

eHEALTH INTEGRATOR – CLINICAL DATA INTEGRATION IN LOWER AUSTRIA*

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Abstract

Interoperability between medical information systems is becoming a necessity in modern health care. Under strong security measures, healthcare organisations are striking to unite and share their (partly very high sensitive) data assets in order to increase the quality of care and to reduce treatment costs. Due to the immense volumes of medical data, the architecture of the future healthcare networks focuses more on interoperability than on integration. Standardized electronic documentation and communication are crucial factors for the necessary modernisation of healthcare systems. In this paper, we present a case study about the "NÖMED WAN Patientenindex" project, in which an IHE-based healthcare network for exchange of patient's documents was developed. "NÖMED WAN Patientenindex" is currently the largest eHealth projects in German-speaking region. It is being implemented in Lower Austria and it involves the stepwise creation of an electronic health network. The goal of the project is the integration of 27 hospitals in this area and building of a shared directory which will contain data about patients' treatments, medical summaries, hospital stays and diagnoses. Due to the consolidation of the mostly heterogeneous hospital information systems, physicians are now able to view all the existing examination findings and reconstruct the medical history of their patients.

1 Introduction

Despite the scientific and technological development progress over the recent years in the healthcare delivery, a significant portion of the decision-making information on the treatment

of a patient's illness is still based on unstructured information or even hand-written notation. Paper based patient health record has many advantages: it is well-established, it is easy to use, understand and browse. Nevertheless, information aggregation and processing of such data has major limitations.

The vast majority of patients receive their healthcare from multiple healthcare providers. Hospitals, physicians, recovery centres, laboratories, pharmacies and health insurance institutions have each their own, isolated patient records and therefore fragmental knowledge about the patient's health condition is stored on different sites. Absence of integrated healthcare bears the risks of medical treatment errors, duplicate examinations, lack of coordination and increased therapy costs. Using genomics data for personalisation of health care and for improving health knowledge is one of the major research concerns in modern health informatics. The fulfilment of this issue depends on the interoperability of biomedical information and patient's health records.

Although the advantages of healthcare information integration are clear, divergence still exists about how such integration should be achieved. Because of the complexity of clinical information, very heterogeneous and rapidly growing source databases involved, an integrated system needs to fulfil some important requirements like flexibility, maintainability and scalability.

The contribution of this paper is the presentation of a case study about the integration of 27 hospitals in Lower Austria into a shared network for exchange of patient's health care documents. This seminal, successfully implemented project endorses the use of the future-proof Integrated Healthcare Enterprise (IHE) [11] standard, which protects the investments through its vendor-independent extendibility.

The rest of the paper is organized as follows: we briefly present the IHE standard, in particular the XDS integration profile. Then we show a case study about the IHE-based healthcare network developed in Austria. We mainly focus on

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creation of Patient index and Medical History as well as on Cross-Enterprise clinical document sharing model. In Security section, we describe the main security aspects for guaranteeing patient's privacy. In related work, we present the most important international standards for healthcare domain. Subsequently, we shortly describe a federated data warehouse model - an alternative approach of consolidation of heterogeneous medical information systems and we finalise the paper with the conclusion.

2 Integrating the Healthcare Enterprise (IHE)

Integrating the Healthcare Enterprise (IHE) [11] is an initiative designed to stimulate the integration of the information systems that support modern healthcare institutions. IHE initiative recommends the use of existing standards, such as HL7 [8], DICOM [5], IETF and others, instead of defining new integration standards.

IHE is strongly supported by the industry: more than 160 companies have developed IHE-compliant systems between 1999 and 2005 and participated in cross-vendor testing events, Connect-a-thon [9, 10], organized by IHE. This means that standards recommended by IHE have a high probability of a quick uptake in the medical market [13].

IHE is organized by clinical and operational domains. For each domain, integration and information sharing preferences are defined. The aim of each IHE domain is to promote the implementation of standard-based interoperability solutions in its specific area, to improve information sharing, workflow and patient care. Following active IHE domains are available: Cardiology, Eye Care, IT Infrastructure, Laboratory, Patient Care Coordination, Patient Care Devices and Radiology.

IHE IT Infrastructure Technical Framework (ITI TF) is an ongoing expanded document, which defines specific implementations of established standards in order to support optimal patient care through beneficial sharing of medical information. This document illustrates IHE functionality showing the transactions organized into functional units called integration profiles.

