Exploring Complexity in Health: An Interdisciplinary Systems Approach
A. Hoerbst et al. (Eds.)
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Patient Portal Integration – A Native IHE Connector Implementation for PEHR

Nilay YÜKSEKOGUL[1], Björn SCHREIWEIS, Nicolas WEISS, Lakshmi S AGUDURI, Antje BRANDNER, Tobias BRONSCH, Peter PENSOLD, Katharina E STEIN, Axel HELMER, Björn BERGH and Oliver HEINZE
Center for Information Technology and Medical Engineering, University Hospital Heidelberg, Germany

Abstract. Providing patients with access to their medical data has recently evolved as a topic in several countries. Different approaches are possible. For example patient portals are used for patient access towards medical data. The University Hospital Heidelberg is engaged in a research project to develop a personal cross-enterprise electronic health record (PEHR). The objective of this work is to describe the architecture and implementation of a component called IHE Connector which represents the native IHE-based integration between the patient portal and the PEHR core components. The architecture of the PEHR is accepted based on international standards. The core components consist out of ready to use software products like a master patient index. The patient portal has been developed using Liferay framework. The IHE Connector is mainly based on the Open eHealth Integration Platform (IPF) Framework, which has been deeply integrated into the patient portal to support the needed IHE transactions. Several IHE profiles for sharing documents and patient information are supported by the IHE Connector. As IPF already provides interfaces for some IHE profiles others had to be developed from scratch. The IHE Connector can not only be used for connectivity between patient portal and PEHR core, but also provide connectivity for third party apps and healthcare providers' information systems.

Keywords. Standardization, IHE, PEHR, Open Source, eHealth, IPF

1. Introduction

The German Bundestag has passed a new E-Health Act stating that by the end of 2018, patient data should be provided in an electronic health record so that the data is available for cross-institutional documentation [1]. Patient access to their medical data has recently become a service for patients in several countries [2-4].

The University Hospital Heidelberg has been working for several years on the research project "INFOrmation technology for PATient-oriented healthcare in the Rhine-Neckar metropolitan region" (INFOPAT) [5], funded by the German Federal Ministry of Education and Research (funding code: 01KQ10038B), and pursues the aim of establishing a personal cross-enterprise electronic health record (PEHR) in the region [6-8]. The aim is to provide an integrated and cross-sectoral care for patients with chronic diseases. To ensure the interoperability with other systems like hospital information systems, the architecture of the PEHR is based on IHE profiles. The

[1] Corresponding Author: nilay.yueksekogul@med.uni-heidelberg.de

components of the PEHR consist of IHE-based implementations like a Master Patient, and an XDS registry and repository. The Liferay-based patient portal empowers patients to manage their health data and to define access rights. To seamlessly integrate the patient portal with the PEHR core, an IHE Connector should be developed.

This work describes the architecture, the implementation as well as the development experiences of standardized data flows between the portal and the PEHR core.

2. Methods

The implementation of standardized data flows within the PEHR is specified as a requirement to the PEHR system architecture [9]. For this reason, the data flows have to be implemented using Integrating the Healthcare Enterprise (IHE) profiles. The supported IHE profiles are listed in Table 1.

Table 1. IHE Profiles to be supported by a PEHR as specified by Heinze [9].

IHE Profile
Patient Identifier Cross-referencing (PIX)
Patient Demographics Query (PDQ)
Cross-Enterprise Document Sharing (XDS.b) incl. XDS Metadata Update
Audit Trail and Node Authentication (ATNA)
Healthcare Provider Directory (HPD)
Cross-Enterprise Document Sharing for Imaging (XDS-I.b)
Consistent Time (CT)
Basic Patient Privacy Consents (BPPC)
Cross Enterprise User Assertion (XUA)

Table 1 shows all IHE profiles that are required for a PEHR. The PIX profile allows for mapping the same patients between different healthcare providers. With the PDQ profile demographic patient data and visit information's can be queried. XDS.b and XDS-I.b profiles are one of the important profiles for PEHR, with that can be shared documents and images between different healthcare systems. For security measures ATNA plays a major role. ATNA provides access information and system authentication. The profile HPD serves as directory structure of healthcare provider information. CT is used for time synchronization between all actors and transactions. To make sure users can be authenticated across systems, XUA has been used. Patient's consents can be made available electronically using BPPC and its extension for more advanced consent rules (Advanced Patient Privacy Consent (APPC)) [10-12].

