumer to Server integration

The GP side prototype is shown in

Figure 6. The system first reads the list of release notes targeting the GP from the registry. All documents are then downloaded from the repository and placed in a temporary folder chosen by the Mediway user.
The OHT Connector also produces accompanying metadata files. All documents are transferred in the original CDA format and require decoding prior to extracting information and then storing it in Mediway.

Timing and results

Two servers were used for testing the prototype. The first, H-Fr was installed in a state server farm for a hospital in Fribourg. The second, named RSV was installed on a physical machine in a hospital in Sion (Valais). Both servers have running instances of Microsoft XDS.b Reference Implementation[10] and ihetools[11], which are described previously in this paper. The first system runs a copy of Windows Server 2003 R2 on an Intel Xeon CPU @ 3.2 GHz with 1GB of memory. The second machine runs Windows XP Pro SP3 on top of a Pentium 4 CPU @ 3GHz with 1 GB of RAM.
All communication tests were performed on both servers using four different GP accounts and a reasonable amount of files for each situation. We measured timings and transfer rates with a T1 connection on a consumer PC. Obtained results are expected to prove the stability of the system for an arbitrary

[8] http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0.pdf

[9] http://www.logival.ch/
[10] http://www.codeplex.com/ihe/
[11] https://iheprofiles.projects.openhealthtools.org/

number of files, and confirm the clear advantage of an electronic system compared to the traditional paper release letters.

For each server, we made a batch of measurements concerning the transfer time (TT) and the transfer rate (TR). The first measure indicates the elapsed time (in seconds) between the start and end of the download. The second measure measures the effective speed (kbps) of the download. For each measure we computed the max, min and average values. Data consisted of PDFs embedded in CDAs. Each file is about 4KB in length.

Table 1 - Timings and rates for H-Fr server

Statistic	UserA	UserB	UserC	UserD
Files	49	86	50	97
Total TT [ms]	6.45	10.66	6.37	11.79
Max TT [ms]	550.79	490.71	540.78	480.69
Min TT [ms]	100.14	100.14	100.14	100.14
Avg. TT [ms]	131.82	124.13	127.58	121.72
Max TR [kbps]	324.61	324.69	325.23	325.16
Min TR [kbps]	59.02	66.26	60.23	67.74
Avg. TR [kbps]	267.49	271.74	274.06	276.49

Table 2 - Timings and rates for the RSV server

Statistic	UserA	UserB	UserC	UserD
Files	23	23	18	26
Total TT [ms]	2.72	3.94	2.52	3.13
Max TT [ms]	200.29	480.69	480.69	180.26
Min TT [ms]	100.16	110.16	110.16	100.14
Avg. TT [ms]	118.81	171.55	140.20	120.56
Max TR [kbps]	295.10	295.10	295.67	324.77
Min TR [kbps]	162.31	67.64	67.74	180.60
Avg. TR [kbps]	278.05	231.47	278.94	274.49

File transfers were 100% successful (all files were transferred). Furthermore, results exhibited linearity (average values and total transfer time) as the number of files increases, which is representative of a stable system.

Discussion

In the context of interoperability, it is important that the information flow is quick and the GP is informed about the status of his/her patients as soon as they leave the hospital. A similar process can then be created for the admission of a patient, the full release letter, and other simple document types.

Traditionally, GPs used to query hospitals for the release letters and wait until they were sent or faxed. Upon reception, a RL had to be stored in the corresponding patient record. This process has inherent costs. The time elapsed between the query and the reception/storage counts in minutes. Our prototype reduced the process time to the millisecond range, which represents an important gain. Time lost for administrative tasks, is thus reduced.

Furthermore, with the integration of a module in Mediway, GPs accustomed to it did not have to change their habits and no additional expensive IT solutions were required.

Thus, results confirm our vision and prove that the solution is feasible. We managed to bring interoperability to actors that were until now isolated from the national eHealth strategy and relied on rather slow communication means. The experience is positive and our solution proved to have an added value.

Acknowledgements

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