IT Infrastructure domain consists of following integration profiles:

- Retrieve Information and Display (RID)
- Enterprise User Authentication (EUA)
- Patient Identifier Cross-referencing (PIX)
- Patient Synchronized Applications (PSA)
- Consistent Time (CT)
- Patient Demographics Query (PDQ)
- Audit Train and Note Authentication (ATNA)
- Personal White Pages (PWP)
- Cross-Enterprise Document Sharing (XDS)

Last integration profile mentioned (XDS) specifies how to manage and share electronic clinical documents that participating healthcare providers are willing to share. Since this corresponds to our research issue, we will describe it in more detail in the next section.

2.1 Cross-Enterprise Document Sharing (XDS)

The task of the Cross-Enterprise Document Sharing (XDS) integration profile is to facilitate registration, storing and sharing of healthcare documents across healthcare enterprises. Thereby, XDS is not concerned with the content of the documents – it handles standard or formatted text as well as images or structured clinical information.

XDS acts on the assumption that healthcare enterprises participating in the document exchange network build a group called Clinical Affinity Domain. A Clinical Affinity Domain is a group of healthcare enterprises that have agreed to work together using a common set of policies and share a common infrastructure [3]. The policies include specification of patient identifiers, definition of document format, structure and content, agreement on access control as well as assignment of metadata representation of the clinical documentation. These are necessary prerequisites for ensuring interoperability between heterogeneous healthcare information systems.

Actors involved with XDS and the transactions between them are depicted in Figure 1.

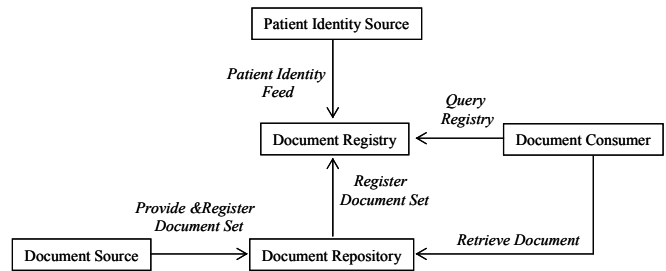


Figure 1: Cross-Enterprise Document Sharing Diagram (XDS) [3]

Document Source is the healthcare institution participating the document sharing network. Document source provides the documents to be shared and corresponding metadata, which is used for document registration.

Document Registry contains and administers the metadata of the documents, and can be queried in order to detect the designated *Document Repository*.

Document Repository stores documents to be shared. Since these are very high-sensitive data, *Document Repository* can not be queried. Users (*Document Consumers*) need to know document's unique ID (stored as metadata in *Document Registry*) in order to retrieve the desired document.

Patient Identity Source is responsible for assigning patient identifiers.

3 Case Study: NÖMED WAN Patientenindex

3.1 Healthcare Providers Landscape in Lower Austria

The Lower Austrian Health and Welfare Fund Area of Health (NÖGUS) is in charge with financing, quality assurance and supply planning for the 22 hospitals distributed over 27 locations and embracing approx. 8200 beds. Currently, 7 different HIS from 4 different vendors are in use. Additionally to the hospitals, around 3000 general

practitioners are providing health care to approx. 1.5 million inhabitants [7]. For the time being, there is now unique patient identifier, medical records are isolated and stored at particular care giver devices. Clinical documentation is hardly reused and exchange of patient's information occurs rarely and only on request.

3.2 Patient Index and Medical History

The goal of "NÖMED WAN Patientenindex" project is to provide direct access to clinical documents at the local document repositories by using standardized IHE XDS integration profiles [7].

Since very heterogeneous information systems and patient identification mechanisms are in use at participating institutions, unique patient identification is the essential prerequisite for establishing interoperability between the healthcare providers. The aim of the project was not to rebuild the existing systems, but to create a superstructure, which would allow the hospitals to keep working with their existing, proved structures. At the same time, this construct would support communication and message exchange between the heterogeneous participating healthcare information systems.

As presented in figure 2, the project comprises two phases:

1. Patient Master Index (MPI)
2. Electronic Patient Record – Index (EPA-I)

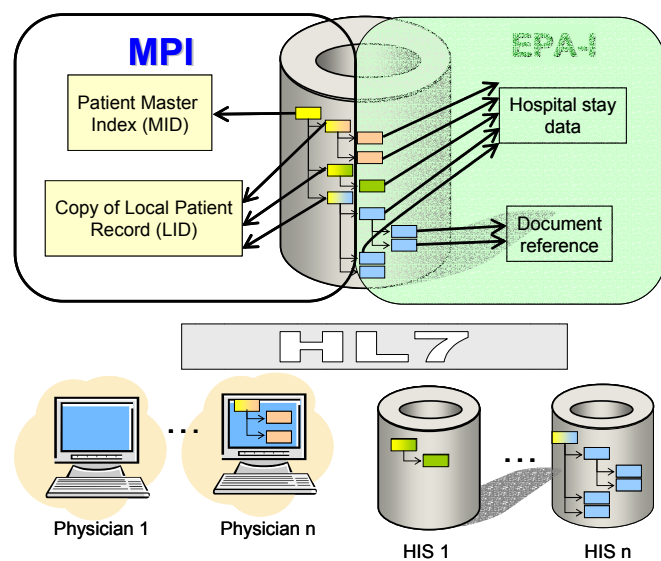


Figure 2: Patient- and Medical History Index: Overview – Data Management [1]

The hospitals deliver their patients' identification numbers to the central systems. Here, a unique patient identifier (MPI) is assigned to each patient. The MPI is confidentially stored in the central system and remains invisible to the originating hospital.

The Electronic Patient Record – Index identifies the collection of patient's clinical documents. This is the history of all interactions patient had in the past with the participating health care providers. It encloses:

- Medical Summaries
- Ambulatory treatments
- Clinical and lab findings
- X-ray images
- Medications etc.

Hospitals as well as the private operating physicians have access to the electronic patient record. When a patient is admitted to the hospital or visits the physician, he (she) is identified by his (her) e-Card. (e-Card is a robust and secure smart card based patient identification solution, which is in use in Austria nation wide.) When the patient is identified, and the access rights of the physician in charge are verified, he (she) is eligible of getting insight into patient's clinical documents.

The project has been implemented by T-Systems [18]. It started in March 2005 and had its first phase (pilot project) accomplished till the end of the year. The goal of the pilot project was to connect five hospitals and a few private medical practices into a healthcare network for exchange of patients' clinical documents. In the subsequent phase, which started in summer 2006, remaining hospitals and private practices joined the network.

The experience gained in this project in Lower Austria will be used for nation wide connection of care providers.

3.3 Cross-Enterprise Clinical Document Sharing in NÖMED WAN Patientenindex

The fulfilment of the goal of the "NÖMED WAN Patientenindex" project - to facilitate clinical document sharing among the healthcare providers in Lower Austria – bears following major requirements on the clinical documentation: renunciation mail transmission of medical findings, change over to online availability of all relevant patient's data and creation of a life time patient's health record.

Figure 3 shows the separation of the XDS-related activities caused by these requirements :

- MAKE = Creation of the documents
- STORE = Storage of the documents
- SEARCH = Retrieval of the documents or particular contents
- VIEW = Presentation of the documents

This kind of separation is in the radiology due to DICOM standard already a common way of document handling. Due to IHE model, it can be applied in all healthcare areas.

Figure 3 presents the clinical document sharing process in Lower Austria. Clinical documents are created (MAKE) in the hospitals, which are participating the document exchange network. Document structure and format are created according to the clinical affinity domain specification. Only pure clinical documents (clinical referrals, hospitalisations, admission, transfer and discharge) are created here, with no additional medical data, which might be interesting for further statistical analyses.

Clinical documents which are released to be shared among other healthcare providers are stored in document repositories (STORE). Following occurrences of document repositories are possible:

- Per organisation
 - hospital
 - hospital group
 - association of doctors with private practice
- Per region
 - state
 - province
 - region
- Per data category
 - discharge letter
 - images
 - medical findings

MAKE and STORE activities are performed by document producers (hospitals), while SEARCH and VIEW are accomplished by document users (hospitals and private practices).

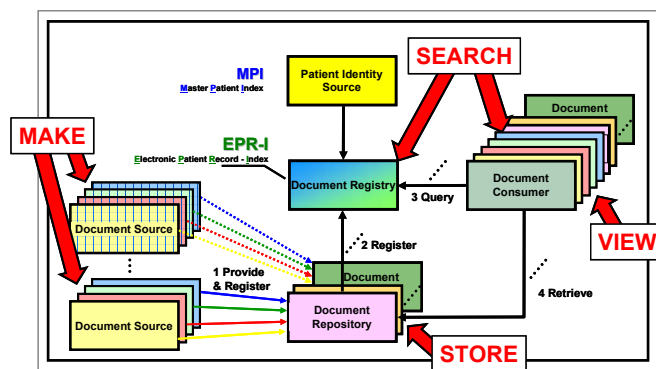


Figure 3: XDS in "NÖMED WAN Patientenindex" project [1]

In order to retrieve a document (SEARCH), document consumer has to know document identification number (EPA-I) and respectively patient master index (MPI). Social security number (SVNR) was natural but not good candidate for MPI, because it can be ambiguous. Moreover, it represents a security threat, since it can be misused to reveal personal, financial, political etc. data of a patient. MPI and EPA-I are created centrally, by the trusted third party and stored in metadata files residing in document registries.