For the implementation of the IHE profiles and the connectivity in the patient portal, the framework Open eHealth Integration Platform (IPF) from the Open eHealth Foundation [13] is used. For the IHE-based connectivity between the patient portal and the PEHR core, a Java library has been implemented using the IPF framework. The library is called "IHE Connector". The IHE Connector is built as an Apache Maven project.

The software development team for the IHE connectivity consists of two software engineers and is managed using the incremental and iterative agile software development process SCRUM. The development takes place in 14-day sprints.

3. Results

In this research project, except the IHE XDS-I.b and SWF profiles, all required profiles of table 1 are implemented. Table 2 shows all IHE profiles and transactions that have been implemented in this work.

Table 2. IHE profiles and transactions implemented in project.

IHE Profile	Transaction
Patient Identifier Cross-referencing (PIX)	ITI-44 PIX Feed v3 ITI-45 PIX Query v3
Patient Demographics Query (PDQ)	ITI-47 PDQ Query v3
Cross-Enterprise Document Sharing (XDS.b)	ITI-41 Provide and Register Document Set-b ITI-18 Register Stored Query ITI-43 Retrieve Document Set
Audit Trail and Node Authentication (ATNA)	ITI-20 Record Audit Event
XDS Metadata Update	ITI-57 Update Document Set
Healthcare Provider Directory (HPD)	ITI-58 Provider Information Query
Consistent Time (CT)	ITI-1 Maintain Time
Basic Patient Privacy Consents (BPPC)	ITI-TF 1 Share Content
Cross Enterprise User Assertion (XUA)	all transactions from XDS.b and ITI-40 Provide X-User Assertion

All transactions are realized in separate Java classes with a constructor method to build a web service message, as well as a send method to submit the messages. The messages are sent using the SOAP protocol. This interface is also built with the IPF framework.

For PIX and PDQ transactions, the Health Level 7 Version 3 (HL7 v3) standard was selected. In order to build the message structure, HL7 v3 message templates (PIX Feed, PIX Feed Record Revised, PIX Query, PDQ Query) are used. These templates are then filled with patient data entered in the patient portal. The patient data are provided during the registration of the patient in the patient portal. The messages are then sent to the Master Patient Index (MPI) endpoint and either register the patient (PIX Feed [ITI-44]) to the MPI (see Figure 1) or request the master patient id (PIX Query [ITI-45]) or master data (PDQ Query [ITI-47]) for that patient.

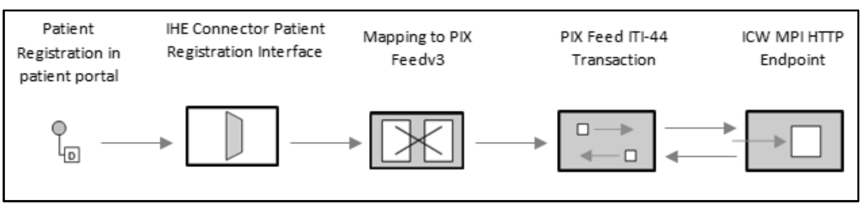

Figure 1. Example of the PIX Feed transaction.

All other transactions are built with the help of the classes provided by the IPF framework. For the XDS.b profile, the IHE Connector serves as a Document Source and Document Consumer. XDS documents in our context are documents (mostly pdf files but also HL7 CDA) and images (jpeg and png). The connector can store these in the PEHR (Provide and Register Document Set-b), request a document list (Registry Stored Query) and retrieve documents (Retrieve Document Set). For the Registry Stored Query transaction query options and combinations have been implemented. Based on the query options with the patient id can be searched all document metadata entries or all document metadata entries (Document Entry), submission sets and folders. It is also possible to get a predetermined list of document IDs to search the document metadata information's.

IHE Connector serves as an interface of the components patient portal, third-party app providers and the IHE adapter for hospital information systems to communicate data and patient information in an IHE compliant way. Those components use the IHE Connector as a library. The library then needs to be integrated into the components' backend (see Figure 2).

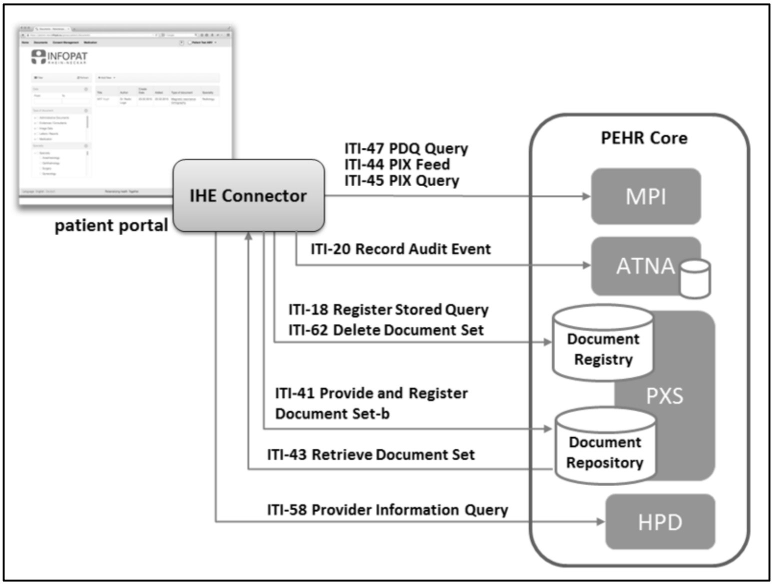

Figure 2. IHE-based data flow between patient portal and the PEHR core components.

Figure 2 presents the various IHE transactions that allow communication between the IHE Connector and the components of the PEHR core. Components of the PEHR core are the MPI, which serves as an identity management system, ATNA (Audit trail and Node Authentication), PXS (implementing the XDS Document Registry and Repository) and the HPD. Furthermore, the individual transactions between the IHE Connector and the components are shown in the diagram. The profiles XUA and BPPC are implemented, too. Both are combined with all other transactions. Therefore, they are not shown in figure 2.

4. Discussion

IHE connector has been developed successfully integrating the patient portal and the PEHR core. By using standards it is possible to ensure an easier and faster connectivity and interoperability of healthcare IT systems such as third-party apps. IPF is used because of promising previous experiences with this framework in other projects [14, 15] and because it is open source software. Through an active community it is easy to get help and to solve development problems. The learning curve for IPF is very steep. Nevertheless, it is a very powerful framework to easily and quickly develop IHE transactions. IPF offers prefabricated classes and methods for many IHE-ITI profiles. It also facilitates the validation of HL7 v2 and v3 messages, as it provides validation methods. Another tool is Open Health Tools [16] that could be used instead of IPF. But Open Health Tools is resembled in IPF as IPF is reusing multiple classes of the Open Health Tools.

Some IHE profiles only required for the IHE adapters in the healthcare providers information systems are not yet implemented due to mapping problems. E.g. a mapping between HL7 v2 messages and XDS-I is not possible since not all of the required metadata are available from HL7 v2 ORM.

Implementing IHE profiles for interoperability is widely done in Europe (e.g. Austria [17], Switzerland [18], Luxembourg [19]) and the US. Additionally, the European Union published a list of IHE profiles eligible for public procurement [20].

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