After the document consumer has identified the desired document, it can be viewed or downloaded (VIEW). One new model of data retrieval is currently being considered: document consumers subscribe for desired documents (i.e. a physician subscribes for all clinical data related to his (her) patient). As soon as such documents are registered in one document registry, subscribers are notified and given a link to the particular document ("push" instead of "pull" mechanism).

4 Security

Over the past few years, we can observe an increased awareness of data privacy and protection in the healthcare sector. Healthcare information systems comprise large volumes of sensitive data and therefore must guaranty a high degree of data protection. Protection of high confidential patient data is subject of international regulations. Issues of

privacy, software regulation and ethical and legal aspects of data processing in healthcare may build main sources of conflicts. Since the usability of clinical information systems is of the extreme importance, overwhelming the medical staff by non-user-friendly security procedures has to be prevented. In "NÖMED WAN Patientenindex" project, the privacy of sensible patients' data is achieved through role-based access model, which guaranties that users can only access those data, which are granted to the role they have.

Stolba et al [14] state that the role should be regarded as a job description regardless of the actor performing it. Roles should exactly be assigned with those authorisations that are needed to fulfil the duties of the job. Each user should be assigned to at least one role, though multiple roles are allowed. A user can play only one role at the time. This policy prevents authorisation conflicts among the roles of a user and it does not mean a limitation to real-life situations, as long as users can easily change their role due to the tasks needed to be fulfilled.

Another aspect of data protection in this project is achieved through patient's self-determination about his (her) clinical documents. After each hospital stay, the patient can decide which of the corresponding lab findings, hospital stay data etc. will appear in his (her) medical history.

Last but not least, creation of a unique patient identifier (as described in section 3.2), which remains centrally stored and hidden from originating information systems is significant step towards building a secure interoperability network.

5 Related Work

5.1 International Standards in Healthcare Domain

The highest level of generalization and portability for the conceptual model can be achieved if an international standard that covers all areas of healthcare is adopted. Current international standards used for healthcare information: HL7, ENV 13606 and openEHR have been developed in parallel since the early 1990s, some of them adopting some concepts of the others.

5.1.1 HL7 CDA

HL7 (Health Level Seven, [8]) is an ANSI-accredited standard developing organization (SDO) for healthcare data. Version 3 of HL7 standards defines the object-oriented Reference Information Model (RIM), the starting point for all HL7 standards. RIM introduces six backbone *foundation classes*. HL7 Clinical Document Architecture (CDA) is an XML-based document markup standard that specifies the structure and semantics of clinical documents for the purpose of their exchange. A CDA document consists of a body (containing medical data) and a header (containing data about people and organizations connected to the data i.e. patient, clinician and hospital). Clinical data within the body of the document can be nested recursively. HL7 is used worldwide in Hospital Information Systems.

5.1.2 OpenEHR

openEHR and ENV 13606 also introduce object-oriented reference models and a modular structure of healthcare documents. The general information model of openEHR [16] describes only the nested hierarchical structure of healthcare records. Clinical data is defined separately for each healthcare domain using an ontology-defining constraint language. ENV 13606 (proposed by the European Committee for Standardization) is currently under a substantial revision due to its unnecessary complexity, which even led to some ambiguity and non-interoperability [6].

5.1.3 xDT

xDT [12] is a de-facto standard in Germany, used by health insurance organisations, pharmacists and primary healthcare ordinations. Meanwhile, German hospitals have adopted HL7 standards. A comprehensive integration of xDT and HL7 standard has been performed by Sciphox [17]. The previously used octet-encoded xDT messages have been abandoned and HL7 CDA and XML introduced. There is no general object model for xDT and its document structure is domain-dependent.

5.2 Federated Data Warehouse Model for Clinical Data Integration

With the raising need for the creation of unified knowledge base, the federated approach to distributed data warehouses (DWH) is getting increasing attention. In their recent work [15], Stolba et al. propose a federated DWH model for consolidation of heterogeneous healthcare information systems.

According to Sheth and Larson [2] a federated database is “a collection of cooperating database systems that are autonomous and possibly heterogeneous”. A federated data warehouse is a functional warehouse, a “big umbrella”. No central, large data warehouse that collects data from smaller component warehouses is created: heterogeneous data warehouses are functionally integrated into a single unit from the conceptual point of view using a unique common conceptual model. Existence of a federation must not have impact on local users of the component warehouse. The sharing process generally includes only a part of the component warehouse data and is under selective control of the local administrators. Each component unit itself must work independently of the federation.

Federated DWH technology enables the acquisition of all available patient’s data from diverse medical data sources participating the federation, transforms that data and creates the unique patient’s electronic health record (EHR). It is not necessary to store the EHR as a single physical entity in a centralized system. Instead, when required, EHR can be aggregated into a single coherent record from data stored in various geographical locations. Moreover the federated approach is a step towards decentralisation of security assurance and is scalable since it is component-based – each new data source can be easily included into the federation, without having to redesign the existing system.

In the federated DWH model (Figure 4), different medical treatment domains, the social insurance domain and the pharmaceutical domain participate in one federation. Some of them communicate with the federation via web services; others may transfer their sensitive data directly to the federation, in case of a federated query.

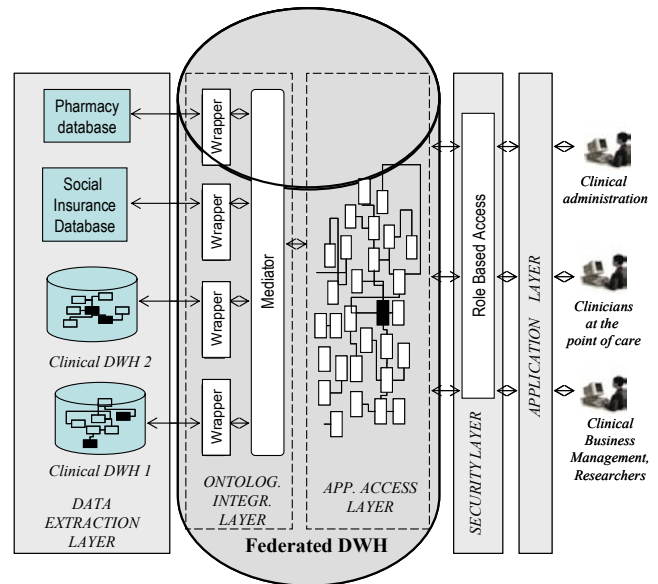


Figure 4: Medical Federated DWH Model

Since only a unique interpretation of the joined data should exist, it is necessary to have a unique common federated schema. As shown in the model in Figure 4, the essential part of the integration of logical schemas of the underlying DWHs as well as of the data structures originating from the diverse participating legacy systems (such as relational or XML databases) is the *ontological integration layer*. Wrappers and mediators [4, 15] are the main architectural components of a mediated query system. Participating organisations use internationally adopted standard message formats for transmission of their health information to the federation. Role based access model guarantees the secure handling of the high sensitive medical data. Diverse users, with diverse software skills and diverse data needs are accessing the federation via Web Services, Data Mining and OLAP Tools. Compared with IHE approach, federated DWH method supports statistical analysis of healthcare data, which is especially interesting for decision support of business management. At the same time, development of a federated DWH is much more time consuming and expensive task. Since the purpose of “NÖMED WAN Patientenindex” project was not to perform any statistical analysis but to facilitate the exchange of patient’s healthcare documents between participating care givers, IHE based approach was chosen.

6 Conclusion

“NÖMED WAN Patientenindex” project, presented in this paper, aims to provide seamless data exchange beyond clinical and local healthcare borders starting from within the

region of Lower Austria and expanding to national and international level in the future. It guarantees the mobility of patients, especially chronic disease patients, while they are in the country or abroad. Through improved patient identification and patient demographics data management by a central patient index system, more efficiency on patient admittance process is achieved. The quality of care has been significantly improved through efficient access to patient's medical history. Due to availability of existing clinical findings and other documents, patients are less exposed to unnecessary duplicate examinations and examination costs can be reduced.

Since patient's data are archived for the period of 30 years, "NÖMED WAN Patientenindex" project comprehends a huge medical repository, which might be used for research purposes as well. Provided that sensitive patients' data is anonymized or pseudonymized, it could be used for purposes of evidence based medicine, disease management or epidemic/outbreak management which leads to improved quality of care, more efficient healthcare management and cost reduction.

The universal, simple and flexible common conceptual model proposed in this case study enables potential future integrations of other healthcare organisations to be done seamlessly and with a minimum effort.

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